WENATCHEE

Subbasin Plan

Prepared for the Northwest Power & Conservation Council

Wenatchee Subbasin Plan

5/28/2004

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1.1 Contributors

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1.2 Subbasin Plan Approach and Public Involvement

Subbasin planning formally began after contracts between the subbasin co-planners and Northwest Power and Conservation Council (NPCC) were signed in October 2003. Under the Washington State Engrossed Substitute House Bill 2514 Watershed Planning Act, the Wenatchee Watershed Planning Unit (WPU) was formed to guide the development of state watershed planning. Many of the activities relevant to the WPU were highly consistent with NPCC subbasin planning. Co-planners chose to use the WPU and the associated subcommittees (water quality, water quantity, instream flow and habitat) as the primary body for public involvement and development of the subbasin plan. The WPU consists of a wide representation of citizen organizations and government agencies. The subcommittees include representatives from many agencies and stakeholders and are primarily responsible for development of the technical information for WPU consideration. The WPU is currently in its third year of formal recognition by the state of Washington and associated parties. All meetings associated with watershed and subbasin planning were advertised and open to the public.

During the early progress of the aquatic assessment, numerous meetings focused upon the development and utilization of the Qualitative Habitat Assessment (QHA) approach, specific to aquatic interests.

Information used for this assessment was derived from existing documents provided by Chelan County, state, federal and tribal government representatives. The primary purpose of the subcommittee work was to develop a concise and meaningful organization of existing technical information so that the information is accurately reflected in the subbasin plan, could be systematically evaluated, and easily understood by the lay audience.

The format used for the Inventory component of the subbasin plan was provided via internet to all publics that have likely sponsored and implemented on-the-ground projects. To date, little response by agency and the general public has been forthcoming. It is not clear if this is an indication of the extent of recent project implementation or a reflection of high work loads by these publics and agencies.

The draft management plan was developed in a manner similar to the assessment. Co-planners sponsored subbasin planning meetings in concert with regularly scheduled monthly meetings associated with state watershed planning. Occasional and additional subbasin planning meetings were held intermittently from February through April. The technical subcommittee was able to identify key areas from the assessment where habitat conditions have been altered to the greatest extent and where fish distribution has probably been most affected. From these findings, management strategies, management objectives and near-term opportunities were developed and organized by key habitat attributes. Much of the direction for both the assessment and management plan was provided during the regularly scheduled meeting times. Work completed outside of the meeting forum was presented to the technical subcommittee and modified by co-planner representatives as needed.

Washington Department of Fish and Wildlife (WDFW) were the primary sponsors in the development of the terrestrial assessment and management plan. Most of this work was accomplished at the regional level which contributed to a consistent document style and approach throughout the Columbia Cascade Province. The draft assessment and management plan were edited by WDFW staff at the local level and made available to the public through the

NPCC website in mid-April. Because of the fundamental differences in assessment techniques between fish and wildlife resources, the draft aquatic and terrestrial management plans are offered in this document separately.

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2 Executive Summary

2.1 Purpose and Scope

National Oceanographic and Atmospheric Administration Fisheries (NOAA Fisheries, formerly the National Marine Fisheries Service (NMFS)) released a biological opinion (BiOp) on the operation of the Federal Columbia River Power System (FCRPS) in 2000. This system is operated by the Bureau of Reclamation (BOR), the Bonneville Power Administration (BPA), and the Army Corps of Engineers (ACOE). The FCRPS operation has impacts on six fish species listed in 1999 under the Endangered Species Act (ESA). The FCRPS BiOp proposed a set of Reasonable and Prudent Alternatives (RPA) for the operation and configuration of hydropower facilities on the Columbia River to mitigate impacts to the survival of threatened and endangered juvenile and adult salmonids in the Columbia River basin. As part of the 2000 FCRPS BiOp, NOAA Fisheries advised the aforementioned federal agencies that, in addition to hydropower facility modifications, offsite mitigation for habitat, hatcheries, and harvest would be required to avoid jeopardy. It also established performance standards and schedules to monitor the success of mitigation measures.

In order to help meet offsite ESA obligations under the 2000 FCRPS BiOp, the Northwest Power and Conservation Council’s (NPCC) Fish and Wildlife Program collaborated with other federal caucus members to develop the subbasin planning process. Subbasin plans identify and prioritize actions needed to recover listed salmonids in tributary habitats within the Columbia River basin and guide the expenditure of BPA revenues on these offsite mitigation projects. The Qualitative Habitat Assessment (QHA) methodology was utilized in the development of subbasin plans in order to compare the ecological effects of proposed actions and determine what benefit is likely from each restoration alternative.

The three main parts of a subbasin plan are:

The Assessment - A subbasin assessment is a technical analysis to determine the biological potential of each subbasin and the opportunities for restoration. It describes the existing and historic environmental resources, conditions, and characteristics within the subbasin.

The Inventory - The inventory includes information on fish and wildlife protection, restoration, and artificial production activities and management plans within the subbasin.

The Management Plan - The management plan is the heart of the subbasin plan. It includes a vision for the subbasin, biological objectives, and strategies. The management plan addresses a 10-15 year planning horizon.

2.2 Wenatchee Subbasin Vision

The vision of the Wenatchee subbasin plan is to voluntarily bring people together in a collaborative setting to improve communication, reduce conflicts, address problems, reach consensus and implement actions to improve coordinated natural resource management on private and public lands in the Wenatchee subbasin. The strategy is to complete a science-based watershed management plan using watershed specific information ultimately leading towards compliance with the federal ESA and Clean Water Act (CWA). End products will reflect a balance between existing natural resources and human uses, and will capitalize on opportunities to improve these values.

Specific goals to advance this vision under the Watershed Planning Act (WPA) are as follows:

- Optimize quantity and quality of water to achieve a balance between natural resources and human use, both current and projected
- Provide for coexistence of people, fish and wildlife while sustaining lifestyles through planned community growth, and maintaining and/or improving habitats
- Prevent avoidable human-caused mortality of state and federal threatened, endangered and candidate species
- Develop and implement an adaptive action plan to address priority issues, emphasizing local customs, and culture and economic stability in balance with natural resources. All actions will comply with existing laws and regulations, however, changes to existing laws and regulations will be recommended as needed to attain the common vision and avoid one-size-fits-all solutions.
- Recognize the significance of the roles of limiting factors outside of the watershed and natural events within the watershed. The long term goal is to have the Wenatchee River's existing and future habitats contribute to the recovery of listed species and to eventually provide harvestable and sustainable populations of fish and other aquatic resources.
- Since 1993, landowner members of the Columbia River Management Plan (CRMP) Group/Wenatchee Planning Unit (WPU) have insisted that good science be applied to the collection and interpretation of information for all resource elements of concern. Landowners hope that through the continued use of good science, the mission and goals of the group will be met and with landowner cooperation during implementation, regulating agencies may not find it necessary to apply one-size-fits-all regulations to achieve their management objectives for the Wenatchee subbasin (CCCD 2004).
- Wildlife and fisheries vision for the Wenatchee subbasin is to have natural habitats with sufficient quantity, quality, and linkages to perpetuate existing native wildlife and fish populations into the foreseeable future. Furthermore, the vision is to restore extirpated wildlife and fisheries through protection and restoration of the subbasin where sufficient habitat exists.

2.3 Goals and Ecological Objectives

Goal 1. Maintain existing high quality habitat and the native fish and wildlife populations inhabiting these areas

Goal 2. Enhance or restore degraded areas, and return natural ecosystem functions to the subbasin

- Maintain, enhance, or restore the distribution, diversity, and complexity of watershed and landscape scale features to ensure protection of the aquatic systems to which species, populations, and communities are uniquely adapted
- Maintain, enhance, or restore biological diversity associated with native species and ecosystems
- Maintain, enhance, or restore sustainable and productive range and upland vegetative communities to promote watershed health and native ecological diversity
- Maintain, enhance, or restore significant culturally related natural resources
- Maintain, enhance, or restore unique habitats associated with riparian corridors along streams and in the upland environments
- Maintain, enhance, or restore spatial and temporal connectivity within and between watersheds. Included are the drainage network connections, floodplains, wetlands, upslope areas, head water tributaries, and intact refugia
- Maintain, enhance, or restore natural stream flow regimes per temporal and spatial patterns
- Maintain, enhance, or restore habitat to support well-distributed populations of native plant and riparian-dependent species, including habitat necessary for sustaining salmonids at critical life history stages of spawning, rearing, and migration
- Maintain, enhance, or restore properly functioning floodplain and riparian conditions
- Maintain, enhance, or restore the water quality necessary to support healthy riparian, aquatic, and wetland ecosystems

Goal 3. Restore, maintain, or enhance fish and wildlife populations to sustainable and harvestable levels, while protecting biological integrity and the genetic diversity of the species

- Maintain or increase abundance of native fish and wildlife species to a level where populations can be harvested and can be sustained through natural reproduction and productivity
- Maintain or rebuild distribution of native fish and wildlife populations to perpetuate spatial structure, life history diversity, and genetic diversity
- Maintain and/or restore performance (productivity, abundance and life history diversity) of wild, indigenous populations in a manner that maintains or enhances genetic similarity

to naturally producing populations. Artificial propagation is considered a relatively short term measure and is not intended to replace naturally producing populations over the longer term

Goal 4. Increase public involvement, knowledge, and appreciation for the protection, restoration, and enhancement of fish and wildlife resources

- Provide scientific basis for protecting aquatic ecosystems and enhance open, public planning processes for sustainable resource management
- Develop tools and processes to increase greater public involvement in accurately assessing the responses in fish and wildlife populations and their habitats to specific strategies recommended and undertaken
- Assess current and future water supply and community needs, and develop a long term strategy for sustainable community growth and efficient water conservation
- Inform, educate, and involve landowners, recreationists, and the general public about the need to protect, restore, and enhance fish and wildlife resources

Goal 5. Improve fish and wildlife management, regulation and enforcement, public involvement, and government incentives and funding to maintain and restore natural ecosystems and the species they support

- Increase effectiveness of decision-making and management of fish and wildlife populations, and their habitats
- Strengthen plans and regulations to restore and maintain habitat that supports healthy, harvestable populations of fish
- Use incentives and government funding to support the protection and restoration of fish, wildlife, and their habitats
- Build citizen support and involvement in restoration, conservation, and enhancement of fish and wildlife habitat

Goal 6. Improve coordination for long term monitoring of fish and wildlife population and habitat, and develop the required institutional infrastructure to better insure consistency and efficiency with other local, tribal, state, and federal monitoring protocols

- Develop and employ a trend monitoring program based on remotely-sensed data obtained from sources such as aerial photography or satellite imagery
- Develop and implement a long term statistically-based monitoring program to evaluate the status of fish populations and habitat (This requires probability-based statistical site selection procedures and establishment of standard protocols and data collection methods.)
- Implement experimental research monitoring at selected locations to establish the underlying causes for the changes in habitat and population indicators

2.4 Logic Path and Documentation of the Subbasin Plan

Of primary interest to the Wenatchee Subbasin Plan is the logic, or rationale that supports the recommendations of the Management Plan. The fundamental premise in the development of this Plan is to identify 1)what habitat conditions have been most effected by developments in the last 200 years, 2)how have important species responded to these changes, and 3) what local resource managers and citizens can do to maintain and enhance these and other important terrestrial and aquatic populations and ecosystems.

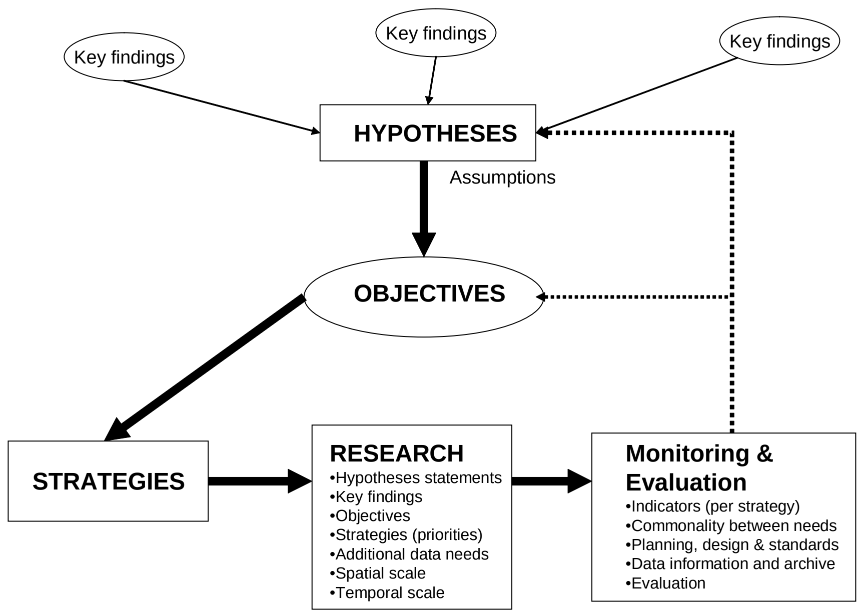

Figure 1. Logic path

While there are 11 numbered sections in this subbasin plan, six make up the major sections of the plan. All six are closely related but can be read and understood independent of the others. Below is a brief summary of the content and intent behind each of the major sections.

Subbasin Overview

Section 3, Subbasin Overview, provides a broad overview of the subbasin with respect to the Columbia Cascade Province and with the key environmental features within the Wenatchee subbasin. This information is simply descriptive in nature and is meant to help orient readers. Section 3 also provides a Scientific Conceptual Foundation which describes the underlying premises of how subbasin planners view and interpret ecological health and population responses within the subbasin, as well as the subbasin's relationship to the larger Columbia basin. This information provides the framework for the interpretation of assessment information and development of management recommendations.

Assessment

Section 4, Assessment, contains descriptive information that addresses terrestrial and aquatic considerations separately. Essentially all of the information used in the assessment exists in published literature, or was derived from technical subcommittee meetings assembled periodically for the development of this subbasin plan.

The terrestrial assessment is based upon focal habitats. These habitats are considered sensitive and/or vulnerable to changes in environmental conditions, especially from rural or urban developments. Representative species that have a direct association are identified for each of the focal habitats.

For aquatic considerations, focal species were selected based upon a) cultural significance, b) fulfillment of a critical ecological function, c) serves as an indicator to environmental health, d) are locally significant, and/or e) are a federally listed species. Focal species are seen as indicator species (canary in the coal mine) for ecosystems. Focal populations' health is a cumulative result of many environmental attributes. If these populations remain healthy, it is reasonable to conclude that the overall environmental condition and function are reasonably healthy. Focal species are described with an emphasis on life history strategies, relationship to various habitats, and population characteristics and status.

A significant component of the assessment is a description of habitat and ecological conditions within the Wenatchee subbasin. For the purposes of this document, the subbasin was dissected into 11 separate assessment anits based primarily upon major watersheds contained within the subbasin. Each assessment anit is described with regards to its overall watershed condition, riparian and floodplain condition, stream channel condition, water quality, water quantity (flow) and ecological condition. These topics are inclusive to key and measurable habitat attributes important to survival and productivity of the focal species. Specific habitat attributes are evaluated and summarized in the QHA report for over 80 stream reaches throughout the subbasin. Although using the QHA was problematic in many ways, it serves as a convenient method to summarize and convey a substantial body of information and a useful tool to identify key areas to consider for future management actions.

Each discussion of the assessment unit concludes with a brief discussion about important environmental/population relationships, areas of special interest, limiting factors (for focal species production) and key data gaps. These topics provide a brief synthesis of the Assessment Unit and highlight habitat conditions and functional relationships that should be considered in the determination of Recommended Management Strategies.

Inventory

Section 5, Inventory, is a list of on-the-ground projects that have been implemented in the recent past, using the last five years as a guideline. The purpose of the inventory is to indicate if recently implemented projects are consistent with the needs identified by the subbasin assessment. Comparing the projects from the inventory with the habitat needs is a gap analysis which serves as the conclusion to this section.

Synthesis and Interpretation

Section 6, Synthesis and Interpretation, focuses primarily upon aquatic resources and is the most complex section within the subbasin plan. The two key elements are 1) the key findings and hypothesis statements and 2) the determination of restoration priorities.

The key findings and hypothesis statements are organized in a similar manner as the assessment. First, a brief description concerning each of the focal species provides an overview of key factors and geographic areas that are and/or may be limiting production of these species. Following this discussion is an identification of key habitat attributes that limit focal species production within the subbasin and identification of attributes that remain in good ecological condition and should be maintained to support long term viability of these and other species. For those habitat attributes that are considered to be impaired, and are particularly important to the overall ecology of the subbasin, specific hypotheses statements are provided that estimate species response if these conditions could be improved to a natural range of variation (or the desired future condition, as discussed in the management plan). These discussions provide the basis for establishing priority actions within the management plan and monitoring strategy. An important component of the key findings is a summarization of four reference conditions: 1)presumed historic, 2)current, 3)existing trend, and 4)desired future condition. A reference condition is a benchmark from which habitat changes and/or population performance can be compared over time. These reference conditions are intended to be qualitative in nature and suggest potential trends rather than serving as absolute indicators of condition.

Concluding the synthesis is the determination of restoration strategies, taken from the Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region (2004) developed by the Regional Technical Team and adopted by the Upper Columbia Salmon Recovery Board. This document describes the basic criteria for determining priorities in species distribution across the landscape, and provides guidance in prioritization of protection and restoration activities. Important to note here is that this logic does not specifically prioritize or discount any potential project or activity to benefit fish and wildlife resources, rather it provides guidance in overall funding considerations.

Management Plan

Section 7, Management Plan, as designed includes three key areas:

The vision, purpose and scope and subbasin planning guidelines provide the basic context and direction for the management plan.

The biological objectives and the habitat objectives establish a future benchmark or desired future condition. The biological objectives describe the basic concepts and units of measure important in long term monitoring of a populations response to conditions within and outside of the Wenatchee subbasin. Because many environmental factors affect populations, it important to have specific habitat objectives defined that can be monitored and evaluated over time. Although the habitat objectives are relatively general as provided, they are quantitative in nature and can be measured for trend and condition. Both biological and habitat objectives are based upon and consistent with criteria used by NOAA Fisheries and the US Fish and Wildlife Service (USFWS).

Management strategy recommendations maintain a consistent format with the Assessment and key findings. For each of the habitat attributes evaluated, general Management Strategy statements are provided, supported by management objective statements, each suggesting specific types of actions that would contribute to the overall strategy, as well as the subbasin goals and vision. Concluding this section of the document are the near-term opportunities and measurable objectives. The management actions recommended could be implemented and/or could be substantially advanced within a 10-year time period if managers are successful in developing an aggressive implementation strategy and secure appropriate funding. Because these actions are generally feasible within the foreseeable future, it is appropriate to identify a measurable level of accomplishment that would signal a highly successful implementation program.

Monitoring and Adaptive Management

Section 8 is Monitoring and Adaptive Management. Over the past two years, the Regional Technical Team of the Upper Columbia Region has been actively involved in the development of a large scale, long term monitoring strategy. This monitoring strategy is designed to be consistent with ongoing federal and state direction and will focus considerable attention to three key levels of monitoring: implementation, effectiveness and validation. Consistent with the ISAB (2003) recommendations, the Wenatchee monitoring strategy will (with an appropriate level of funding) 1)contain a trend monitoring program based upon remotely-sensed data obtained from sources such as aerial photography and/or satellite imagery, 2)develop and implement a long term statistical monitoring program to evaluate the status of fish populations and habitat (this requires statistical site selection procedures and establishment of common (standard) protocols and data collection methods), and 3)implement experimental research monitoring at selected locations to establish the underlying causes for the changes in habitat and population indicators.

2.5 Synopsis of Key Findings and Conclusions

Key findings are concise statements and determinations about environmental attributes found to have a relatively high importance to the focal species existence within the assessment unit. These statements describe habitat conditions that are functioning properly as well as those that have been altered or degraded to the point that they limit the ability for the focal species to thrive or exist within the assessment unit. Key findings are first described for terrestrial and then for aquatic considerations.

2.5.1 Key Findings: Terrestrial

The terrestrial assessment viewed the subbasin from a perspective of key and major vegetative communities. Three community types were identified as focal habitat for this evaluation include: ponderosa pine, shrubsteppe and riparian ecosystems. Within each of these focal habitats, representative species that are directly associated with these vegetative communities are identified for monitoring.

Factors Affecting Ponderosa Pine Habitat

- Repeated timber harvest removed large diameter ponderosa pine and snags, and left the understory. This has resulted in accelerated successional advancement and increased the Douglas fir component.

- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Historically, extensive grazing by domestic sheep may have altered understory composition, resulting in loss of forbs and a decrease in shrub densities.
- Overgrazing has resulted in lack of recruitment of sapling trees, particularly pines.
- Invasion of exotic plants has altered understory conditions and increased fuel loads.
- Fragmentation of remaining tracts has negatively impacted species with large area requirements
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.
- The timing (spring/summer versus fall) of restoration/silviculture practices such mowing, thinning, and burning of understory removal may be especially detrimental to single-clutch species.
- Spraying insects that are detrimental to forest health may have negative ramifications on lepidopterans (butterflies) and other non-target bird species.

Factors Affecting Shrubsteppe Habitat

- Permanent habitat conversions of shrubsteppe/grassland habitats (e.g., approximately 60 percent of shrubsteppe in Washington to other uses (e.g., agriculture, urbanization). Significant acreage of shrubsteppe habitat continues to be converted to residential development between Wenatchee and Monitor (USFS 1999b).
- Fragmentation of remaining tracts of moderate to good quality shrubsteppe habitat
- Degradation of habitat from intensive grazing and invasion of exotic plant species, particularly annual grasses such as cheatgrass and woody vegetation such as Russian olive
- Degradation and loss of properly functioning shrubsteppe/grassland ecosystems resulting from the encroachment of urban and residential development and conversion to agriculture. Best sites for healthy sagebrush communities (deep soils, relatively mesic conditions) are also best for agricultural productivity; thus, past losses and potential future losses are great. Most of the remaining shrubsteppe in Washington is in private ownership with little long term protection (57%).

- Loss of big sagebrush communities to brush control (may not be detrimental relative to interior grassland habitats)
- Conversion of Conservation Reserve Program (CRP) lands back to cropland
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities
- High density of nest parasites (brown-headed cowbird) and domestic predators (cats) may be present in hostile/altered landscapes, particularly those in proximity to agricultural and residential areas subject to high levels of human disturbance.
- Agricultural practices that cause direct or indirect mortality and/or reduce wildlife productivity. There are a substantial number of obligate and semi-obligate avian/mammal species; thus, threats to the habitat jeopardize the persistence of these species.
- Fire management, either fire suppression (USFS 1999b), which has resulted in succession of vegetation communities, or overuse of fire, both of which have lead to loss of shrubsteppe
- Much of the low-elevation shrubsteppe vegetation is currently dominated by cheatgrass and other nonnative plants (USFS 1999b). Invasion and seeding of crested wheatgrass and other introduced plant species reduces wildlife habitat quality and/or availability.

Factors Affecting Riparian Wetland Habitat

- Loss of habitat due to numerous factors including riverine recreational developments, inundation from impoundments, cutting and spraying of riparian vegetation for eased access to water courses, gravel mining, etc
- Habitat alteration from 1)hydrological diversions and control of natural flooding regimes (e.g., dams) resulting in reduced stream flows and reduction of overall area of riparian habitat, loss of vertical stratification in riparian vegetation, and lack of recruitment of young cottonwoods, ash, willows, etc., and 2)stream bank stabilization which narrows stream channel, reduces the flood zone, and reduces extent of riparian vegetation
- Habitat degradation from conversion of native riparian shrub and herbaceous vegetation to invasive exotics such as reed canary grass, purple loosestrife, perennial pepperweed, salt cedar, and indigo bush
- Fragmentation and loss of large tracts necessary for area-sensitive species
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.
- High energetic costs associated with high rates of competitive interactions with European starlings for cavities may reduce reproductive success of cavity-nesting species such as Lewis' woodpecker, downy woodpecker, and tree swallow, even when outcome of the competition is successful for these species

- Recreational disturbances (e.g., offroad recreational vehicles (ORVs)), particularly during nesting season, and particularly in high-use recreation areas

2.5.2 Key Findings: Aquatic

For the purposes of the aquatic assessment, the Wenatchee subbasin was divided into 11 independent assessment units. Within each assessment unit, information was organized by key environmental attributes including riparian/floodplain conditions, stream channel conditions, water quality, water quantity, obstructions to fish passage, and ecological conditions. The degree that habitat conditions have changed over the past 200 years and the presumed response of the focal fish species have been evaluated. Environmental conditions that limit the ability for a species to thrive are called limiting factors. Limiting factor are defined as a habitat element that limits the biological productivity and/or life history diversity of a focal species.

The focal species selected for this assessment include spring chinook salmon, late-run chinook salmon, sockeye salmon, coho salmon, steelhead trout, bull trout, Westslope cutthroat trout and Pacific lamprey. The key limiting factors that have been identified are summarized below by assessment unit.

Table 1. Summary of key limiting factors to focal fish populations by assessment unit

	Lower Wenatchee	Middle Wenatchee	Mission Creek	Peshastin Creek	Chumstick Creek	Icicle Creek	Nason Creek	Little Wenatchee	White River	Chiwawa River	Lake Wenatchee
Key Habitat	X		X	X	X		X				
Riparian Floodplain		X	X	X	X		X		X		
Habitat Diversity	X	X	X	X	X	X	X		X		
Channel Stability	X		X	X	X		X				
Sediment	X	X	X	X	X		X				
Flow	X		X	X	X	X	X				
Temperature	X		X	X		X	X				
Contaminants	X		X								
Obstructions		X	X	X	X	X	X				
Competition						X	X	X	X	X	

2.5.3 Summary of Restoration and Conservation Measures: Terrestrial

Ponderosa Pine

Goal: Provide sufficient quantity and quality ponderosa pine habitats to support the diversity of wildlife as represented by sustainable focal species populations

- Habitat Objective 1: Determine the necessary amount, quality, and juxtaposition of ponderosa pine habitats by the year 2008
- Habitat Objective 2: Based on findings of Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010
- Habitat Objective 3: Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silvicultural practices, fire management, weed control, livestock grazing practices, and road management in existing and restored ponderosa pine habitat
- Biological Objective 1: Determine population status of white-headed woodpecker, flammulated owl, and pygmy nuthatch by 2008

- Biological Objective 2: Within the framework of the focal species population status determinations, inventory other ponderosa pine obligate populations to test assumption of the umbrella species concept for conservation of other ponderosa pine obligates

Shrubsteppe

Goal: Provide sufficient quantity and quality shrubsteppe habitat to support the diversity of wildlife as represented by sustainable focal species populations.

- Habitat Objective 1: Determine the necessary amount, quality, and juxtaposition of shrubsteppe by the year 2008
- Habitat Objective 2: Based on findings of Objective 1, identify and provide biological and social conservation measures to sustain focal species populations and habitats by 2010
- Habitat Objective 3: Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving agricultural practices, fire management, weed control, livestock grazing practices, and road management on existing shrubsteppe
- Biological Objective 1: Determine population status of Brewer's sparrow by 2008
- Biological Objective 2: Within the framework of the Brewer's sparrow population status determination, inventory other shrubsteppe obligate populations to test assumption of the umbrella species concept for conservation of other shrubsteppe obligates
- Biological Objective 3: Maintain and enhance mule deer populations consistent with state/tribal herd management objectives

Riparian Wetlands

Goal: Provide sufficient quantity and quality riparian wetlands to support the diversity of wildlife as represented by sustainable focal species populations.

- Habitat Objective 1: Determine the necessary amount, quality, and connectivity of riparian wetlands by the year 2008.
- Habitat Objective 2: Based on findings of Habitat Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010.
- Habitat Objective 3: Enhance beaver (*Castor canadensis)* habitat where appropriate to increase the quantity and quality of riparian wetlands for focal species by 2009.
- Habitat Objective 4: Enhance beaver populations to benefit habitat for threatened/endangered fish species.
- Habitat Objective 5: Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silviculture and agricultural practices, fire management, weed control, livestock grazing practices, and road construction and maintenance on and adjacent to existing riparian wetlands.

- Biological Objective 1: Determine population status of red-eyed vireo (*Vireo olivaceous)* and yellow-breasted chat by 2008.
- Biological Objective 2: Within the framework of the focal species population status determinations, inventory other riparian wetlands obligate populations to test assumption of the umbrella species concept for conservation of other riparian wetlands obligates.

2.5.4 Summary of Restoration and Conservation Measures: Aquatic

Contained within the management plan are management strategies. These strategies outline general guidance for future management practices to move towards the stated vision and goals. Various management objectives are identified which suggest a range of activities that would contribute to achieving a specific management strategy. Listed below are the key management strategies identified for each of the assessment units.

Lower Wenatchee River Assessment Unit

- Reduce late summer mainstem temperatures
- Reduce elevated fine sediment in the mainstem and tributary stream substrates
- Enhance water quality for both mainstem and tributary streams
- Enhance mainstem flows
- Improve riparian and floodplain conditions in both mainstem and tributary streams
- Restore and enhance in-channel habitat diversity and structural complexity in both mainstem and tributary streams
- Continue to monitor and evaluate fish passage at Dryden Dam

Middle Wenatchee Assessment Unit

- Reduce late summer mainstem temperatures
- Reduce elevated fine sediment in the mainstem and tributary streams
- Maintain existing good water quality
- Maintain flows and hydrograph to current condition
- Maintain and improve mainstem riparian and floodplain conditions, particularly above Tumwater Canyon
- Maintain and improve mainstem in-channel structural diversity and habitat quality
- Improve tributary habitat quality and quantity in some locations
- Continue to monitor and evaluate fish passage at Tumwater Dam. Restore unhindered juvenile and adult passage if determined to be appropriate

Mission Creek Assessment Unit

- Improve water temperatures in Mission Creek and tributaries
- Reduce elevated fine sediment in the mainstem and tributary stream substrates
- Enhance water quality primarily for the mainstem of Mission and Brender creeks and preserve water quality in tributary streams
- Enhance mainstem flows by improving overall watershed vegetative and hydrologic conditions and water use efficiency
- Restore tributary flows towards the natural hydrograph
- Improve riparian and floodplain characteristics where feasible
- Improve in-channel attributes for the mainstem and tributary streams
- Restore adult and juvenile fish passage
- Control or eliminate brook trout

Peshastin Creek Assessment Unit

- Improve elevated water temperatures by improving low flow conditions and increasing riparian shade and floodplain function
- Improve elevated water temperatures in tributaries by reducing channel confinement and improving degraded riparian conditions
- Reduce elevated fine sediment in the mainstem and tributary stream substrates
- Enhance water quality in the mainstem Peshastin Creek
- Enhance mainstem flows by improving overall watershed vegetative and hydrologic conditions, and water use efficiency
- Improve tributary flows to the natural hydrograph by improving the road network, improving stream channel confinement, and relocating valley bottom roads where feasible
- Improve riparian and floodplain characteristics where feasible
- Improve in-channel attributes for the mainstem and enhance or maintain tributary streams
- Restore adult and juvenile fish passage

Chumstick Creek Assessment Unit

- Enhance elevated stream temperatures in the mainstem and tributaries
- Reduce elevated fine sediment in the mainstem and tributary stream substrates
- Enhance water quality primarily for the mainstem of Chumstick Creek

- Enhance water quality in tributary streams
- Enhance mainstem flows by improving overall watershed vegetative and hydrologic conditions and water use efficiency
- Restore tributary flows towards the natural hydrograph
- Improve riparian and floodplain characteristics where feasible
- Improve in-channel attributes for the mainstem and tributary streams
- Restore adult and juvenile fish passage
- Control or eliminate brook trout

Icicle Creek Assessment Unit

- Enhance elevated stream temperatures in the lower mainstem creek by improving low flow and degraded riparian conditions and maintain existing condition in tributaries
- Reduce fine sediment level in the lower mainstem and maintain existing conditions in tributaries
- Maintain or enhance water quality in the lower mainstem
- Improve stream flow in lower mainstem
- Improve riparian and floodplain characteristics in the lower portion of the assessment unit (mainstem river below Snow Creek) and enhance local conditions in the upper watersheds
- Enhance in-channel attributes in the lower portion of the assessment unit (mainstem river below Snow Creek) and in local areas in the upper watershed
- Restore adult and juvenile fish passage within the lower Icicle Creek (below Snow Creek)

Nason Creek Assessment Unit

- Improve elevated stream temperatures in the lower mainstem (below Mill Creek) by improving low flow conditions, channel confinement, and degraded riparian conditions
- Reduce fine sediment level in the lower mainstem
- Enhance water quality in the lower mainstem (below Mill Creek)
- Enhance mainstem flows by improving overall watershed vegetative and hydrologic conditions and water use efficiency
- Improve riparian and floodplain characteristics in the lower mainstem (below Mill Creek) where feasible
- Improve in-channel attributes for the mainstem (focus on lower 15 miles of Nason Creek) and some tributary streams

- Restore adult and juvenile fish passage

Little Wenatchee Assessment Unit

- Maintain existing water quality condition and trend in mainstem and tributary streams
- Maintain existing water quantity condition for mainstem and tributaries
- Maintain and enhance lower mainstem riparian vegetation along the Little Wenatchee River
- Enhance lower Little Wenatchee River in-channel habitat diversity
- Control or eradicate brook trout

White River Assessment Unit

- Maintain existing water quality condition for mainstem and tributaries
- Maintain existing water quantity condition for mainstem and tributaries
- Enhance in-channel attributes for the mainstem (focus on lower 11 miles of the White River)

Chiwawa River Assessment Unit

- Maintain existing water quality condition and trend for mainstem and tributaries
- Bring sediment delivery into the range of natural conditions in Big Meadow Creek
- Maintain existing condition for water quantity for mainstem and tributaries
- Maintain and enhance riparian and floodplain conditions in the lower mainstem
- Enhance lower mainstem in-channel habitat attributes

Lake Wenatchee Assessment Unit

- Maintain the existing high quality riparian and perennial wetland habitats surrounding Lake Wenatchee
- Develop and implement long term water quality evaluation strategy to monitor condition and trend of Lake Wenatchee
- Develop and implement a long term biological community evaluation and strategy to monitor condition and trend with a particular focus on bull trout and sockeye salmon abundance and ecological relationships
- Evaluate the effects of existing and future developments surrounding the lake on the associated floodplains and biological conditions
- Evaluate the benefits and risks of enhancing nutrients in Lake Wenatchee to salmonid, specifically sockeye production

2.6 Summary of Monitoring and Infrastructure Needs

2.6.1 Summary of Monitoring and Infrastructure Needs: Terrestrial

Recommended monitoring and evaluation strategies summarized below for each focal habitat type are derived from national standards. Deer and elk sampling methodology follow standard protocols established by the Washington Department of Fish and Wildlife (WDFW). Protocols for specific vegetation monitoring/sampling methodologies are drawn from US Department of Agriculture (USDA) Habitat Evaluation Procedure (HEP) standards. A common thread in the monitoring strategies contained in this subbasin plan is the establishment of permanent census stations to monitor bird populations and habitat changes.

Wildlife managers will include statitistically rigorous sampling methods to establish links between habitat enhancement prescriptions, changes in habitat conditions, and target wildlife population responses.

Specific methodology for selection of monitoring and evaluation (M&E) sites within all focal habitat types follows a statistical sampling procedure, allowing for statistical inferences to be made within the area of interest. Protocols identified in this document describe how M&E sites will be selected. The following summarizes the basic concepts of the wildlife monitoring strategy.

Ponderosa Pine

Focal Species: Flammulated owl, white-headed woodpecker, and pygmy nuthatch.

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed Ponderosa pine sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat:

- Direct loss old growth forest and associated large diameter trees and snags
- Fragmentation of remaining Ponderosa pine habitat
- Agricultural and sub-urban development and disturbance
- Hostile landscapes which may have high densities of nest parasites, exotic nest competitors, and domestic predators
- Fire suppression/wildfire
- Overgrazing
- Noxious weeds
- Silvicultural practices
- Insecticide use

Shrubsteppe

Focal Species: Sharp-tailed Grouse, Brewer's sparrow, and mule deer.

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed shrubsteppe sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat:

- Direct loss shrubsteppe due to conversion to agriculture, residential, urban and recreation developments
- Fragmentation of remaining shrubsteppe habitat, with resultant increase in nest parasites
- Fire Management, either suppression or overuse, and wildfires
- Invasion of exotic vegetation
- Habitat degradation due to overgrazing, and invasion of exotic plant species
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities.

Riparian Wetlands

Focal Species: Red-eyed vireo, yellow-breasted chat, and American Beaver.

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed Riparian Wetland sites to monitor focal species population and habitat changes and evaluate success of efforts.

Overall Habitat and Species Monitoring Strategy: Establish permanent census stations to monitor bird population and habitat changes.

Focal Habitat Monitoring:

Factors affecting habitat:

- Direct loss of riparian deciduous and shrub understory
- Fragmentation of wetland habitat
- Flooding and dewatering of areas by beaver
- Agricultural and sub-urban development and disturbance
- Reduction in water quality
- Organochlorines such as dieldrin or DDE may cause thinning in egg shells which results in reproductive failure

2.6.2 Summary of Monitoring and Infrastructure Needs: Aquatic

The monitoring plan described section 8 draws from the existing regional strategies (ISAB, Action Agencies/NOAA Fisheries, and Washington Salmon Recovery Funding Board) and outlines an approach specific to the Wenatchee subbasin. The plan addresses the following basic questions:

What are the current habitat conditions and abundance, distribution, life-stage survival, and age-composition of ESA-listed fish in the Wenatchee subbasin (status monitoring)?

How do these factors change over time (trend monitoring)?

What effects do tributary habitat actions have on fish populations and habitat conditions (effectiveness monitoring)?

The monitoring plan is designed to address these questions and at the same time eliminate duplication of work, reduce costs, and increase monitoring efficiency. The implementation of valid statistical designs, statistical sampling designs, standardized data collection protocols, consistent data reporting methods, and selection of sensitive indicators will increase monitoring efficiency. For this plan to be successful, all organizations involved must be willing to cooperate and freely share information. Cooperation includes sharing monitoring responsibilities, adjusting or changing sampling methods to comport with standardized protocols, and adhering to statistical design criteria. In those cases where the standardized method for measuring an indicator is different from what was used in the past, it may be necessary to measure the indicator with both methods for a few years so that a relationship can be developed between the two methods. Measurements generated with a former method could then be adjusted to correct for any bias.

The monitoring report is divided into eight major parts. The first part (section 2) identifies valid statistical designs for status/trend and effectiveness monitoring. Section 3 discusses issues associated with sampling design, emphasizing how one selects a sample and how to minimize measurement error. Section 4 examines how sampling should occur at different spatial scales. Section 5 describes the importance of classification and identifies a suite of classification variables. Section 6 identifies and describes biological and physical/environmental indicators, while Section 7 identifies methods for measuring each indicator variable. These 7 sections provide the foundation for implementing an efficient monitoring plan in the Wenatchee subbasin. The last two sections deal with how the program will be implemented. Section 8 provides a checklist of questions that need to be addressed in order to implement a valid plan. Section 9 begins to lay out a monitoring plan for the Wenatchee subbasin by answering the questions identified in Section 8.

At this time entities that collect information relevant to fish and wildlife interests in the Wenatchee subbasin do not have a centralized location to store or retrieve critical or timely information. Key questions yet to be addressed at the subbasin and regional level concerns data management, data interpretation and data presentation. One of the significant challenges yet to be resolved is in describing the organizational and cooperative manner in which agencies and entities can integrate the regular collection and interpretation of natural resource information and provide this information to the public in a manner that allows full involvement in future decision making processes.

3 Subbasin Overview

3.1 Wenatchee Subbasin in Regional Context

3.1.1 Introduction and Objectives

The NPCC is responsible for implementing the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) and the Fish and Wildlife Program mandated by the act. For planning purposes, the NPCC divided the more than 50 subbasins comprising the Columbia River basin south of the Canadian border into 11 ecological provinces.

Each of the 11 ecological provinces will develop its own vision, biological objectives, and strategies consistent with those adopted at the subbasin level. NPCC's intent is to amend these subbasin plans into the 2000 Fish and Wildlife Program during later rulemaking. The biological objectives at the ecological province scale will then guide development of the program at the subbasin scale.

3.1.2 Columbia Cascade Province

The Columbia Cascade Ecological Province extends over an area of 14,333 sq. mi. It is defined as the Columbia River from Wanapum Dam to the limit of anadromous fish passage at Chief Joseph Dam and is situated in north central Washington. Tributary subbasins are, for the most part, high gradient streams that begin in the North Cascade Mountains and drain directly to the Columbia River. The province also includes a few smaller streams that drain smaller watersheds adjacent to the Columbia as well as a number of gulches that arise from the channeled scablands to the east. The Columbia Cascade Ecological Province is divided into 6 subbasins: the Wenatchee, Entiat, Lake Chelan, Methow, Okanogan, and Upper Middle Mainstem Columbia River.

The Wenatchee subbasin is located in north central Washington and lies entirely within Chelan County. The subbasin comprises 9.3% of the Columbia Cascade Province and consists of approximately 854,000 acres (1,300 mi^2) (Table 2). Approximately 81% of the subbasin is in federal (primarily US Forest Service (USFS)) and state ownership. The remaining 19% of the lands in the subbasin is in private ownership (Table 3).

Table 2. Subbasin size relative to the Columbia Cascade Ecoprovince

Subbasin	Size		Percent of Ecoprovince	Percent of State
	Acres	Mi^2		
Entiat	298,363	466	3.2	.7
Lake Chelan	599,925	937	6.5	1.4
Wenatchee	851,894	1,333	9.3	2.0
Methow	1,167,795	1,825	12.7	2.8
Okanogan	1,490,079	2,328	16.2	3.5
Upper Middle Mainstem Columbia River	1,607,740	2,512	17.5	3.8
Crab	3,159,052	4,936	34.4	7.4
Total for Ecological Province	**9,174,848**	**14,337**	**100**	**21.6**

Ashley and Stovall 2004

Note: Values may be somewhat inconsistent with other tables in this document due to differing sources of information. Values may be revised as significant errors are discovered and time is available.

Table 3. Land ownership of the Columbia Cascade Province

Subbasin	Federal Lands (acres)	Tribal Lands (acres)	State Lands (acres)	Local Government Lands (acres)	Private Lands (acres)	Water (acres)	Total (subbasin) (acres)
Entiat	247,064	0	13,629	0	37,670	0	298,363
Lake Chelan	517,883	0	3,549	0	78,493	0	599,925
Wenatchee	682,295	0	11,836	0	159,182	0	853,313
Methow	985,234	0	55,836	0	126,724	0	1,167,794
Okanogan	400,496	311,826	261,598	0	516,159	0	1,490,079
Upper Middle Mainstem Columbia River	124,492	29,507	284,996	0	1,168,744	0	1,607,739
Crab	303,136	0	13,629	25	2,681,363	16,100	3,014,253
Total for Ecological Province	**3,260,600**	**341,333**	**645,073**	**25**	**4,768,335**	**16,100**	**9,031,466**

Asheyly and Stovall 2004

Note: Values may be somewhat inconsistent with other tables in this document due to differing sources of information. Values may be revised as significant errors are discovered and time is available.

Native American Tribes

Native people traditionally lived, hunted, gathered and fished within the Columbia Cascade Province. The province includes land ceded by the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation) under the Treaty of 1855 to the United States. Members of the Yakama Nation and the Confederated Tribes of the Colville Reservation continue to exercise their hunting, gathering, and fishing rights within the province.

3.1.3 Terrestrial/Wildlife Context

The upper watersheds in the Columbia Cascade Province are primarily forested and have undergone substantial management activities. Lower reaches of the principal streams within each of the subbasin are almost completely privately owned and primarily managed through agricultural practices. In all cases, habitat conditions range from pristine to significantly altered.

[No further information to date]

3.1.4 Aquatic/Fish Context

Construction of Grand Coulee Dam in 1934 blocked over 1,000 miles of habitat in upstream of the Columbia Cascade Province in the upper Columbia River basin. Another 52 miles of habitat was blocked in 1961 by the completion of the Chief Joseph Dam. In addition, there are 6 hydroelectric projects downstream of this ecological province: Wanapum Dam and Priest Rapids Dam, and four federally owned projects, McNary Dam, John Day Dam, The Dalles Dam and Bonneville Dam.

To offset the loss of anadromous salmonid production by the federally built projects, the federal government built and continues to operate the Leavenworth National Fish Hatchery (NFH) in the Wenatchee subbasin, and later, the Entiat and Winthrop NFHs in the Entiat and Methow subbasins, respectively. No federal mitigation facility was constructed in the Okanogan subbasin.

With the construction of each of the privately owned mid Columbia hydroelectric projects, additional production/hatchery facilities were developed in the Columbia Cascade Province. The recent Habitat Conservation Plan (HCP), initiated by Chelan and Douglas Public Utility Districts (PUDs) for ESA Section 10 consultation, identified the mitigation obligation of the PUDs. The HCP also provides the groundwork for future changes in facility production goals and operations. Details of these changes in hatchery production will be resolved over the next several years.

In spite of past mitigation efforts, declining salmonid populations in the Columbia Cascade Province have resulted in ESA listings of spring chinook (endangered March 1999) and summer steelhead (endangered August 1997). Upper Columbia late-run chinook and Lake Wenatchee sockeye were also petitioned (March 1998) but were determined not warranted for listing. Recent years have shown improved salmonid runs to the province, consistent with findings throughout the Columbia basin.

3.1.5 Subbasin Planning and the Regulatory Context

Federal

The US Forest Service (USFS) manages approximately 76% of the Wenatchee subbasin. Other federal land mangers include the Bureau of Land Management (BLM) and the US Fish and Wildlife Service (USFWS), the latter of which is responsible for the operation and management of the Leavenworth NFH. Actions on USFS, BLM and USFWS lands within the Wenatchee subbasin result from the execution of various federal laws and regulations. Some of the major federal laws governing agency practices that were considered during the development of this plan are described below.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 mandates that all federal agencies "utilize a systematic, interdisciplinary approach that will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making, which may have an impact on [the] environment." NEPA integrates with a wide variety of existing environmental legislation, including the: Clean Air Act (CAA), Clean Water Act (CWA), Coastal Zone Management Act (CZMA), National Historic Preservation Act (NHPA), Marine Protection, Research and Sanctuaries Act (MPRSA), Pollution Prevention Act (PPA), and the ESA. NEPA further requires that a detailed statement on the environmental impact of major federal actions that significantly affect the environment be included in every recommendation or report on proposals for legislation.

Endangered Species Act

The Endangered Species Act (ESA) of 1973 applies to the management of fish, wildlife and plant species that are in danger of or threatened with extinction. The purpose of the ESA is to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, and to provide a program for the conservation of such threatened and endangered species. All federal departments and agencies must seek to conserve threatened and endangered species and utilize their authorities to further the purposes of the ESA. Federal agencies are also required to cooperate with state and local agencies to resolve water resource issues in concert with conservation of endangered species.

In addition to mandating specific federal management actions, the ESA also applies to the actions of any person subject to the jurisdiction of the United States. It prohibits the harm or “take” of species listed as threatened or endangered under the ESA. Significant consideration is given to the ESA when any type of activity within the Wenatchee subbasin is proposed or undertaken, as threatened and endangered species exist within the management area on lands under both public and private management. Proposed habitat recommendations in this plan have been designed to help protect and restore endangered spring chinook and steelhead habitat as well as threatened bull trout habitat on private lands within the subbasin.

Clean Water Act

The Federal Water Pollution Control Act of 1972, as amended in 1977, is commonly known as the Clean Water Act (CWA). The CWA was established a basic structure to regulate discharge of pollutants into United States waters, and gave the EPA the authority to implement pollution control programs. The EPA set federal water quality standards, and delegated authority to the Washington Department of Ecology (WDOE) to monitor federal water quality standards within the state's surface waters. WDOE is also required to maintain a list of impaired streams. The water quality recommendations in this plan have been designed to help address these concerns within the Wenatchee subbasin.

Federal Land Policy and Management Act

The Federal Land Policy and Management Act (FLPMA) requires the BLM to develop land use plans. In order to meet this requirement the BLM developed the Spokane Resource Management Plan (RMP), which includes lands within the Wenatchee subbasin (approximately 200 acres). BLM administered lands in the subbasin are designated as Scattered Tracts, and allow most resource activities including recreation, timber harvest, and grazing. These lands have high value as wildlife winter range.

National Forest Management Act and Northwest Forest Plan

The National Forest Management Act (NFMA) is a significant law affecting the management and decisions of USFS. The NFMA directs the USFS to develop a RMP for each national forest. In 1990, the Wenatchee NF released a Final Environmental Impact Statement (FEIS) and a Record of Decision (ROD) for the preferred Land and Resource Management Plan. The forest plan contains management direction in the form of forest-wide standards and guidelines and management prescriptions for specific management areas (USFS 1990). The various management areas emphasize certain key values and indicate what practices will or will not occur within each management area.

The Northwest Forest Plan amended the Wenatchee Forest Plan in April 1994. This amendment modified the Wenatchee management designations and created Late Successional and Riparian Reserves. The Northwest Forest Plan also provides numerous standards and guidelines directing management practices on federal lands. Table 4 summarizes the resulting national forest land allocations by acreage within the Wenatchee subbasin and describes permitted management actions. The BLM's management plan was not affected by the amendment because its administrative lands in the Wenatchee subbasin are outside of the range of the northern spotted owl.

Table 4. USFS land allocations, acreages, and management emphasis

LAND ALLOCATION	ACRES	MANAGEMENT EMPHASIS
Congressionally Withdrawn Areas	25,554.37	Part of the Glacier Peak Wilderness Area. Managed for primitive recreation and research in a primitive setting. No timber harvest.
Late-Successional Reserves	60,139.33	Managed to protect and enhance habitat for late-successional and old-growth related species. No scheduled timber harvest, but allows some tree thinning to enhance desired late successional/old-growth habitat.
Administratively Withdrawn	34,834.61	Wenatchee Forest Plan: Unroaded Dispersed Recreation. No timber harvest.
Riparian Reserves		Emphasizes protection along all streams, wetlands, ponds and lakes. No scheduled timber harvest but some silvicultural treatments are permitted when they benefit riparian resources.

LAND ALLOCATION	ACRES	MANAGEMENT EMPHASIS
Matrix	130,822.96	Lands outside of reserves and managed under prescriptions described in The Wenatchee Forest Plan land allocations. Approximately 65% or 62,958 acres are available for regularly scheduled timber harvest.
Forest Service Pending	3531.31	Lands acquired through exchange or purchase that do not have a Forest Plan allocation assigned to them yet.

CCCD 2004

In addition to creating reserves and prescribing standards and guidelines, the Northwest Forest Plan identified key watersheds in Washington, Oregon and northern California as part of the Aquatic Conservation Strategy. Key watersheds provide habitat critical for the maintenance and recovery of anadromous salmonids and resident fish species.

The Northwest Forest Plan requires that watershed assessments be completed before federal land managers proceed with most activities within key watersheds. Each of these plans has been completed in the Wenatchee subbasin and is incorporated into this document.

A key product of the watershed assessment process was the description of existing resource conditions, identification of desired ecological conditions, and the development of management strategies that would move elements in the watershed to ward the desired future condition.

State

Many Washington state laws that regulate actions on private lands within the Wenatchee subbasin, and that direct state and local agency decision-making about projects, were also considered while developing this plan. Some of these pertinent laws include, but are not limited to:

Salmon Recovery Act of 1998 (Chapter 75.46 RCW) and Watershed Planning (Chapter 90.82 RCW)

Additional detail about the Salmon Recovery Act (SRA) is provided below because of the close link between SRA and the State Watershed Planning Act. For more information about these and other state laws, see the following link: http://www.leg. wa.gov/rcw/index.cfm

The SRA authorizes a lead entity to coordinate the development of locally-directed Habitat Restoration Project lists and salmon recovery plans. The lead entity for salmon recovery activities occurring in Chelan County is the county. If a planning unit opts to include the habitat component in its plan, and restoration activities are already being developed under the SRA, the planning unit is required to rely upon those activities as “the primary non-regulatory habitat component” of their plan.

The habitat restoration actions put forth in this plan were developed using the Critical Path ways Methodology identified in the SRA, and are the result of a locally-directed, collaborative effort among federal, tribal, state, local, and other stakeholder interests.

Various state legislative actions have provided guidance to natural resource management. Several of the more important regulatory acts are listed below:

- Shoreline Management Act of 1971 (Chapter 90.58 RCW)
- Water Resources Act o f 1971 (Chapter 90.54 RCW)
- Growth Management Act of 1990 (Chapter 36.70A RCW)
- Forestry Practices Act of 1974 (Chapter 76.09 RCW)
- State Environmental Policy Act of 1971 (Chapter 42.21C RCW)

Regional/Local

Regional Salmon Recovery Planning

It is anticipated that information contained in this document pertinent to habitat restoration and salmon recovery in the Wenatchee subbasin will contribute to the regional recovery strategy being developed for the Columbia Cascade Province.

Tribal Recovery Planning; Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon)

Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon) is the Columbia River anadromous fish restoration plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes developed with the Columbia River Inter-Tribal Fish Commission (CRITFC). One of the plan's long term objectives is to restore salmon populations to a level that will support tribal ceremonial, subsistence, and commercial harvests. For more information on tribal recovery, refer to the following link: http://www.critfc.org/text/ water_action.html

Chelan County Comprehensive Land use Planning

Planning units are required to consider city and county planning activities during the development of their watershed plan. The WPU has given particular attention to local planning being done under the Growth Management Act (GMA). GMA is significant in that it mandates cities and counties to plan for land use and development, and designate and protect critical areas including wetlands, aquifer recharge areas, frequently flooded areas, and fish and wildlife habitat conservation areas. GMA also guides the development of comprehensive plans using other goals such as enhancing water quality and water availability, promoting new businesses, and involving citizen participation in the planning process. Actions recommended in this plan were designed in consideration of the goals used to guide planning under GMA and to provide local input to Chelan County during the update of its Comprehensive Plan, which is scheduled for completion by December 1, 2006.

3.2 Subbasin Description

3.2.1 Location

The Wenatchee subbasin drains a portion of the east Cascade Mountains in north central Washington within Chelan County. The Wenatchee River enters the Columbia River at river mile (RM) 470. The subbasin covers 849,777 acres, with 231 miles of major streams. Wenatchee River has about163 lineal miles of stream accessible to anadromous salmonids. The watershed originates in the Cascade Mountains, including the Alpine Lakes and Glacier Peak wilderness areas.

3.2.2 Topography and Climate

During the last large scale glaciation more than 10,000 years ago, large masses of ice gradually moved from higher elevations down slope cutting through rock masses and filling the watershed. This glacial action also provided huge amounts of melt water that flowed downstream towards the Columbia River creating out wash deposits composed of deep deposits of silt, sand, and gravel.

More recently rivers have scoured the bedrock and glacial deposits and redeposited them as sand and gravel terraces and plains. A review of well logs indicates that sediments thicken to over 170 ft. along the main axis of the Lake Wenatchee valley (Economic and Engineering Services and Golder Associates 1998). In some places within the subbasin, e.g., near the confluence of Icicle Creek and the Wenatchee River, the deposits may be up to 300 ft. (Andonaegui 2001).

Prevailing west winds uplift moist air from the Pacific over the Cascade Mountains. As a result, temperature and precipitation vary widely in the basin, depending upon elevation and nearness to the mountains.

The Cascade Mountain area of the subbasin is characterized by heavy precipitation, with nearly 150 in. of precipitation occurring annually at points along the Cascade crest. Snow depths in the mountains range from 10 to 25 ft., and snow covers the mountain areas from late fall through early summer. Daily temperatures in winter average 25 to 40°F, while average summer temperatures range from 60° to 80°F.

Air masses rapidly lose moisture as they move east ward resulting in semi-arid conditions in the lowermost portion of the subbasin. In contrast with the mountainous areas, the semiarid city of Wenatchee has an annual precipitation of less than 9 in., with maximum summer temperature of 95 to 100°F. Summer thunderstorms occur periodically and can result in flash flood conditions in local watersheds (Andonaegui 2001).

Vegetation and Land Cover

The climatic, elevation, and geologic diversity of the Wenatchee subbasin is reflected in its plant communities. Although most of the subbasin is forested, the species composition of the forest plant communities changes as elevation decreases and distance from the Cascade Mountain crest increases. Non-forest vegetation occurs primarily at the lowest elevation in shrubsteppe communities and the highest elevation in alpine meadow communities (Table 5).

Assessment units (sub watersheds in the subbasin are referred to as assessment units in this plan) closest to the Cascade Mountain Crest experience a maritime climatic influence as moist maritime air incursion occur. Maritime-influenced vegetation is dominant in the White, Nason, Chiwawa, and Little Wenatchee assessment unit. Icicle Creek assessment unit supports significant amounts of both maritime and arid continental vegetation. Shrubs and herbs dominate the vegetated alpine areas of these assessment units; wetter areas support more herbaceous vegetation while red mountain heather and moss-heathers are found in well-drained areas. Mountain hemlock, silver fir and western hemlock dominate the maritime influenced forest communities which also support numerous understory plants such as cascade huckleberry, rusty menziesia, devil's club, rosy twisted stalk and coolwort foamflower. Open forests of mountain hemlock, whitebark pine and subalpine larch can be found at the extreme upper elevation limit for trees.

In the eastern portion of the subbasin, assessment units are lower in elevation and experience much less moisture, resulting in a more arid continental climate. Plant communities found in the mainstem Wenatchee, Mission, Chumstick and Peshastin assessment units, as well as portions of the Icicle assessment unit are more continental in nature. Vegetated alpine areas can still be moist herb dominated or drier shrub or grasslands not often seen in maritime-influenced alpine areas. Green fescue usually dominates these high elevation dry grasslands. Forest areas in these assessment units are dominated at climax by subalpine fir, grand fir, Douglas fir, or ponderosa pine. Understory plants include pinegrass, elk sedge, heartleaf arnica, dull Oregon grape, bigleaf sandwort, vanilla leaf, oceanspray, serviceberry and lupine. Nonforest plants occurring at the lowest elevation include bitterbrush, bluebunch wheatgrass, arrowleaf balsamroot, and yarrow among others.

Wetter habitats, such as riparian areas and wetlands support moisture dependent species including willows and sedges, while dry forest openings favor forest understory species or plants from drier plant communities common to lower elevations. Aspen, black cottonwood, bigleaf maple, alder and red osier dogwood are common in riparian communities.

A summary of vegetation is provided below.

Table 5. Land cover in the Wenatchee subbasin

Classification	Acres	% of Basin Area
Water	8,449	1.0%
Perennial Ice, Snow	2,944	0.3%
Low Intensity Residential	1,759	0.2%
Commercial, Industrial, and/or Transportation	1,497	0.2%
Bare Rock, Sand or Clay	45,252	5.3%
Quarries, Strip Mines, or Gravel	28	0.0%
Transitional	15196	1.8%
Deciduous Forest	17,417	2.1%
Evergreen Forest	567,650	67.0%
Mixed Forest	7,907	0.9%
Shrubland	66,488	7.9%

Classification	Acres	% of Basin Area
Orchards, Vineyards, Other	11,573	1.4%
Grasslands, Herbaceous	98,054	11.6%
Pasture, Hay	933	0.1%
Row Crops	28	0.0%
Small Grains	257	0.0%
Fallow	8	0.0%
Urban, Recreational Grasses	38	0.0%
Woody Wetlands	1,402	0.2%
Emergent Herbaceous Wetlands	73	0.0%
Total	**846,951**	**100.0%**

Montgomery et al. 2003

Land Ownership and Land use

The largest landowner in the Wenatchee subbasin is the federal government. The USFS is responsible for 76% of the subbasin (671,220 acres), while the BLM manages about 200 acres. USFS land is divided into 316,561 acres of congressional-designated wilderness, 242,957 acres multiple resource (including timber harvest) land and 111,702 acres is managed as non-harvest areas. Washington Department of Natural Resources (WDNR) manages about 8,700 acres of state-owned land. Longview Fiber Company owns about 47,760 acres, while other private commercial and non-commercial landowners own the remaining 149,560 acres of the subbasin. Although less than 25% of the subbasin is privately owned, nearly two-thirds of the lineal area of the anadromous streams, primarily lower gradient streams, is bordered by private lands (Chelan County PUD 1998). (Table 6)

Table 6. Estimates of land area and zoning in the Wenatchee subbasin

Land Use Classification	**Area within each assessment unit (acres)**												
	Chiwaukum	**Chiwawa**	**Chumstick**	**Icicle**	**Lake Wenatchee**	**Little Wenatchee**	**Lower Wenatchee**	**Mission**	**Nason**	**Peshastin**	**Upper Wenatchee**	**White**	**Totals**
Commercial Agricultural	0	0	0	0	0	0	6,161	1,412	0	622	0	0	8,195
Commercial Forest	30,243	123,758	39,454	131,586	10,322	64,146	16,079	46,288	63,407	81,923	30,104	94,899	732,209
Public	0	0	4	171	801	0	179	0	71	0	0	0	1,226
Total Rural Residential/Resource	1,655	3,118	11,924	5,436	1,536	816	42,802	11,356	5,339	3,501	5,349	5,001	97,833
Rural Village	0	0	100	1	59	0	1,628	71	0	0	0	0	1,860
Rural Commercial	0	0	0	0	3	0	83	0	105	34	10	0	236
Rural Industrial	155	0	0	0	0	0	221	0	0	0	0	0	376
Rural Recreational and Resource	0	183	20	0	212	0	0	0	322	108	8	0	853
Rural Waterfront	0	387	57	11	402	0	32	0	0	0	581	15	1,484
City Urban Growth Area	0	0	1,315	0	0	0	667	668	0	0	19	0	2,669
Open water	8	73	95	120	2,984	1	438	0	7	0	438	159	4,325
Totals	**32,092**	**127,518**	**52,969**	**137,325**	**16,321**	**64,963**	**68,311**	**59,794**	**69,252**	**86,369**	**36,509**	**100,104**	**851,527**

Montgomery et al. 2003

Demographics

The majority of the population and industry within the Wenatchee subbasin is located in the lower elevations along the mainstem of the Wenatchee River. A discussion of current and projected demographic trends is located in Montgomery et al., 2003. Provided below is a summary of existing and projected population estimates in the Wenatchee subbasin.

Table 7. Forecasted population growth in the Wenatchee subbasin

Census By County Division	2000	2002 Projection	2035 Projection
Cashmere	10,824	11,217	17,092
Leavenworth – Lake Wenatchee	5,902	6,068	8,453
Wenatchee	34,678	35,895	54,061
Total Population Forecasted	**51,404**	**53,180**	**79,606**

Montgomery et al. 2003

3.2.3 Hydrologic

Four large tributaries; the Chiwawa River, White River, Little Wenatchee River and Nason Creek; join at or near Lake Wenatchee Lake to form the Wenatchee River, which flows 53 miles to the Columbia River. Snowmelt in the upper subbasin is the principal source of water for the subbasin's larger streams and provides over 80% of the total runoff from the subbasin. The 1,328 sq. mi. of subbasin drainage produces 2.5 million acre ft. of annual runoff.

Most of the stream flow in the Wenatchee River subbasin originates from tributaries in the upper subbasin. Five major tributaries; the Chiwawa, White, Little Wenatchee rivers and Nason and Icicle Creek; are the source of over 94% of the surface waters within the subbasin even though their drainage area only represents 58% of the total subbasin area (CCCD 1998).

Annual peak instantaneous flows usually occur from mid May through mid June fueled by snow melt in the upper regions of the subbasin. Record high flows have been recorded in November and December due to rain-on-snow events. Average flows recorded at Monitor (RM 7) during the months of August (1500 cubic feet per second (cfs)) and September (800 cfs) are16.7% and 9.2% of average June flows, respectively. Winter flows are typically almost double that of September flows but they occasionally drop below 300 cfs (Chelan County PUD 1998).

Water Quality

Although the Wenatchee River is rated Class AA, (extraordinary) by the Washington Department of Ecology (WDOE) from the head waters to the Wenatchee NF boundary near Leavenworth and Class A (excellent) from that point to the confluence with the Columbia River, significant water quality problems have been documented.

The 1998 approved 303(d) report from WDOE to the US Environmental Protection Agency (EPA) listed sections of the mainstem Wenatchee River, and Icicle, Chumstick and Peshastin creeks as exceeding standards for dissolved oxygen, temperature, instream flow and pH.

Sections of Mission Creek were listed for not meeting instream flow standards, as well as for elevated pesticide and fecal coli form levels. Sections of Little Wenatchee River, Chiwakum and

Nason creeks were also cited for exceeding temperature standards. Brender Creek, a tributary of Mission Creek was listed for low dissolved oxygen and elevated fecal coli form levels. Of these concerns, low instream flow and elevated temperatures pose the greatest threats to anadromous fish production.

Water Uses

Domestic Water Supply

Total municipal and domestic water use for the Wenatchee subbasin is estimated to be 3.9 million gallons per day (mgd) on an average daily basis and 9.4 mgd on a maximum daily basis. This equates to 6.0 cfs on an average day and 14.6 cfs on a maximum day. The total annual amount used is 4,400 acre ft. per year (AF/yr). The Chelan County Conservation District (CCD) contains the highest water use, at 2,170 AF/yr. Of this amount, 45% is associated with exempt well use. In the Leavenworth CCD, the majority of water usage is accounted for by the city of Leavenworth, with less than 15% of total usage associated with individual household wells. As noted earlier, the majority of the population residing within the Wenatchee CCD receives water from outside the subbasin. However, 548 AF/yr is produced from within the subbasin, the majority of which is associated with exempt wells. Considering the entire subbasin, public water systems comprise 58% of the total municipal and domestic water use, with 42% of usage accounted for by exempt wells (Montgomery et al. 2003).

Industrial Use

Several industries in the Wenatchee area rely on ground water for processing requirements and others are able to use the untreated Columbia River water to meet their needs. Industrial water use is not great in the basin and includes principally fruit packing, processing, and warehouse operations.

Impoundments and Irrigation

Irrigation has been practiced in the Wenatchee River valley from the time of the first settlers. The Gunn ditch began taking water from the Wenatchee River in 1891, and in the years that followed, several other ditches were constructed on tributary streams. The Peshastin ditch was built about 1898 to irrigate lands near Peshastin, Dryden, and Cashmere. The Peshastin Irrigation District took over the operation of this canal in 1917 and added lands served by the Tandy and Gibb ditches. The three irrigation entities have a cooperative service area agreement among them for distribution of irrigation water. The Icicle Irrigation District, which serves lands near Leavenworth and Cashmere, is also integrated with the Peshastin District and Tandy-Gibb Company.

The four major irrigation districts in the Wenatchee subbasin and two smaller irrigation groups have about 68% of the total issued water rights; other users are domestic (10%), commercial and industrial (8%), municipal (6%), fish hatcheries (3%) and all others (4%). Combined, these users have 420 cfs in water rights permits and certificates (357 cfs surface water, 63cfs ground water). The largest user is the Wenatchee Reclamation District, which serves over 9,000 users by diverting up to 200 cfs at Dryden Dam

Estimated irrigation water demand for consumptive use based on 1992 land cover data shows the estimated irrigation water demand for each assessment unit and the Wenatchee subbasin. The total estimated consumptive use of water for irrigation purposes is 35,000 acre ft. per year. The on-farm demand, including field application efficiency, would likely be 30-40% greater. Most of the additional water used will seep into shallow ground water aquifers and may be a source of water supply for ground water users or may return to surface water via a stream or wetland.

Table 7. Agricultural crops and acres planted by assessment unit

Land Cover Type	Chiwawa	Upper Wenatchee	Chumstick	Icicle	Peshastin	Mission	Lower Wenatchee	Wenatchee Subbasin
Orchards Vineyards Other	94	536	1255	416	1,889	5,290	23,210	32,690
Pasture Hay	133	457	168	122	42	0	709	1,631
Row Crops	0	0	0	0	2	0	69	71
Small Grains	0	0	5	0	2	0	545	552
Fallow	0	0	0	0	0	0	20	20
Urban Recreational Grasses	0	0	56	0	0	0	1	57
Total Consumptive	**227**	**992**	**1,485**	**538**	**1934**	**5,290**	**24,554**	**35,020**

Montgomery et al. 2003

Additional quantities of water are diverted from the Wenatchee River for use outside of the watershed. The Wenatchee Reclamation District delivers water to 12,500 acres; approximately 8,114 acres are located outside of the Wenatchee subbasin and water delivered to them would not return to the Wenatchee River. It is assumed that the diversion of flow for those water users represents a consumptive use to the Wenatchee River. The estimated consumptive use is 33,000 acre ft. (Montgomery et al. 2003).

Mandated instream flow requirements were established in 1983 for three reaches on the Wenatchee River, one reach on Icicle Creek and one reach on Mission Creek. In each case, these flow requirements are often not met during the winter and late summer as a result of naturally low flows and diversions during summer. These flow requirements condition issuance of new water rights but do not affect water rights acquired prior to adoption. There are no minimum instream flow protection levels established for the upper watershed tributaries.

3.2.4 Terrestrial/Wildlife

Wildlife Species

There are an estimated 341 wildlife species that occur in the subbasin. Of these species, 96 (28%) are closely associated with riparian and wetland habitat and 76 (21%) consume salmonids during some portion of their life cycle. Seventeen wildlife species are non-native. Eight wildlife species that occur in the Subbasin are listed federally and 42 species are listed in Washington as threatened, endangered, or candidate species. A total of 98 bird species are listed as Washington

State Partners in Flight priority and focal species. A total of 57 wildlife species are managed as game species in Washington.

Ninety-three percent of the wildlife species that occur in the Columbia Cascade Province occur in the Wenatchee subbasin. In addition, 94% of the amphibian species and 100% of the reptile species that occur in the province occur in the subbasin. A general summary of species richness is provided in Table 8 below. For additional information, refer to Appendix A.

Table 8. Species richness and associations for the Wenatchee subbasin

Class	Wenatchee	% of Total	Total (Ecoprovince)
Amphibians	16	94	17
Birds	215	92	234
Mammals	91	94	97
Reptiles	19	100	19
Total	**341**	**93**	**367**
Association			
Riparian Wetlands	70	90	78
Other Wetlands (Herbaceous and Montane Coniferous)	26	68	38
All Wetlands	96	83	116
Salmonids	76	93	82

Ashley and Stovall 2004

Wildlife

The wide diversity of available habitats in the Wenatchee subbasin provides a diverse assemblage of wildlife species. Table 9 lists information on species of particular importance to the Wenatchee subbasin including their listing status under Washington Department of Fish and Wildlife (WDFW) Priority Habitat Criteria.

1=Species determined to be in danger of failing, declining, or vulnerable due to factors such as limited numbers, disease, predation, exploitation, or habitat loss or change

2=Uncommon species, including Monitor species, occurring in forest environments and that may be affected by habitat loss or change

3=Species in forest environments for which the maintenance of a stable population and surplus for recreation may be affected by habitat loss or change)

And their formal listing regarding WDFW Species of Concern State status (E=endangered, T=threatened, S=sensitive, C=candidate) and ESA status (E=endangered, T=threatened, C=candidate, SC=species of concern, PT=proposed threatened, PE=proposed endangered)

Special Plant Species

Some of the most rare plant species endemic to Washington state are found in the subbasin, including showy stickseed, Wenatchee larkspur, Wenatchee checkmallow, clustered lady's slipper, several grapeferns, Thompson's chaenactis, bristly sedge, bulb-bearing waterhemlock, pine broomrape, Ross' avens, and long-sepaled globe mallow, Spalding’s Catchfly, and Ute Ladies. A number of other sensitive plants are also found in the subbasin (Andonaegui 2001).

Exotic Plant Species

Introduced plant species are having a significant deleterious impact on the vegetation of the subbasin. Exotic weed species include cheatgrass, knapweed, dalmation toadflax, and purple loosestrife. These species have become established in some areas and are capable of excluding native vegetation, particularly in non-forest, riparian or open forest conditions (CCCD 1996).

Table 9. Species of particular importance in the Wenatchee subbasin

Species	Scientific Name	WDFW PHS Criteria	State SOC Listing Federal ESA Status	Habitat Types
Amphibians				
Larch Mountain Salamander	*Plethodon larselli*	1	C/SC	Talus slopes, caves, boulders, cirques
Columbia Spotted Frog	*Rana luteiventris*	1	C/SC	Montane coniferous wetlands, riparian-wetlands
Birds				
Common Loon	*Gavia immer*	1,2	S/	Open water
Harlequin Duck	*Histrionicus histrionicus*	2,3	/SC	Riparian wetlands, open water
Northern Goshawk	*Accipiter gentiles*	1	C/SC	Interior mixed conifer
Bald Eagle	*Haliaeetus leucocephalus*	1	T/T	Riparian-wetlands, open water
Peregrine falcon	*Falco peregrinus*	1	E/SC	Cliffs, talus slopes
Flammulated Owl	*Otus flammeolus*	1	C/	Montane mixed conifer, Ponderosa pine
Northern Spotted Owl	*Strix occidentalis*	1	E/T	Interior mixed conifer, Lodgepole & Ponderosa pine
Vaux's Swift	*Chaetura vauxi*	1	C/	Montane coniferous wetlands, riparian-wetlands
White-headed Woodpecker	*Picoides albolarvatus*	1	C/	Ponderosa pine, montane mixed conifer, interior mixed conifer
Golden Eagle	*Aquila chrysaetos*	1		Shrubsteppe, interior grasslands
Marbled Murrlet	*Brachyyamphus marmoratus marmoratus*	1	T	Montane coniferous wetland – crest of the Cascades
Yellowbilled Cuckoo	*Coccyzuz americanus*	1	C	Riparian wetland

Mammals				
American Beaver	*Castor canadensis*			Upland aspen, montane coniferous wetlands, riparian-wetlands
Western Small-footed Myotis	*Myotis ciliolabrum*	2		Talus slopes, cliffs, Ponderosa pine
Gray Wolf	*Canis lupus*	1	E/E	Lodgepole pine, sub alpine parklands, alpine grass/shrub
Black Bear	*Ursus americanus*			Urban and agricultural mixed environs, montane coniferous wetlands, Riparian-wetlands
Grizzly Bear	*Ursus arctos*	1	E/T	Montane mixed conifer, Lodgepole pine, montane coniferous wetlands, riparian-wetlands
American Marten	*Martes americana*	3		Alpine grass/shrub, montane mixed conifer, interior mixed conifer, riparian-wetlands
Canada Lynx	*Lynx Canadensis*	1	T/T	Montane mixed conifer, interior mixed conifer, alpine grasslands
Mule Deer	Odocoileus hemionus	3		Ponderosa pine, riparian-wetlands, Interior mixed conifer, agricultural (everywhere)
Mountain Goat	Oreamnos americanus	3		Cliffs, talus slopes
Elk	Cervus elaphus	3		Sub alpine parkland, alpine grasslands, agricultural, urban mixed, montane mixed conifer
Fisher	Martes pennanti	1	E/SC	
Wolverine	Gulo gulo	1	C/SC	Talus slopes, caves

3.2.5 Aquatic/Fish Resources

The Wenatchee River is unique among subbasins in the upper Columbia region in that it supports the greatest diversity of populations and overall abundance of salmonids. There are core populations of sockeye salmon, steelhead, bull trout and both spring and later-run chinook salmon in the upper Wenatchee subbasin that are relatively strong, when compared to other populations in the Columbia basin.

Anadromous fish

The Washington state Salmon and Steelhead Stock Inventory (SASSI) has identified four spring chinook stocks in the Wenatchee subbasin; the Chiwawa River, Nason Creek, Little Wenatchee River, and White River stocks. A fifth stock, the Leavenworth NFH stock is unlisted and supports the only spring chinook fishery in the mid and upper Columbia basin. Spring chinook and steelhead trout are listed as endangered under the ESA. SASSI has also identified the Wenatchee River late-run chinook stock. It is likely that a fall run chinook salmon once used the lower Wenatchee River to varying extent, although very little information is available to substantiate this. For the purposes of this subbasin plan, fall and summer chinook life history types will be consolidated as late-run chinook. One stock of sockeye has been identified for this subbasin as well as one summer steelhead stock, the Wenatchee summer steelhead (WDF/WDW 1993).

Indigenous coho salmon no longer occur in the upper Columbia River region. By the early 1900s coho salmon populations were already decimated by lower Columbia River harvest rates, impassable dams, unscreened irrigation diversions, logging, mining, grazing, and water use practices in the tributaries. Through current and substantial efforts by the Yakama Nation, naturally reproducing coho salmon have been reintroduced into the Columbia Cascade Province. The restoration program is generally in its infancy but the YN and other resource managers intend to continue and expand the re-introduction effort in the Province.

Pacific lamprey is known to exist in the Wenatchee subbasin but at this time there is no empirical information to suggest population abundance or distribution.

Resident fish

A number of resident fish are present in the assessment units comprising the Wenatchee subbasin.

Table 10 lists the location of these species by watershed. The Wenatchee subbasin supports adfluvial, fluvial and resident forms of bull trout. The upper Columbia distinct population segment (DPS) of bull trout is listed as threatened (June 1998) under the federal ESA. Westslope cutthroat trout are fairly widespread within the subbasin, found mostly in the head water and higher elevation streams. Two species, the mountain sucker and Umatilla dace are Washington state priority habitat species and have state candidate listings.

Table 10. Resident fish present in the Wenatchee subbasin

Species Present	Assessment Units in the Wenatchee subbasin							
	White/Little Wenatchee	Chiwawa	Nason	Mainstem Wenatchee	Icicle	Mission	Peshastin	Chumstick
Bull Trout	X	X	X	X	X		X	
Westslope Cutthroat	X	X	X	X	X	X?	X	
Rainbow Trout	X	X	X	X	X	X	X	
Eastern Brook Trout	X	X	X	X	X	X		
Sculpin	X	X	X	X	X	X	X	
Northern Pike Minnow	X			X	X			
Redside Shiner	X			X	X	X		
Mountain Whitefish	X	X		X	X			
Sucker	X	X	X		X	X	X	
Bridgelip sucker				X	X			
Largescale sucker				X				
Kokanee salmon	X							
Pacific Lamprey	X			X	X			
Yellow perch				X				
Speckled dace				X	X	X	X	
Shiner perch				X		X		
Crappie				X		X	X	
Long nose Dace					X		X	
Long nose Sucker					X			
Chiselmouth				X				

Species Present	Assessment Units in the Wenatchee subbasin							
	White/Little Wenatchee	Chiwawa	Nason	Mainstem Wenatchee	Icicle	Mission	Peshastin	Chumstick
Mountain Sucker				X				

European carp have been introduced to Lake Wenatchee

3.3 Scientific Conceptual Foundation

3.3.1 Definition and Overview of a Scientific Conceptual Foundation

A conceptual foundation is a set of scientific theories, principles and assumptions, which in aggregate describe how a system functions. The conceptual foundation determines how information is interpreted, what problems are identified and, as a consequence, it also determines the range of appropriate solutions to achieve desired management goals. It is through the conceptual foundation that management goals are translated into the conditions within the system that are needed to achieve those goals; and management strategies which could achieve the appropriate or desired conditions (NPPC 1997). The importance of the conceptual foundation is emphasized in the above citations, and most thoroughly discussed in *A Conceptual Foundation for the Management of Native Salmonids in the Deschutes River* (Lichatowich 1998). The latter forms the basis for much of the conceptual foundation of this Wenatchee Subbasin Plan.

3.3.2 Purpose and Scope

The conceptual foundation plays a powerful, albeit often unrecognized, role in natural resource management and restoration programs. It forms the premise and framework from which management goals and actions are based. Management goals should be achievable within the logical framework of the conceptual foundation and conditions within the ecosystem should relate to each other in ways which are specified in the logical framework. Managers need to recognize and clearly describe the implications of strategies derived from our conceptual foundation.

Laws and policies typically form the basis for many management plans. Often, these are based on a set of theories, premises or simply ideas which in whole define a conceptual foundation. Although these theories or premises guide the development and implementation of a program, rarely are they explicitly stated. As long as the conceptual foundation remains unstated it cannot be reviewed, evaluated and debated in open forums. False assumptions, outdated science, unsupported principles and unintended consequences in the conceptual foundation cannot be identified and corrected unless they are explicitly stated and publicly discussed.

A conceptual foundation must address ecosystems at various scales. Clear definitions of ecosystems are always problematic because ecosystem function occurs at various temporal and spatial scales simultaneously. For example, organisms are a product of their native environment, but just as importantly, many environments are products of certain species and populations. Species like anadromous salmonids use many ecosystems and are very sensitive to environmental changes. Changes in one ecosystem, such as the ocean can change salmonid abundance in the fresh water environments, which in turn can alter environmental conditions for other organisms.

The focus and organization of the assessment, inventory, and management strategies of a subbasin plan should directly reflect the conceptual foundation. The foundation should also consider the increasingly broader geographic scales within which other fish and wildlife management plans or actions operate. For example, in the Columbia Basin, this means that the way the conceptual foundation views events at the smallest scale—the individual fish and its surrounding habitat—should be consistent with and mirror how the fish communities and habitat characteristics are viewed at the river reach scale, subbasin tributary, entire subbasin, multiple subbasins or regional scale (e.g., Evolutionary Significant Unit (ESU) scale), and aggregate Columbia basin anadromous fish stocks in the estuary and ocean environments. Ensuring conceptual consistency across multiple geographic scales in the management and recovery of fish, wildlife, and their habitats is a daunting challenge which has yet to be fully realized—primarily because the conceptual foundation at each geographic level is not explicitly stated and there has not been adequate communication and coordination regarding scientific principles and assumptions between the ever increasing numbers of management entities and governmental boundaries (i.e., local, state, and national) as geographic scale increases.

The conceptual foundation is defined at the largest geographic scale applicable to a planning effort. In this case, the Columbia Basin will usually be the largest geographic scale, although other out of basin scales may be appropriate for some migratory birds and the salt water life stage of anadromous fish. As the plan focuses with increasing detail on management strategies for smaller geographic areas, subbasin planners should then continue to check for conceptual consistency. The only current examples of an explicitly stated conceptual foundation are the "alternative conceptual foundations" of *Return to the River* and the NPCC's An Integrated Framework for Fish and Wildlife Management in the Columbia Basin (NPPC 1997), which are reviewed and synthesized in Lichatowich (1998).

3.3.3 Guiding Principles

Four sets of guiding principles derived from Lichatowich's (1998) synthesis in the Columbia Basin Conceptual Foundation introduce principles and corollaries relevant to the Wenatchee subbasin. These four guiding principles, in bold and shaded, have been modified to make them applicable to both fish and wildlife. Following them, and interspersed with the Guiding Principles are the thirteen numbered principles applicable to the Wenatchee Subbasin Conceptual Foundation with discussion.

The Columbia River is a natural-cultural system characterized by natural environmental variability and fluctuation in production. Salmon restoration and management must consider the whole ecosystem, natural as well as cultural, in the fresh water, estuary, and ocean. Suitable ecosystem attributes can be achieved by managing human interference in the natural habitat forming processes and by use of technology to support those processes. The use of technology to circumvent natural ecological processes should be avoided, if possible.

Principle 1. Strategies for recovery or maintenance of viable populations need to be evaluated within the context of the entire life history of the populations.

The Wenatchee Subbasin Plan can only identify, evaluate and prioritize alternative strategies for anadromous and migrating species recovery that can be fully implemented within the subbasin by authorized local, state, federal and tribal managers. The subbasin plan addresses strategies that can be implemented locally and that effect life stages that subbasin managers can influence or control through their decisions. However, planning and implementing actions for fish and wildlife within the Wenatchee subbasin must also consider out of basin affects, which will influence the success or failure of population recovery.

Ideally, populations should be tracked or accounted for throughout the geographical range of their life history to ensure that differential survival/mortality rates specific to that population can be evaluated in preparation of management or recovery strategies.

For species whose entire life history is confined to the Wenatchee subbasin, it is possible to make informed and logical decisions regarding all strategies necessary for management. For fish and wildlife species that spend a portion of their life history outside of the subbasin boundaries, management goals, the desired ecosystem attributes, and restoration strategies should generally be universal and integrated across the subbasin, eco-region (ESU), Columbia Basin, and full life history including estuary and marine scales to be successful. Where differing parts of a population's life history or habitat are managed by different entities, those populations and their interactions with the environment, with other populations, and their responses to management actions should be monitored and communicated in a common language. The broader and more inclusive the management planning process becomes, the greater the potential that these common and integrated goals, attributes, strategies will be successful in recovering far-ranging migratory species.

Principle 2. The Wenatchee Subbasin contains an evolving, natural-cultural system that will continue to change into the future.

The Wenatchee subbasin's natural and cultural elements must be considered in any management planning. Unless a balance between the needs and constraints of the natural and cultural components of the ecosystem is achieved, the status of many of the native fish and wildlife populations in the basin will continue to decline. To move to ward a balance, science and resource managers need to present the values and benefits of the natural elements and must show when their benefits outweigh the costs of protection and recovery. In addition, it must be made clear that healthy natural and cultural elements are not mutually exclusive.

Principle 3. Important environmental attributes that determine the distribution and productivity of fish and wildlife populations have been influenced by human activity in and outside the subbasin.

Cultural impacts have occurred at different rates and to varying degrees throughout the subbasin. For example the transportation system and rural along the mainstem Wenatchee River and along Chumstick, Peshastin and Nason creeks has directly altered floodplain, riparian and in-channel characteristics to a large degree. Many culverts or other obstacles have reduced or eliminated fish passage into areas that could significantly contribute to increased productivity and/or life history diversity. Possibly one of the greatest impacts to overall stream condition is channel and riparian simplification, present throughout much of the subbasin which has dramatically altered channel morphology, habitat diversity and geo-fluvial processes important for maintaining critical ecological functions. These changes undoubtedly have affected habitat use and the relationship many of these species once had to these effected areas.

Many habitat attributes, now out of synch or timing with the life history strategies that fish and wildlife populations had evolved prior to those alterations, may be lethal to fish or wildlife for part of the year, or have directly resulted in habitat loss. These alterations have resulted in decreased abundance and productivity, and changes in the distribution of native fish and wildlife populations.

Fish and wildlife productivity requires a network of complex, interconnected habitats that are created, altered, and maintained by natural physical processes in terrestrial, fresh water, estuary, and ocean areas. Management and restoration goals depend on achieving suitable ecosystem attributes.

Principle 4. Viable native fish and wildlife populations are dependent upon the natural environment and the natural processes that sustain them.

Discovering which of the natural processes most influence various populations is fundamental to management direction. Usually the original conditions represent the best models we will ever have. Subbasin planners and managers must avoid a common tendency to become excessively or exclusively species-centric in developing management strategies. Instead, focusing on restoring terrestrial and aquatic/riparian ecosystem health and function will provide habitat attributes that will enable holistic management or recovery for larger assemblages of native biota.

Principle 5. Changes to the physical characteristics and connectivity of the Wenatchee subbasin have contributed to the decline of native fish and wildlife populations.

Understanding the predevelopment conditions, the current conditions, the trend in these conditions, and their effect on ecosystem attributes is crucial to formulation of recovery strategies. Throughout much of the Wenatchee subbasin, management and recovery of fish and wildlife productivity requires an emphasis on restoration of the natural range of hydrological attributes and fluvial processes, reconnection of isolated physical habitat, and protection or reintroduction of populations once reconnection has been achieved.

Principle 6. Changes to the physical characteristics of the alluvial valley and floodplains of the Wenatchee River have resulted in changes in ecosystem attributes.

Changes to the physical characteristics of the alluvial valley and floodplains of the Wenatchee River have resulted in changes in relatively largescale ecosystem attributes. Some of these changes are reversible from a societal perspective; some are not. Floodplain management and restoration where possible is a key to successful recovery of physical and biological characteristics that support native fish and wildlife species.

Principle 7. The historical distribution of fish and wildlife populations and species in the Wenatchee Subbasin was controlled by relatively abrupt changes in physical attributes, i.e. steep environmental gradients.

In the Wenatchee subbasin, examples of environmental gradients existed at:

- Mouths of the lakes (thermal control or feeding stations for bull trout)
- Presence of lakes (refuge for cutthroat or rearing for sockeye juveniles)
- Stream temperature (segregation of species)
- Stream gradients (slope) (provision to habitat types more conducive to certain species or life stages)
- Aspect, elevation or precipitation-based changes in vegetation zones (such as the forest/shrubsteppe interface)

Changes to or elimination of the environmental gradients are expected to affect the presence and distribution of species or populations. Not all species respond in the same way to a similar gradient. Increasing the summer water temperature and lowering the winter temperature would have a powerful effect on aquatic species distribution and life history. Similarly, reducing the quality and quantity of “edge effects” from vegetative interfaces can significantly reduce habitat diversity required for many species to thrive.

Species diversity and the biotic community are a reflection of the ecosystem attributes. The co-evolved assemblage of species share requirements for similar ecosystem attributes and those attributes can be estimated by intensive study of focal or indicator species.

Principle 8. For aquatic and fish related interests, selection of a broad range of focal species provide a basis for developing holistic management strategies. For terrestrial and wildlife related interests, the selection of focal habitats and related focal species provide a basis for developing holistic management strategies.

Bull trout, cutthroat trout, sockeye, coho, spring chinook, late-run chinook, steelhead, and Pacific lamprey are the aquatic focal species for the Wenatchee subbasin. Through evaluating and planning for these species we assume that viable and sustainable ecosystem function and processes occurs in most geographic areas for important floodplain and riverine associated habitats.

In the case of terrestrial wildlife, focal habitat types can often be characterized by vegetation patterns. By maintaining adequate quality, quantity and connectivity of key vegetative communities we assume that viable and sustainable habitats are available and ecosystem function occurs over a wide range of the focal species. Ponderosa pine forests and woodlands, shrubsteppe and riparian habitats are the terrestrial focal habitats which cover most of the mid and low elevation areas within the subbasin.

Viability, a key concept in the context of conservation planning, refers to the ability of a species or a community/ecological system referred to in this document as focal habitats to persist over some specified time period. Species viability at the population level is affected by chance events that may dictate whether a species remains viable or goes extinct. Three general factors generally referring to size, condition, and landscape context, characterize community or ecological systems viability:

- demography of component species populations
- internal processes and structures among these component species
- landscape level processes that sustain the community or system

Principle 9. The scientific concept of environmental stress is a legitimate means to evaluate the degree to which a threat to an environment by natural or human induced stressors may result in significant and undesired ecological changes or the vulnerability of an environment to those stressors.

Environmental stressors such as an altered fire regime, rapid spread of invasive species or pathogens, or altered habitat composition can affect environmental conditions at relatively small and large scales. Environmental stressors operate on habitat size and condition as well as landscape-scale attributes. The sources of these stresses are both natural and human-caused. Understanding the causes and likelihood of environmental stressors provides for long term perspective of how future environmental conditions may relate to long term management goals. The combination of stresses and sources provides a deeper analysis of potential viability impairment, thus forming a basis for management strategies.

Principle 10. Fish and wildlife are components of their own environment.

Inter and intra-specific competition are the drivers for species abundance, fitness and life history diversity within a given species assemblage. Restoration of individual populations may not be possible without restoration of other fish or wildlife populations with which they co-evolved. Beyond direct relationships between various populations, fish and wildlife alter key habitat characteristics (e.g., nutrients, cleaned spawning beds, beaver ponds, forest understory, etc.) which can directly and indirectly affect other species/populations by changing important environmental characteristics.

Life history, genetic diversity, and metapopulation organization are ways that fish and wildlife adapt to their habitat. Diversity and population structure are how fish and wildlife species cope with spatial and temporal environmental variations. Such diversity promotes production and long term persistence at the species level.

Principle 11. Most native fish and wildlife populations are linked across large areas which decrease the possibilities for extinctions or extirpations. An important component for recovery of depressed populations is to work within this framework and maintain or recreate largescale spatial diversity.

Attempting to maintain or restore populations outside a framework of largescale spatial diversity will be difficult or impossible. Management of Wenatchee subbasin fish and wildlife populations in the wild and in the hatchery environment should include strategies to maintain a close connection to the ecosystem attributes that influence and shape the population (i.e., environmental selective pressures), while also allowing for gene flow across populations. Any program to restore fish and wildlife to the Wenatchee subbasin must be capable of detecting and monitoring new, locally adapted life histories, if and when they occur in unique habitats.

Reintroduction or supplementation programs for fish or wildlife should concentrate on specific environments within the basin, selection of an appropriate stock for reintroduction to that environment or locally adapting a donor stock where a local stock no longer exists. When supplementing native populations, the facilities and programs should mimic the native environment as closely as possible. For example, in the hatchery environment, this includes maintenance of life history diversity such as spawn timing, matching hatchery incubation temperatures to the natural incubation environment, and simulating the natural rearing environment in the hatchery to the extent feasible.

Population management using supplementation must consider habitat quality and quantity to determine if existing habitat has the carrying capacity to support the number of fish or wildlife needed for genetic expression and to meet population goals.

Principle 12. Populations with the least amount of change from their historic spatial diversity are the easiest to protect and restore, and will have the best response to restoration actions.

The ability to predict population responses to changes in the environment is highest for those populations that are closest to their pre-settlement population structure. At some point along the scale from intact populations to former populations that have had entire metapopulation (groups of related populations that share genes at low rates over time) extirpated from the basin and adjacent basins, emphasis on recovery actions is better focused on rebuilding population structure than on habitat restoration. If the goal of cost- effective restoration is to be achieved, subbasin planners need to assess the optimal mix of habitat restoration and population structure restoration to achieve biological goals.

Populations that have multiple life histories (e.g., multiple locations or times where rearing takes place, multiple ages/times of year when out-migration occurs, multiple ages at sexual maturity, multiple spawning areas) minimize risk to the population as a whole. These life history strategies are linked to population structure and genetics.

Principle 13. All else being equal, small populations are at greater risk of extinction than large populations, primarily because several processes that affect population dynamics operate differently in small populations than they do in large populations.

In some cases, small populations will need measures in addition to habitat protection and/or restoration if they are to survive into the future. Such measures may include specific forms of artificial production (broodstock collection programs for supplemented salmonid populations), artificial introduction from outside the population, or special consideration where habitat alterations or restoration modifies the only known sites where a particular life history is expressed.

4 Assessment

4.1 Focal Species

A focal species will be used to evaluate the health of the ecosystem and the effectiveness of management actions. Focal habitat types are used as the basis for the wildlife assessment.

Terrestrial/Wildlife: Because terrestrial wildlife species often are wide ranging and typically have varied habitat needs, key focal habitats were used as bio-indicators and several different species that are obligated to these habitats were selected for this evaluation. The three focal habitats and representative species selected for this evaluation are listed in Table 11.

Table 11. Wildlife focal habitats and representative species in the Wenatchee subbasin

Focal habitats	Wildlife Species Represented
Ponderosa – Mixed hardwood	White-headed woodpecker, Pygmy nuthatch, Flammulated owl, Grey flycatchers
Shrubsteppe	Sharp-tailed grouse, Grasshopper sparrow, Brewer's sparrow, Mule deer
Riparian	Red-eyed vireo, Yellow-breasted chat, Beaver

Aquatic/Fish: Fish focal species were defined that a) have special cultural significance, b) fulfill a critical ecological function, c) serve as an indicator of environmental health, d) are locally significant or rare as determined by applicable state or federal resource management agencies and/or are federally listed species. Eight anadromous and resident fish species were chosen as focal species. Each of these species is considered to be culturally important, three of the species are listed under the ESA and each species uniquely represent different and important habitat characteristics. The eight species and their representative habitat types are listed in Table 12.

Table 12. Fish focal species and representative habitats in the Wenatchee subbasin

Focal Fish Species	Habitats Represented
Spring chinook	Mid elevation tributary streams, Stream order 2-3.
Late-run chinook	Mid and lower Wenatchee River mainstem
Sockeye	Lake Wenatchee, lower White and Little Wenatchee rivers.
Coho	Lower – mid elevation mainstem and tributaries, side channel and backwater environments.
Steelhead	Lower – mid elevation mainstem and tributaries
Pacific lamprey	Undefined habitat, culturally important species.
Bull trout	Mid upper elevation tributaries
Cutthroat trout	Upper elevation, higher gradient tributaries.

4.2 Terrestrial/Wildlife Assessment

Methodology

The wildlife assessment was developed from a variety of tools including subbasin summaries, the Interactive Biodiversity Information System (IBIS), WDFW Priority Habitats and Species (PHS) database, Washington GAP Analysis database, Partners in Flight (PIF) information, National Wetland Inventory maps, Ecoregion Conservation Assessment (ECA) analyses, and input from local state, federal, and tribal wildlife managers. Specific information about these data sources is located in Appendix A.

Although IBIS is a useful assessment tool, it should be noted that the historic habitat maps have a minimum polygon size of 247 acres (1 km^2) while current IBIS wildlife habitat maps have a minimum polygon size of 250 acres (Ashley and Stovall 2004). In either case, linear aquatic, riparian, wetland, subalpine, and alpine habitats are under-represented, as are small patchy habitats that occur at or near the canopy edge of forested habitats. It is also likely that micro habitats located in small patches or narrow corridors were not mapped at all.

Another limitation of IBIS data is that they do not reflect habitat quality nor do they associate habitat elements (key ecological correlates or KECs) with specific areas. As a result, a given habitat type may be accurately depicted on IBIS map products, but may be lacking quality and functionality. For example, IBIS data do not distinguish between shrubsteppe habitat dominated by introduced weed species and pristine shrubsteppe habitat.

Washington State GAP data were also used extensively throughout the wildlife assessment. The GAP-generated acreage figures may differ from IBIS acreage figures as an artifact of using two different data sources. The differences, however, are relatively small (less than 5%) and will not impact planning and/or management decisions.

The ECA spatial analysis is a relatively new terrestrial habitat assessment tool developed by The Nature Conservancy. The ECA has not been completed in all areas within the greater Columbia River Basin. Where possible, however, WDFW integrated ECA outputs into ecoprovince/ subbasin plans.

The major contribution of ECA is the spatial identification of priority areas where conservation strategies should be implemented. ECA products were reviewed and modified as needed by local wildlife area managers and subbasin planners.

Wildlife Focal Species and Representative Habitats

Focal Wildlife Species Selection and Rationale

The focal species selection process is described in Appendix A. Ecoprovince and subbasin planners identified focal species assemblages for each focal habitat type.

Nine bird species and two mammalian species were selected to represent three priority habitats in the subbasin (Table 13). Life requisite habitat attributes for each species assemblage were pooled to characterize a range of management conditions, to guide planners in development of future habitat management strategies, goals, and objectives.

General habitat requirements, limiting factors, distribution, population trends, and analyses of structural conditions, key ecological functions, and key ecological correlates for individual focal species are included in Appendix A.

Establishment of conditions favorable to focal species will benefit a wider group of species with similar habitat requirements.

Table 13. Focal species selection matrix for the Columbia Cascade Ecoprovince

Common Name	Focal Habitat[1]	Status[2]		Native Species	Priority Habitat Species	Partners in Flight	Game Species
		Federal	State				
Sage thrasher	SS	n/a	C	Yes	Yes	Yes	No
Brewer's sparrow	SS	n/a	n/a	Yes	No	Yes	No
Grasshopper sparrow	SS	n/a	n/a	Yes	No	Yes	No
Sharp-tailed grouse	SS	SC	T	Yes	Yes	Yes	No
Sage grouse	SS	C	T	Yes	Yes	No	No
Pygmy rabbit	SS	E	E	Yes	Yes	No	No
Mule deer	SS	n/a	n/a	Yes	Yes	No	Yes
Willow flycatcher	RW	SC	n/a	Yes	No	Yes	No
Lewis woodpecker	RW	n/a	C	Yes	Yes	Yes	No
Red-eyed vireo	RW	n/a	n/a	Yes	No	No	No
Yellow-breasted chat	RW	n/a	n/a	Yes	No	No	No
American beaver	RW	n/a	n/a	Yes	No	No	Yes
Pygmy nuthatch	PP	n/a	n/a	Yes	No	No	No
Gray flycatcher	PP	n/a	n/a	Yes	No	No	No
White-headed woodpecker	PP	n/a	C	Yes	Yes	Yes	No
Flammulated owl	PP	n/a	C	Yes	Yes	Yes	No

1 SS = Shrubsteppe; RW = Riparian Wetlands; PP = Ponderosa pine;

2 C = Candidate; SC = Species of Concern; T = Threatened; E = Endangered

Ashley and Stovall 2004

Focal Representative Habitats

Focal representative habitats selected for the subbasin include ponderosa pine, shrubsteppe, and riparian wetlands. Neither the IBIS nor the Washington GAP analysis data recognize the historic presence of riparian wetlands. The current extent of this habitat type as reflected in these databases is suspect at best; however, riparian wetland habitat is a high priority habitat wherever it is found in the ecoprovince. Agriculture, a habitat of concern, is not included as a focal habitat type at the subbasin level. Focal wildlife habitat types are fully described in Appendix A.

Areas Currently Under Protection Status

An estimated 312,670 acres (37%) are permanently protected in the subbasin. These lands have permanent protection from conversion of natural land cover, and a mandated management plan is in operation to maintain a natural state within which disturbance events of natural type are allowed to proceed without interference or are mimicked through management (high protection). Approximately 0.18% (1,611 acres) of the subbasin has permanent protection from conversion of natural land cover, and a mandated management plan is in operation to maintain a primarily natural state (medium protection status). The majority (361,418 acres; 42%) of lands in the subbasin has permanent protection from conversion of natural land cover but is subjected to uses of either a broad, low intensity type or localized intense type (low protection status). Approximately 21% (177,614 acres) of the lands within the subbasin lack irrevocable easements or mandates to prevent conversion of natural habitat types to anthropogenic habitat types (no protection). Lands owned by WDFW fall within the medium and low protection status categories.

Additional habitat protection, primarily on privately owned lands, is provided through the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP). The CRP is intended to reduce soil erosion on upland habitats through establishment of perennial vegetation on former agriculture lands. Similarly, CREP conservation practices reduce stream sedimentation and provide protection for riparian/riverine habitats using buffer strips comprised of herbaceous and woody vegetation.

Both programs provide short-term (CRP-10 years; CREP-15 years), high protection of habitats enrolled in either program. Congress authorizes program funding /renewal, while the US Department of Agriculture (USDA) determines program criteria. Program enrollment eligibility and sign-up is decentralized to state and local Natural Resources Conservation Service (NRCS) offices.

Rare Plant Communities

The Wenatchee subbasin contains 22 rare plant communities Approximately 32% of the rare plant communities are associated with shrubsteppe habitat, and 68% with upland forest habitat.

Noxious Weeds

Changes in biodiversity have been closely associated with changes in land use. Grazing, agriculture, and accidents have introduced a variety of exotic plants, many of which are vigorous enough to earn the title noxious weed. Twenty-six species of noxious weeds occur in the subbasin. The primary weed species in the subbasin are cheatgrass, knapweeds, and Dalmatian toadflax (USFS 1999).

Vegetation Zones

Eight historic (potential) vegetation zones that occur within the subbasin. The three-tip sage, central arid steppe, and ponderosa pine vegetation zones are described in detail in Ashley and

Stovall (2004).These vegetation zones constitute focal habitat types. Douglas-fir, grand fir, mountain hemlock, subalpine fir, and alpine parkland are not focal habitat types, but these vegetation zones occur extensively throughout the subbasin.

Changes in Wildlife Habitat

Dramatic changes in wildlife habitat have occurred throughout the subbasin since pre-European settlement (c.1850). Quantitative changes in all subbasin wildlife habitat types are compared in Table 14 (Ashley and Stovall 2004).

Table 14. Historic and current wildlife habitat types in the Wenatchee subbasin

Status	Historic	Current	Change (%)	Habitat Type Description
Westside Lowlands Conifer-Hardwood Forest	11,618	1,411	-88	One or more of the following are dominant: Douglas fir, western hemlock, western red cedar, Sitka spruce, red alder.
Montane Mixed Conifer Forest	201,957	149,209	-25	Coniferous forest of mid to upper montane sites with persistent snowpack; several species of conifer; understory typically shrub-dominated.
Eastside (Interior) Mixed Conifer Forest	175,260	389,213	56	Coniferous forests and woodlands; Douglas fir commonly present, up to 8 other conifer species present; understory shrub and grass/forb layers typical; mid montane.
Lodgepole Pine Forest and Woodlands	117,417	4,287	-97	Lodgepole pine dominated woodlands and forests; understory various; mid to high elevations.
Ponderosa Pine Forest and Woodlands	208,137	51,912	-74	Ponderosa pine dominated woodland or savannah, often with Douglas fir, shrub, forb, or grass understory; lower elevation forest above steppe, shrubsteppe.
Upland Aspen Forest	742	0	-100	[No information to date]
Subalpine Parkland	65,754	36,044	-44	Coniferous forest of subalpine fir, Engelmann spruce and lodgepole pine.
Alpine Grasslands and Shrublands	21,506	108,886	81	This habitat is dominated by grassland, dwarf-shrubland (mostly evergreen microphyllous), or forbs.
Eastside (Interior) Grasslands	28,180	38,377	11	Dominated by short to medium height native bunchgrass understory with forbs, crust.
Shrubsteppe	9,146	24,248	64	Sagebrush and/or bitterbrush dominated; bunchgrass understory with forbs, cryptogram crust.
Agriculture, Pastures, and Mixed Environs	0	30,700	100	Cropland, orchards, vineyards, nurseries, pastures, and grasslands modified by heavy grazing; associated structures.
Urban and Mixed Environs	0	1,752	100	High, medium, and low (10-29% impervious ground) density development.
Open water—Lakes, Rivers, Streams	1,236	8,154	82	Lakes are typically adjacent to Herbaceous Wetlands, while rivers and streams typically adjoin Eastside Riparian Wetlands and Herbaceous Wetlands.
Herbaceous Wetlands	0	41	100	[No information to date]
Montane Coniferous Wetlands	0	8,937	100	Forest or woodland dominated by evergreen conifers; deciduous trees may be co-dominant; understory dominated by shrubs, forbs, or graminoids; mid to upper montane.

Status	Historic	Current	Change (%)	Habitat Type Description
Eastside (Interior) Riparian Wetlands	0	141	100	Shrublands, woodlands and forest; less commonly grasslands; often multi-layered canopy with shrubs, graminoids, forbs below.

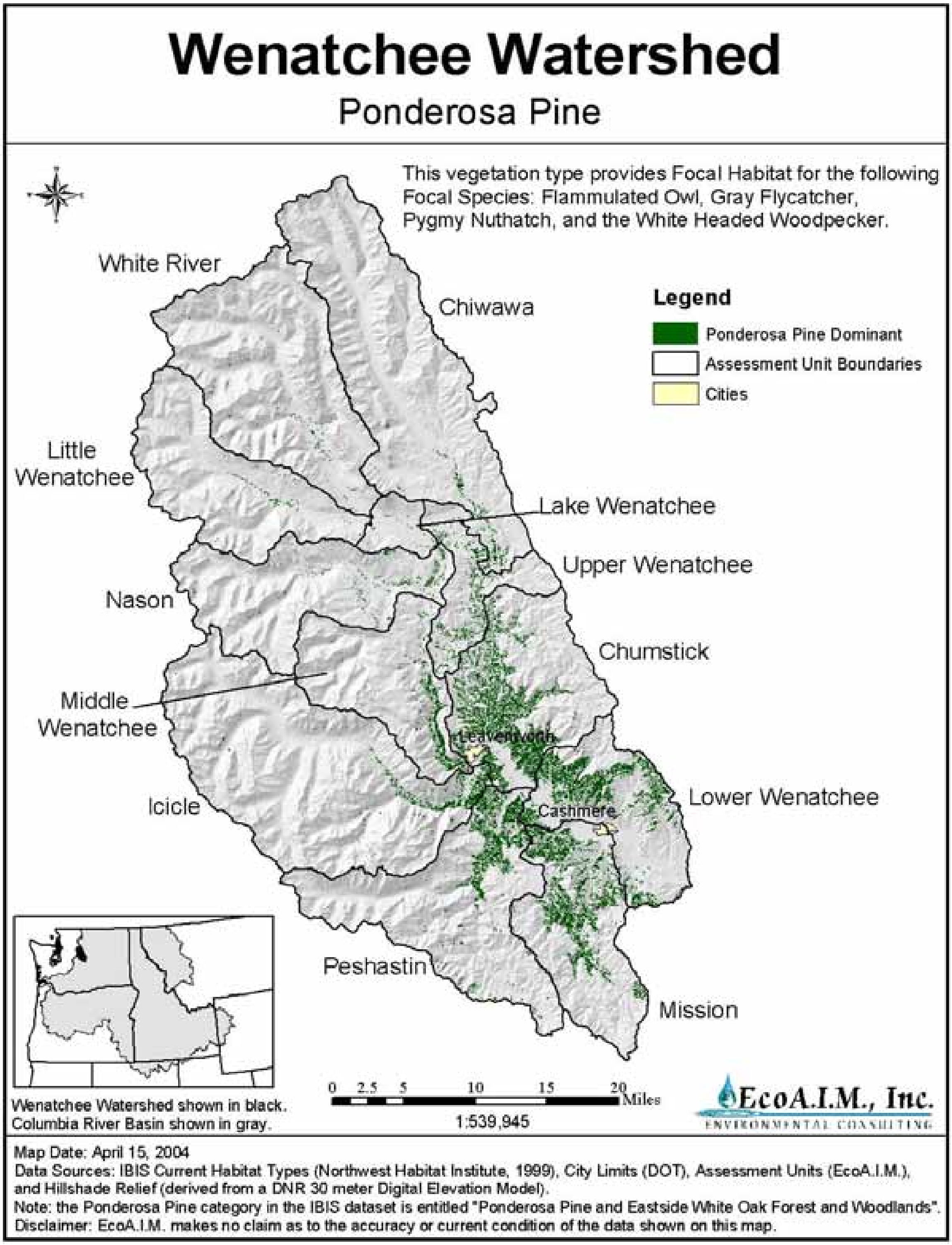

Figure 2. Ponderosa Pine distribution in the Wenatchee subbasin

4.3 Ponderosa Pine

Historically in the subbasin, old-growth ponderosa pine forests occupied areas between the shrubsteppe zone and moister forest types at higher elevations. Large, widely spaced, fire-resistant trees and an understory of forbs, grasses, and shrubs characterized these forests. Periodic low-intensity fires maintained this habitat type. With the settlement of the subbasin, most of the old pines were harvested for timber, and the frequent low-intensity fire regime has been aggressively suppressed. With the settlement of the subbasin, most of the old pines were harvested for timber, and frequent fires have been suppressed. As a result, much of the original forest has been replaced by dense second growth of Douglas-fir and ponderosa pine with little understory.

Extant ponderosa pine habitat within the subbasin currently covers a wide range of seral conditions. Forest management and fire suppression have led to the replacement of old-growth ponderosa pine forests by younger forests with a greater proportion of Douglas-fir than pine stands.

Currently, much of this habitat has a younger tree cohort of more shade-tolerant species that gives the habitat a more closed, multi-layered canopy. . For example, this habitat includes stands previously maintained by natural fire in which grand fir can eventually become the canopy dominant. Large late-seral ponderosa pine and Douglas-fir are harvested in much of this habitat type. Under most management regimes, tree size decreases and tree density increases.

Introduced annuals, especially cheatgrass and invading shrubs under heavy grazing pressure, have replaced native herbaceous understory species. Four exotic knapweed species *(Centaurea* spp.*)* are spreading rapidly through the ponderosa pine zone and threatening to replace cheatgrass as the dominant increaser after grazing. Dense cheatgrass stands eventually change the fire regime of these stands often resulting in stand replacing, catastrophic fires. Bark beetles, primarily of the genus *Dendroctonus* and *Ips*, kill thousands of pines annually and are the major mortality factor in commercial saw timber stands.

Historically in the Wenatchee subbasin, 7% (3,577 acres) of the dry forest was in openings, 80% (40,876 acres) was low density park-like with 10-55% canopy closure, and 13% (6,642 acres) was high density with >55% canopy closure (USFS 1999). Currently, 7% (3,767 acres) remains in dry forest openings (nonforested, i.e., recent fire, clear cut), 41% (20,661 acres) is dry forest low density and lacking understory of more than 75% of the area, and 51% (25,907 acres) is high-density dry forest that is successionally advanced (USFS 1999).

In the North Cascades region, including sampled watersheds in the Lake Chelan and Wenatchee subbasins, ponderosa pine cover decreased from 16.5 to 13.2% (Peven 2003. This information was based on comparison of 337 randomly selected sub- watersheds in 43 of 164 watersheds using 1932-1966 aerial photos compared to 1981-1993 aerial photos. Other changes noted included decreased connectivity and decreased patch size (increased fragmentation). Douglas fir cover increased during the same interval.

Protection Status

The protection status of remaining ponderosa pine habitat in all watersheds fall primarily within the low to no protection status categories. As a result, this habitat type will likely suffer further degradation, disturbance, and/or loss in all ecoprovince subbasins.

Factors Affecting Ponderosa Pine Habitat

Factors affecting ponderosa pine habitat are explained in detail in section Appendix A and are summarized below:

- Repeated timber harvest removed large diameter ponderosa pine and snags and left the understory. This has resulted in accelerated successional advancement and increased the Douglas fir component.
- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Historically, extensive grazing by domestic sheep may have altered understory composition, resulting in loss of forbs and a decrease in shrub densities.
- Overgrazing has resulted in lack of recruitment of sapling trees, particularly pines.
- Invasion of exotic plants has altered understory conditions and increased fuel loads.
- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.
- The timing (spring/summer versus fall) of restoration/silviculture practices such mowing, thinning, and burning of understory removal may be especially detrimental to single-clutch species.
- Targeting insects that are detrimental to forest health for biocide application may have negative ramifications on lepidopterans and non-target avian species

Ponderosa Pine Community

4.3.1 White-headed Woodpecker

The white-headed woodpecker represents species that require/prefer large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10–50% and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags grater than 31 in. in diameter at breast height (DBH). Abundant white-headed woodpecker populations can be present on burned or cut forest with residual large diameter live and dead trees and understory vegetation that is usually very sparse. Openness however, is not as important as the presence of mature or veteran cone producing pines within a stand.

4.3.2 Pygmy Nuthatch

The pygmy nuthatch represents species that require heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age and those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 in. DBH) trees characteristic of mature undisturbed forests. Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

4.3.3 Flammulated Owls

Flammulated owls represent wildlife species that occupy ponderosa pine sites comprised of multiple-canopy, mature ponderosa pine stands or mixed ponderosa pine/Douglas-fir forest interspersed with grassy openings and dense thickets. Flammulated owls nest in habitat types with low to intermediate canopy closure, two layered canopies, tree density of 508 trees/acre (9-ft. spacing), basal area of 250 sq. ft./acre, and snags greater than 20 in. diameter at breast height (DBH) and 3-39 ft. tall. Food requirements are met by the presence of at least one snag greater than 12 in. DBH/10 acres and 8 trees/acre greater than 21 in. DBH.

4.3.4 Gray Flycatchers

Gray flycatchers represent wildlife species that occupy the pine/shrubsteppe interface (pine savannah) with a shrub/bunchgrass understory. Gray flycatchers require nest trees 18 in. DBH and a tree height of 52 ft. for their reproductive life requisites.

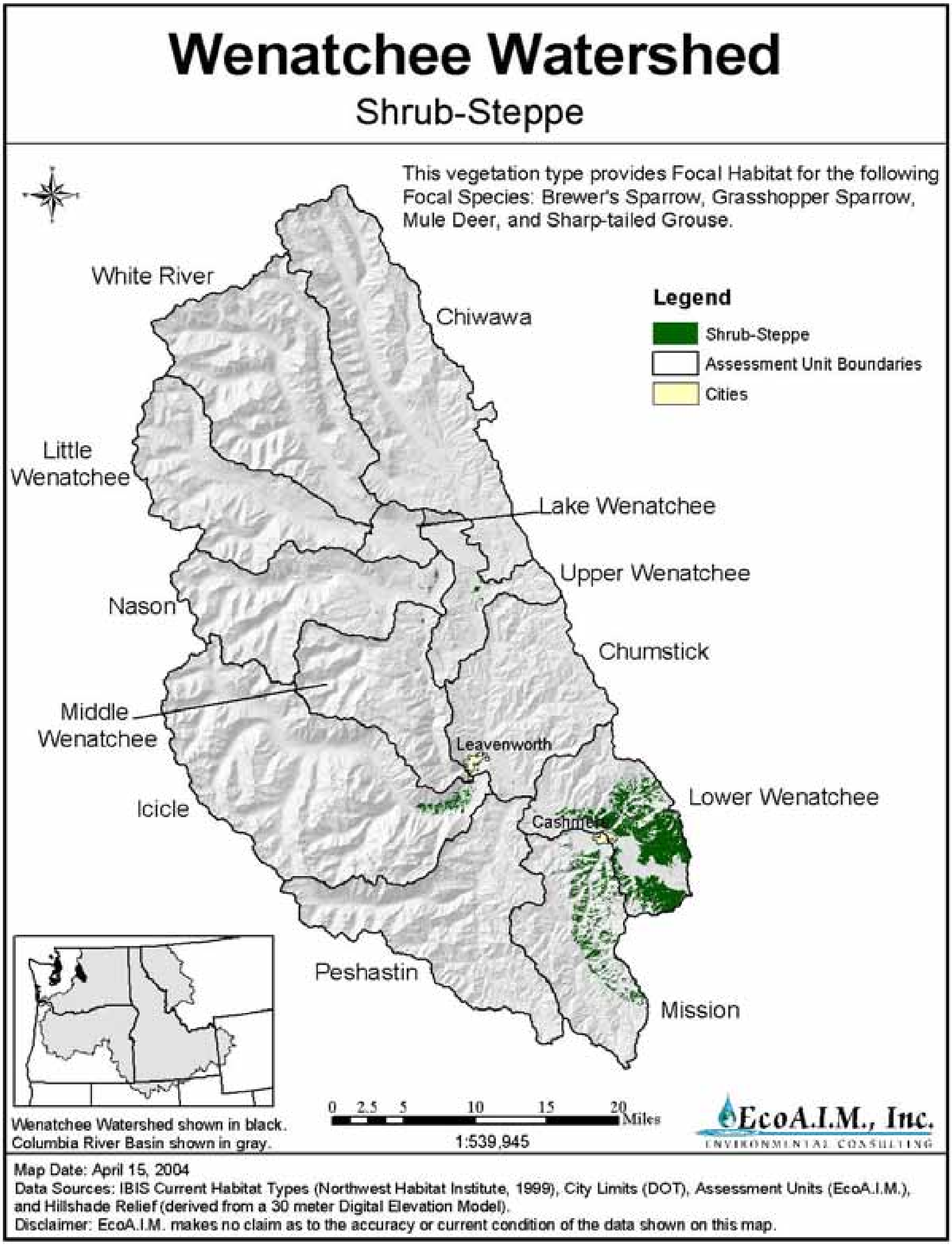

Figure 3. Shrubsteppe distribution in the Wenatchee subbasin

4.4 Shrubsteppe

The greatest changes in shrubsteppe habitat from historic conditions are the reduction of bunchgrass cover in the understory and an increase in sagebrush cover. Soil compaction is also a significant factor in heavily grazed lands affecting water percolation, runoff and soil nutrient content. A long history of grazing, fire, and invasion by exotic vegetation has altered the composition of the plant community within much of the extant shrubsteppe in this region, and it is difficult to find stands which are still in relatively natural condition.

Fire has relatively little effect on native vegetation in the three-tip sagebrush zone, since three-tip sagebrush and the dominant graminoids resprout after burning. Three-tip sagebrush does not appear to be much affected by grazing, but the perennial graminoids decrease and are eventually replaced by cheatgrass (*Bromus tectorum*), plantain *(Plantago* spp.), big bluegrass (*Poa secunda),* and/or gray rabbitbrush (*Chrysothamnus nauseosus).* In recent years, diffuse knapweed (*Centaurea diffusa)* has spread through this zone and threatens to replace other exotics as the chief increaser after grazing.

In areas of central arid steppe with a history of heavy grazing and fire suppression, true shrublands are common and may even be the predominant cover on non-agricultural land. Most of the native grasses and forbs are poorly adapted to heavy grazing and trampling by livestock. Grazing eventually leads to replacement of the bunchgrasses with cheatgrass, Nuttall's fescue (*Festuca microstachys*), eight flowered fescue (*F. octofiora),* and Indian wheat (*Plantago patagonica*). In recent years, several knapweeds (*Centaurea spp*.), have become increasingly widespread. Russian star thistle (*Centaurea repens)* is particularly widespread, especially along and near major watercourses.

Based on 1992 aerial photographs, 1994 post-burn photographs, and limited ground truthing, there was 25,882 acres of steppe communities in the Wenatchee watershed. Historically, the total number and distribution of steppe communities was likely greater than today (USFS 1999).

Protection Status

The protection status of remaining shrubsteppe habitats in all subbasins fall primarily within the low to no protection status categories. As a result, this habitat type will likely suffer further degradation, disturbance, and/or loss in all ecoprovince subbasins.

Factors Affecting Shrubsteppe Habitat

Factors affecting shrubsteppe habitat are explained in detail in Appendix A and are summarized below:

- Permanent habitat conversions of shrubsteppe/grassland habitats (e.g., approximately 60% of shrubsteppe in Washington (Dobler et al. 1996)) to other uses (e.g., agriculture, urbanization). Significant acreage of shrubsteppe habitat continues to be converted to residential development between Wenatchee and Monitor (USFS 1999)
- Fragmentation of remaining tracts of moderate to good quality shrubsteppe habitat
- Degradation of habitat from intensive grazing and invasion of exotic plant species, particularly annual grasses such as cheatgrass and woody vegetation such as Russian olive

- Degradation and loss of properly functioning shrubsteppe/grassland ecosystems resulting from the encroachment of urban and residential development and conversion to agriculture. Best sites for healthy sagebrush communities (deep soils, relatively mesic conditions) are also best for agricultural productivity; thus, past losses and potential future losses are great. Most of the remaining shrubsteppe in Washington is in private ownership with little long term protection (57%)
- Loss of big sagebrush communities to brush control (may not be detrimental relative to interior grassland habitats)
- Conversion of CRP lands back to cropland
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities
- High density of nest parasites (brown-headed cowbird) and domestic predators (cats) may be present in hostile/altered landscapes, particularly those in proximity to agricultural and residential areas subject to high levels of human disturbance.
- Agricultural practices that cause direct or indirect mortality and/or reduce wildlife productivity. There are a substantial number of obligate and semi-obligate avian/mammal species; thus, threats to the habitat jeopardize the persistence of these species.
- Fire management, either fire suppression (USFS 1999), which has resulted in succession of vegetation communities, or overuse of fire, both of which have lead to loss of shrubsteppe.
- Much of the low-elevation shrubsteppe vegetation is currently dominated by cheatgrass and other nonnative plants (USFS 1999). Invasion and seeding of crested wheatgrass and other introduced plant species reduces wildlife habitat quality and/or availability.

Shrubsteppe Community

4.4.1 Mule Deer

Mule deer were selected to represent species that require and prefer diverse, dense (30 to 60% shrub cover less than 5 ft. tall) shrubsteppe habitats comprised of bitterbrush, big sagebrush, rabbitbrush, and other shrub species with a palatable herbaceous understory exceeding 30% cover.

4.4.2 Brewer’s Sparrow

Brewer’s sparrow was selected to represent wildlife species that require sagebrush dominated sites. Brewer’s sparrow prefers a patchy distribution of sagebrush clumps, 10-30% cover, lower sagebrush height (between 20 and 28 in.), 1981), 10 to 20% native grass cover, less than 10% non-native herbaceous cover, and bare ground greater than 20%. It should be noted, however, that shrublands comprised of snowberry, hawthorne, chokecherry, serviceberry, bitterbrush, and rabbitbrush were also used by Brewer’s sparrows for nesting in southeast Washington. Specific, quantifiable habitat attribute information for this mixed shrub landscape could not be found.

4.4.3 Sharp-tailed Grouse

Sharp-tailed grouse was selected to represent species that require multi-structured fruit/bud/catkin producing deciduous trees and shrubs dispersed throughout the landscape (10 to 40% of the total area). Other habitat conditions include:

- Native bunchgrass greater than 40% cover
- Native forbs at least 30% cover
- Visual obstruction readings (VOR) at least 6 in. least 75% cover deciduous shrubs and trees
- Exotic vegetation/noxious weeds less than 5% cover
- Shrubsteppe habitat with native bunch grasses

4.4.4 Grasshopper Sparrow

Grasshopper sparrow was selected to represent species that require healthy steppe habitat dominated by native bunch grasses. Grasshopper sparrow require native bunchgrass cover greater than 15% and comprising greater than 60% of the total grass cover

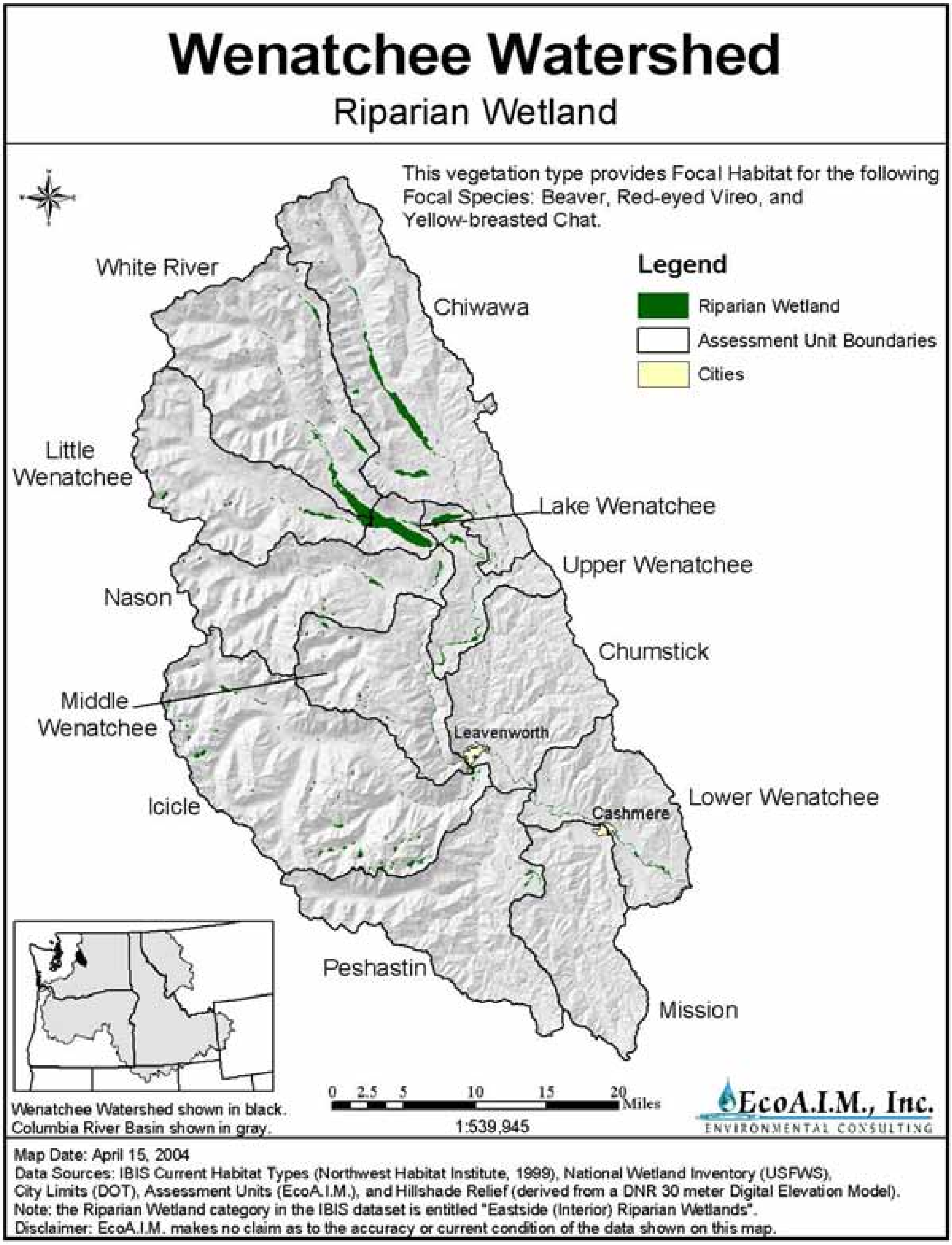

Figure 4. Riparian composition in the Wenatchee subbasin

4.5 Eastside (Interior) Riparian Wetlands

The eastside (interior) riparian wetlands habitat type refers only to riverine and adjacent wetland habitats in both the ecoprovince and individual subbasins. Historic (c.1850) and, to a lesser degree, current data concerning the extent and distribution of riparian wetland habitat are a significant data gap at both the ecoprovince and subbasin level. The lack of data is a major challenge as ecoprovince and subbasin planners attempt to quantify habitat changes from historic conditions and develop strategies that address limiting factors and management goals and objectives.

Due to the lack of historic riparian wetland data, the IBIS database cannot be relied upon for comparisons in the ecoprovince and individual subbasins between the historic and current extent of riparian wetlands. Riparian wetland habitat is being lost because of lack of permanent protection, and this habitat continues to be at risk.

Historically, riparian wetland habitat was characterized by a mosaic of plant communities occurring at irregular intervals along streams and dominated singularly or in some combination by grass-forbs, shrub thickets, and mature forests with tall deciduous trees. Beaver activity and natural flooding are two ecological processes that affected the quality and distribution of riparian wetlands.

Historically, riparian-stream habitat was higher than what currently exists (USFS 1999b). Construction of roads, fields and houses along the Wenatchee River has decreased the effectiveness and amount of riparian habitat. The change in extent of the riparian wetland habitat type from c.1850 to 1999 is not included because of inaccurate IBIS (2003) data and geographic information system (GIS) products. The current acreage, however, which consists of 32,050 acres of riparian habitat and 1,468 acres of wetlands, are believed to be similar to historic (USFS 1999b).

Protection Status

The vast majority of province riparian habitat is designated low or no protection status and is at risk for further degradation and/or conversion to other uses.

Factors Affecting Eastside (Interior) Riparian Wetland Habitat

- Loss of habitat due to numerous factors including riverine recreational developments, inundation from impoundments, cutting and spraying of riparian vegetation for eased access to water courses, gravel mining, etc.
- Habitat alteration from 1) hydrological diversions and control of natural flooding regimes (e.g., dams) resulting in reduced stream flows and reduction of overall area of riparian habitat, loss of vertical stratification in riparian vegetation, and lack of recruitment of young cottonwoods, ash, willows, etc., and 2) stream bank stabilization which narrows stream channel, reduces the flood zone, and reduces extent of riparian vegetation
- Habitat degradation from conversion of native riparian shrub and herbaceous vegetation to invasive exotics such as reed canary grass, purple loosestrife, perennial pepperweed, salt cedar, and indigo bush
- Fragmentation and loss of large tracts necessary for area-sensitive species

- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance
- High energetic costs associated with high rates of competitive interactions with European starlings for cavities may reduce reproductive success of cavity-nesting species such as Lewis' woodpecker, downy woodpecker, and tree s wallow, even when outcome of the competition is successful for these species
- Recreational disturbances (e.g., ORVs), particularly during nesting season, and particularly in high-use recreation areas

Riparian Community

4.5.1 Red-eyed Vireo

Red-eyed vireo was selected to represent species that require greater than 60% canopy closure. For their food and reproductive requirements red-eyed vireo require mature deciduous trees greater than 160 ft. tall. Greater than 10% of the shrub layer should be young cottonwoods.

4.5.2 American Beaver

Beaver were selected to represent species that require 40-60% tree/shrub canopy closure and shrub height greater than 6.6 ft. Beavers also require trees less than 6 in. DBH.

4.5.3 Yellow-breasted Chat

Yellow-breasted chat were selected to represent species that require riparian habitat with a dense shrub layer 3-13 ft. tall, 30-80% shrub cover, scattered herbaceous openings, and less than 20% tree cover.

4.6 Agriculture

Agricultural habitat varies substantially in composition among the cover types it includes. Cultivated cropland includes at least 50 species of annual and perennial plants, and hundreds of varieties ranging from vegetables such as carrots, onions, and peas to annual grains such as wheat, oats, barley, and rye. Row crops of vegetables and herbs are characterized by bare soil, plants, and plant debris along bottomland areas of streams and rivers and areas having sufficient water for irrigation. Annual grains, such as barley, oats, and wheat are typically produced in almost continuous stands of vegetation on upland and rolling hill terrain without irrigation.

Improved pastures are used to produce perennial herbaceous plants for grass seed and hay. Alfalfa and several species of fescue and bluegrass, orchardgrass (*Dactylis glomerata*), and timothy (*Phleum pratensis*) are commonly seeded in improved pastures. Grass seed fields are single-species stands, whereas pastures maintained for haying are typically composed of several species.

The improved pasture cover type is one of the most common agricultural uses in and is produced with and without irrigation. Unimproved pastures are predominantly grassland sites often abandoned fields that have little or no active management such as irrigation, fertilization, or herbicide applications. These sites may or may not be grazed by livestock. Unimproved pastures include rangelands planted to exotic grasses that are found on private land, state wildlife areas, federal wildlife refuges, and CRP sites. Grasses commonly planted on CRP sites include crested wheatgrass (*Agropyron cristatum*), tall fescue (*F. arundinacea*), perennial bromes (*Bromus* spp.), and wheatgrasses.

Intensively grazed rangelands have been seeded to intermediate wheatgrass (*Elytrigia intermedia*), crested wheatgrass to boost forage production, or are dominated by increaser exotics such as Kentucky wheatgrass or tall oatgrass (*Arrhenatherum elatius*). Other unimproved pastures have been cleared and intensively farmed in the past, but are allowed to convert to other vegetation. These sites may be composed of uncut hay, litter from previous seasons, standing dead grass and herbaceous material, invasive exotic plants including tansy ragwort (*Senecio jacobea*), thistle (*Cirsium* spp.), Himalaya blackberry (*Rubus discolor*), and Scot’s broom (*Cytisus scoparius*) with patches of native black hawthorn, snowberry, spirea (*Spirea* spp.), poison oak (*Toxicodendron diversilobum*), and various tree species, depending on seed source and environment.

Because agriculture is not a focal wildlife habitat type and there is little opportunity to effect change in agricultural land use at the landscape scale, ecoprovince and subbasin planners did not conduct a full-scale analysis of agricultural conditions. However, agricultural lands converted to CRP can significantly contribute to ward benefits to wildlife habitat and other species that utilize agricultural lands.

4.7 Summary of Factors Affecting Focal Habitats and Wildlife Species

Several factors have altered the historic vegetation of much of the subbasin and thus, to varying degrees, the species that occupy it. These factors include timber management, road development, fire, mining, and recreation associated disturbance.

Timber Management

Timber management activities, including extensive timber harvest in sections of the Wenatchee subbasin, have resulted in the wide-scale removal of large ponderosa pine trees and subsequently reduced populations of dependant species, as well as snag dependent species in some areas. Past timber harvest has created early to mid successional stand stages that affect forest-story function in the upper and lower layers, reduced forest interior habitat, created homogenous stands, and impacted the effectiveness of riparian functions in the subbasin. Early to mid successional stages across the landscape provide for homogenous stand structures that provide potential for increased pathogen and insect infestation. Logging has contributed to fragmentation of habitat, soil erosion, sediment delivery to creeks and streams, and changes to upland and riparian vegetative communities, including displacement of native plant communities with exotic species.

Grazing

In 1999, there was only one active grazing allotment in the subbasin, the Eagle/Blagg allotment. Problems identified with this allotment include high levels of erosion, noxious weeds, and conflict with bighorn sheep because of possible transmission of the disease Pasturella from domestic sheep to bighorns. Pasturella in bighorn sheep causes pneumonia and often proves fatal.

Road Development

The over-all road density in the subbasin is high in zones of human influence and riparian areas. Roads and motorized trails have significantly altered habitat for many species, particularly for the grizzly bear, gray wolf, mule deer, elk and lynx. Species proximity to roads and trails also impacts their behavior.

Fire

Fire is the dominant agent of change in this subbasin. Management attempts to influence ecosystem processes such as fire have had widespread and significant effects on the condition of wildlife habitat throughout the area, resulting in decreased habitat for some species and increased habitat for others. Fire suppression has created unnatural vegetation patterns. Forested stand conditions on north/northeast facing slopes have a higher number of smaller (pole-sized) stems per acre of Douglas-fir, lodgepole pine and *ceanothus*, causing the canopy to be more closed than would naturally have occurred. Fire suppression has lead to an increase in tree density in some areas as well as increased abundance of more shade tolerant trees such as grand fir (Andonaegui 2001).

Mining

Mining currently is a minor activity in the subbasin; however, patented mining claims exist in private inholdings throughout the subbasin.

4.8 Aquatic/Fish Assessment

4.8.1 Fish Focal Species and Representative Habitats

Eight fish focal species were selected. Four species of anadromous salmonids; spring chinook and late-run chinook *(Oncorhynchus tshawytscha)*, sockeye *(Oncorhynchus nerka)*, and summer steelhead *(Oncorhynchus mykiss)* are present in the Wenatchee subbasin. Coho stocks (*Oncorhynchus kisutch*), historically abundant in the subbasin, became extripated in the early 1900's and have since been reintroduced through ongoing efforts by the Yakama Nation. Natural reproduction is occurring in the Wenatchee basin. Pacific lamprey *(Lampetera tridentate)*, also an anadromous species, is present in the Wenatchee subbasin, but very little information about this culturally and ecologically important species is available. Of the other resident fish that also occur throughout the subbasin, bull trout *(Salvelinus confluentus)*, which is present in fluvial, adfluvial and resident life history forms and Westslope Cutthroat trout *(Oncorhynchus clarkia)* were selected.

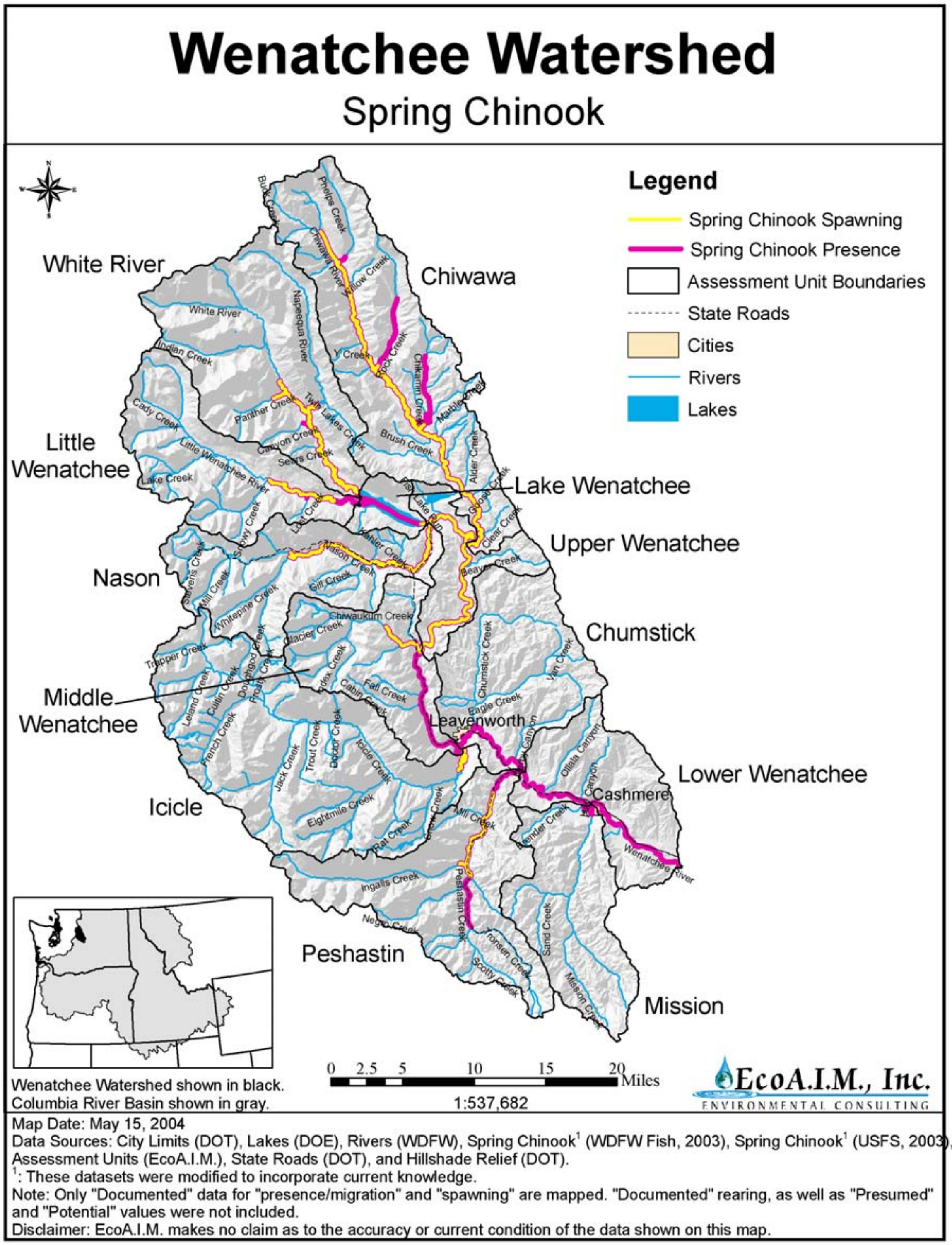

Figure 5. Spring chinook distribution in the Wenatchee subbasin

4.8.2 Spring Chinook (*Oncorhynchus tshawytscha*)

Rationale for Selection

Spring chinook salmon (stream type) are considered depressed throughout most of their current range and many stocks are at danger of extinction. All remaining populations and habitats are considered to be vital to the continued persistence of chinook salmon in the interior Columbia basin

The Wenatchee spring chinook is included by NOAA Fisheries into the upper Columbia ESU and are listed as endangered under the ESA. Spring chinook salmon utilize much of Wenatchee subbasin and are sensitive to many environmental conditions and changes. Spring chinook provide a good biological indicator of ecosystem health for the lower reaches of many tributaries of the Wenatchee River.

Key Life History Strategies: Relationship to Habitat

Time of entry and spawning

Adult spring chinook begin entering the Wenatchee River basin in May. Spawning begins in very late July through September, peaking in mid to late August (Chapman et al. 1995 CPa). The onset of spawning in a stream reach is temperature driven (usually when temperatures drop below 60.8°F). Temperature can be influenced by riparian conditions.

Prespawning

Adults hold in the deeper pools and under cover of the mainstem Wenatchee or natal tributaries. The availability and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Healy (1991) reports the range of depths of spawning as between approximately 1-23 ft. and velocities of between approximately 0.33-5 ft/s) for chinook salmon (this includes ocean-type chinook too). Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Healy (1991) reports that incubation and emergence success was related to oxygen levels and percolation through the gravel. When percolation was 0.001 ft/s, survival to hatching was 97%. However, emergence reduced to 13% when percolation was 0.002 ft/s. When oxygen fell below 13 parts per million (ppm), mortality of eggs increased from 3.9% at 13 ppm to about 38% at 5 ppm.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel increasing sediment deposition that can reduce oxygen and percolation through the redd. Healy states that siltation may be more lethal earlier in the incubation period than in later phases. Overall, Healy reports that egg survival from spawning to emergence ranged from 40-100% (these estimates include ocean-type chinook too) (Peven 2003).

In the Wenatchee subbasin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the subbasin, and conditions have improved in most watersheds. However, Nason Creek because of its location near a railroad and major high way has long term restoration needs that could most likely increase incubation success, although empirical information is needed to determine if this is a need first.

Fry

Spring chinook fry utilize near-shore areas, primarily eddies, within and behind large woody debris, undercut tree roots, or other cover (Hillman et al. 1989a; Healy 1991). Conservation and restoration of riparian areas of natal streams within the Wenatchee subbasin would increase the type of habitat that fry utilize.

Parr

Downstream movement of parr from natal streams is well documented. French and Wahle (1959) found that juvenile chinook migrated past Tumwater Dam on the Wenatchee River (RM 33) from spring through late fall. Since 1992, sampling by WDFW has found spring chinook emigrating from the Chiwawa River as pre-smolts from late summer through the fall. In general, movement from the Chiwawa River included some yearlings leaving as early as March, extending through May, followed by subyearlings leaving through the summer and fall (until trapping ceases because of inclement weather (Peven 2003).

Movement of juvenile chinook from the higher-order streams in the fall appears to be a response to the harsh conditions encountered in the upper tributaries. Bjornn (1971) related subyearling chinook movement in an Idaho stream indirectly to declining temperature in the stream as fish try to find suitable overwintering habitat. Hillman and Chapman (1989a) suggested that biotic factors, such as intraspecific interaction for available habitat with naturally- and hatchery-produced chinook, nocturnal sculpin predation, and interspecific interactions may accelerate movement of subyearlings from the mainstem Wenatchee River and into the Columbia River. This may or may not be true of the higher order streams that feed the upper reaches of the Wenatchee River, which produce most of the spring chinook in that basin. Hillman et al. (1989a) related subyearling chinook movement from an Idaho stream to declining temperatures, but acknowledged that it may consist of fish seeking higher-quality winter habitat, as suggested by Bjornn (Peven 2003).

Hillman and Chapman (1989a) found that Tumwater Canyon is where most fish rear over the winter before their smolt migration begins in the spring. During the daytime, juvenile chinook used instream and overhead cover extensively, although as they got larger (and stream flows reduced), they sought areas that were deeper and higher velocity (Hillman et al. 1989 CPa). Substrate preference also changed as the juvenile chinook got larger and hydraulic conditions changed from predominantly sand, large boulder, and bedrock to sand, sand-gravel, and cobble. As temperatures dropped below 50°F, salmon were observed primarily near boulder rip-rap, or concealed themselves in the substrate.

During night time hours during the warmer months, chinook moved inshore and rested all night in shallow, quiet water. In the colder months, chinook sought deeper water with larger substrate.

Conservation of high functioning habitat in natal tributaries and Tumwater Canyon, restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Wenatchee River spring chinook smolts begin migrating in March from natal areas. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated. If areas are shown to unnaturally impede migration or injure or kill fish, then they should be fixed.

Population Characterization

Distribution

Historic

Mullan (1987) felt that because of the geology of the region upstream of the current Grand Coulee Dam site, that spring chinook were not very abundant, with the possible exceptions of the San Poil and Spokane River basins. Fulton (1968) described the historic distribution of spring chinook in the Wenatchee River. He relied heavily on the fieldwork of French and Wahle (1965) for his information on distribution. He combines descriptions of spring chinook distributions in the Wenatchee subbasin as: most of main river; portions of Chiwawa, Little Wenatchee, and White rivers; and Nason, Icicle, and Peshastin creeks (Peven 2003).

Current

Spring chinook currently spawn and rear in the upper main Wenatchee River upstream from the mouth of the Chiwawa River, overlapping with summer chinook in that area (Peven 1994). The primary spawning grounds of spring chinook in the Wenatchee River, in order of importance, are: Chiwawa River, Nason Creek, Little Wenatchee, and White River (Icicle River is not included because it is believed that most of the spawning population from this stream consist of adult returns to the Leavenworth NFH (Peven 2003)). Also see Figure 6.

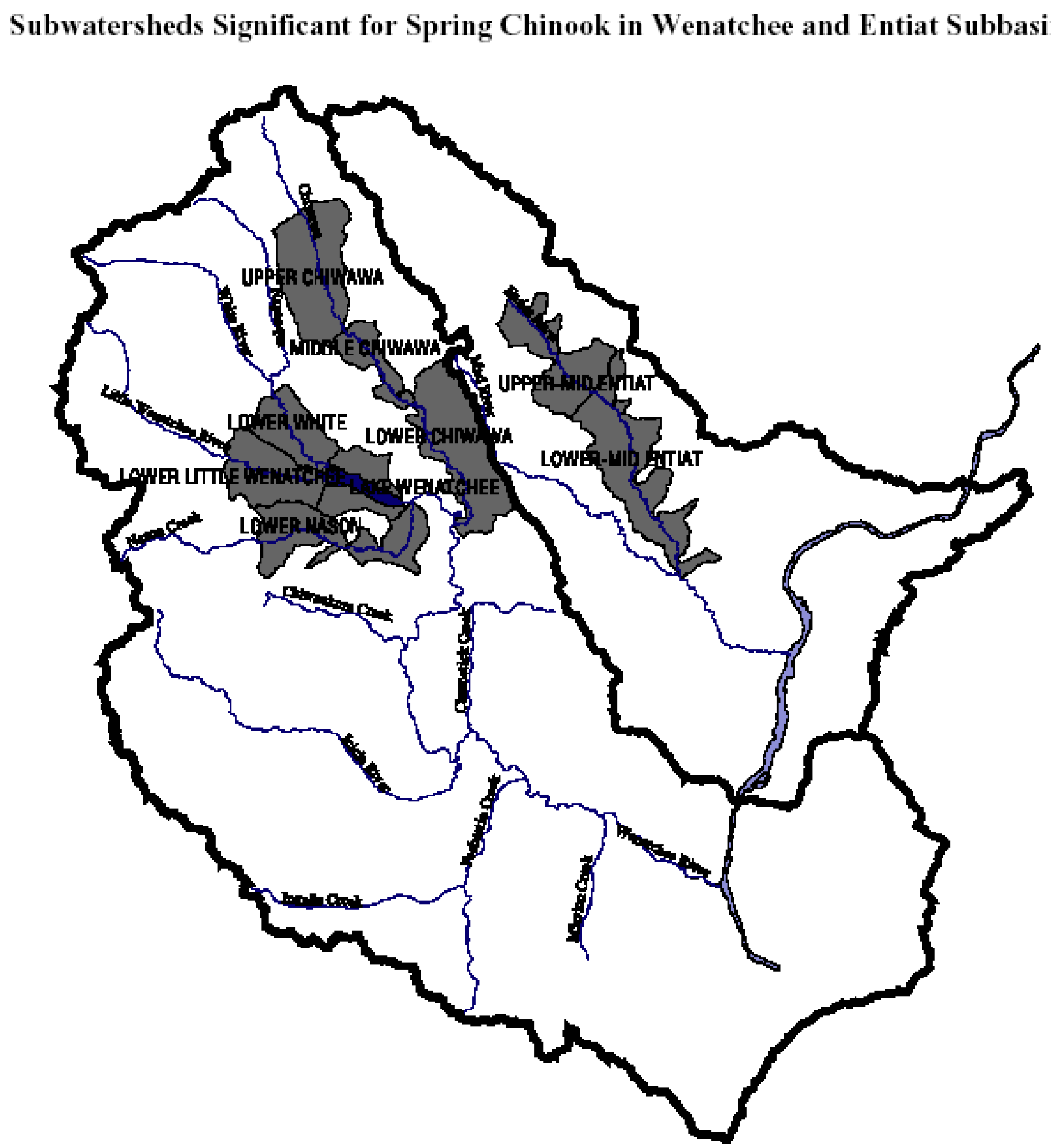

Figure 6. Significant spring chinook watersheds in Wenatchee and Entiat subbasins (RTT 2004)

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 588,000 spring chinook was the best estimate of predevelopment run sizes. Spring chinook were relatively abundant in upper Columbia River tributary streams prior to the extensive resource exploitation in the 1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, unscreened irrigation intakes, poor logging and mining practices, overgrazing (Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of upper Columbia basin salmonids (Peven 2003).

Spring chinook counting at Rock Island Dam began in 1935. Numbers (adults and jacks) in the period 1935-39 averaged just over 2,000 fish. Average counts fluctuated on a decadal average from the 1940s to 1990s from just over 3,200 (1940s) to over 14,400 (1980s), with recent counts (2000-2002) averaging almost 29,000. The long term average of spring chinook passing Rock Island Dam is just over 8,900.

Current

In the Wenatchee River, redds counts have fluctuated widely since 1958, the earliest date for which systematic data were available. Spring chinook redd counts averaged 637, 564, and 621 every ten years between 1958 and 1990. In the 1990s, the average dropped to 232, but has increased to over 1,100 since 2000. The long term average is 560 over the period 1958-2002.

Ford et al. (2001) recommended an interim recovery level for spring chinook of the Wenatchee River at an eight-year geometric mean of 3,750 natural spawners per year. LaVoy (1994) estimated the average number of fish per redd as 2.2. Applying that expansion to the estimated (unadjusted for harvest prior to the 1970s) redd counts, escapement has ranged between 70 to over 4,100, with a long term average of over 1,200 (Peven 2003).

Productivity

Historic

Historic production of spring chinook is difficult to determine, although it was most likely not as high as sockeye or late-run chinook. While it is known that in some years, there was drastic failure of certain year classes (primarily due to ocean conditions; see Mullan et al. 1992), it is assumed that historic production of salmon was high, especially for late-run chinook and sockeye (Pevan 2003).

Current

Current productivity is affected by loss or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Mullan et al. (1992) postulated that current production may not be greatly different than historic for spring chinook. Caveats to this postulate are that native coho are extinct, production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced (e.g., over 80% in the lower Columbia River in the late 1930s and early 1940s). However, recent estimates of natural replacement rates for spring chinook suggest that they are not replacing themselves in most years until the broods of the late 1990s (Peven 2003).

There are still habitat areas in need of restoration (e.g., Peshastin and Mission creeks) within the Wenatchee subbasin. By increasing known areas in need of restoration, it is reasonable to assume that production of spring chinook would increase.

Diversity

Because some areas within the Wenatchee subbasin are in need of habitat improvements, diversity within the subbasin is believed to be lower than historic. While the Wenatchee population is still believed to be an *independent population* increased habitat would most likely increase spatial and life history diversity.

Currently, genetic sampling suggests that the White River subpopulation may be distinct from other subpopulations within the subbasin (Appendix A).

Table 15. Summary of spring chinook population characterization

	Distribution	**Abundance**	**Productivity**	**Diversity**
Historic	High	Moderate-High	Moderate	High
Current	Moderate-High	Low-Moderate	Low-Moderate	Moderate

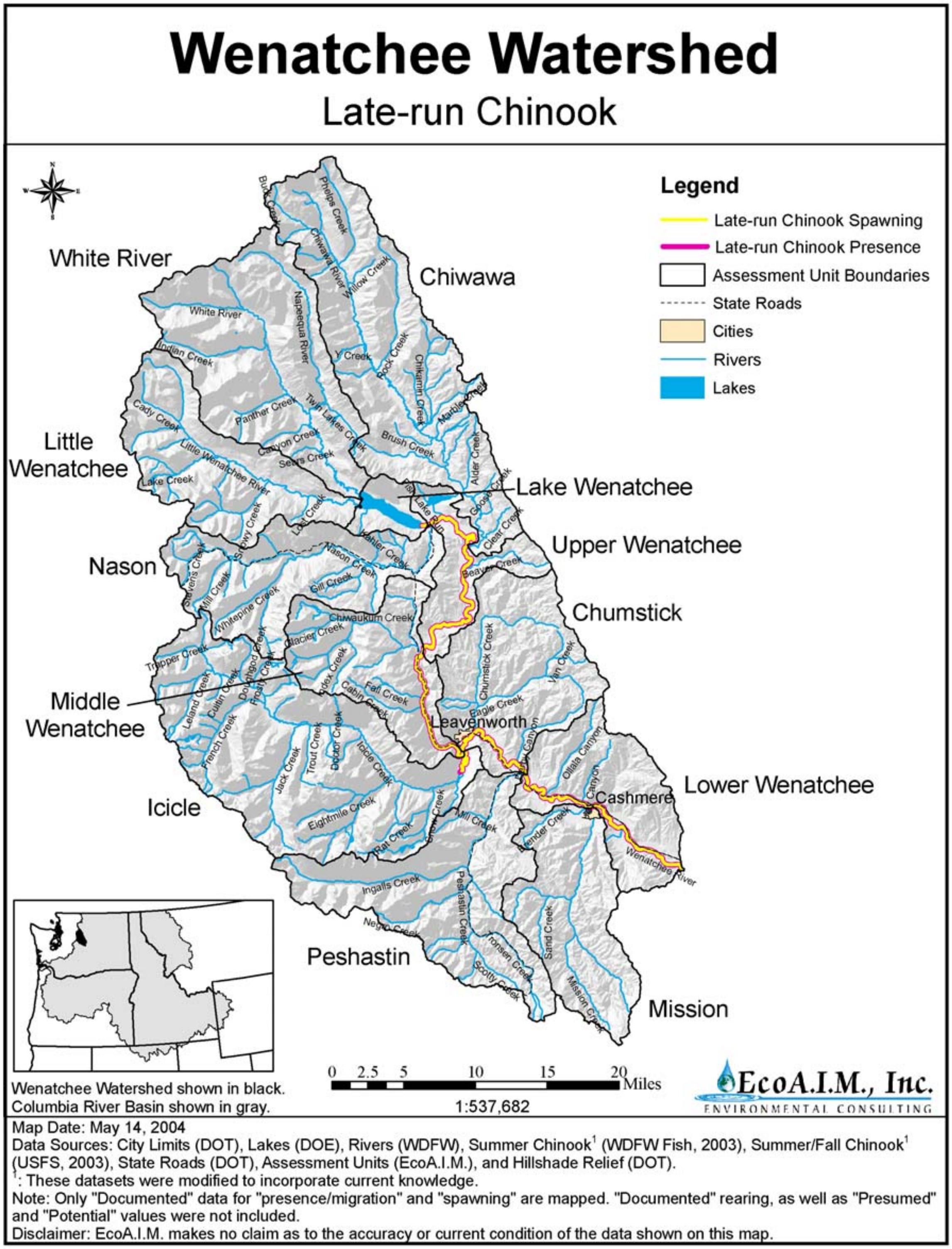

Figure 7. Late-run chinook distribution in the Wenatchee subbasin

4.8.3 Late-run Chinook (*Oncorhynchus tshawytscha*)

Rationale for Selection

NOAA Fisheries determined that the Wenatchee, Entiat, Methow and Okanogan late-run chinook are part of a larger population that includes late-run chinook in the upper Columbia (Chapman et al. 1994a). Late-run chinook provide a good biological indicator of ecosystem health to the mainstem Wenatchee River.

Key Life History Strategies: Relationship to Habitat

Time of entry and spawning

Adult late-run chinook begin entering the Wenatchee subbasin in June. Spawning begins in very late September through mid November, peaking in mid to late October. The onset of spawning in a stream reach is temperature driven (usually when temperatures drop below 60.8 °F). Temperatures in the mainstem Wenatchee are influenced by climate, Lake Wenatchee, and tributary flows.

Prespawning

Adults hold in the deeper pools and under cover of the mainstem Wenatchee. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase or maintain the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Healy (1991) reports the range of depths of spawning as between approximately 1-23 ft. and velocities of between 0.33-5 ft/s for chinook salmon (this includes spring chinook). Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Healy (1991) reports that incubation and emergence success was related to oxygen levels and percolation through the gravel. When percolation was 0.001 ft/s, survival to hatching was 97%. However, emergence reduced to 13% when percolation was 0.002 ft/s. When oxygen fell below 13 ppm, mortality of eggs increased from 3.9% at 13 ppm to about 38% at 5 ppm.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases. Overall, Healy (1991) reports that spawning to emergence ranged from 40-100% (these estimates include spring chinook) (Peven 2003).

In the Wenatchee subbasin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the subbasin, and conditions have improved in most watersheds. Because of naturally occurring conditions and major events like fire, Peshastin, Mission, and Icicle creeks have had heavy sediment load events in the last 10-15 years. Most of the spawning area for Wenatchee late-run chinook occurs upstream of these tributaries.

Fry

Fry emerge mostly in April and May. Most subyearling late-run chinook leave the Wenatchee River within a few weeks after emergence. Beak (1980) found that weekly catches of chinook salmon fry declined sharply from over 700 in early June to about 25 in early July, then to zero by early August. This decline comports well with the observations of Hillman and Chapman (1989). Hillman and Chapman (1989) also demonstrated that the rate of emigration of subyearling chinook was highest in June, and then declined through the summer (Peven 2003).

Late-run chinook fry utilize near-shore areas, primarily eddies, within and behind large woody debris, undercut tree roots, or other cover (Hillman et al. 1989a; Healy 1991). They noted that in the spring this type of habitat was scarce in the Wenatchee River, but where it did occur, it was fully occupied. Conservation and restoration of riparian areas and increases in off-channel habitat in the lower Wenatchee subbasin may increase the type of habitat that late-run chinook fry utilize, although they may still emigrate through the system without utilizing these habitats (Peven 2003).

Population Characterization

Distribution

Historic

Late-run chinook historically used the mainstem of the Wenatchee River, from its mouth to Lake Wenatchee (Peven 2003).

Tumwater Dam (RM 32.7) and Dryden Dam (RM 17.6) on the Wenatchee River were partial obstacles to upstream passage of adults before 1957. Between 1957 and 1986, some observers considered fish passage facilities inadequate and new facilities were constructed in the late 1980s. Mullan et al. (1992) were skeptical that the dams were serious obstacles before the fish ways were improved (Peven 2003).

Current

Late-run chinook salmon currently spawn in the Wenatchee River between RM 1.0 and Lake Wenatchee (RM 54). Within that area the distribution of redds of late-run chinook has changed. Peven (1992) notes that, since the early 1960s, numbers of redds have decreased downstream from Dryden Dam (RM 17.5), while they have increased upstream from Tumwater Dam (RM 32.7). On a smaller scale, Peven (1992) reports that, since at least 1975, densities of redds (i.e., redds/mile) were highest near Leavenworth (RM 23.9-26.4) and in Tumwater Canyon (RM 26.4-35.6). Also see Figure 8.

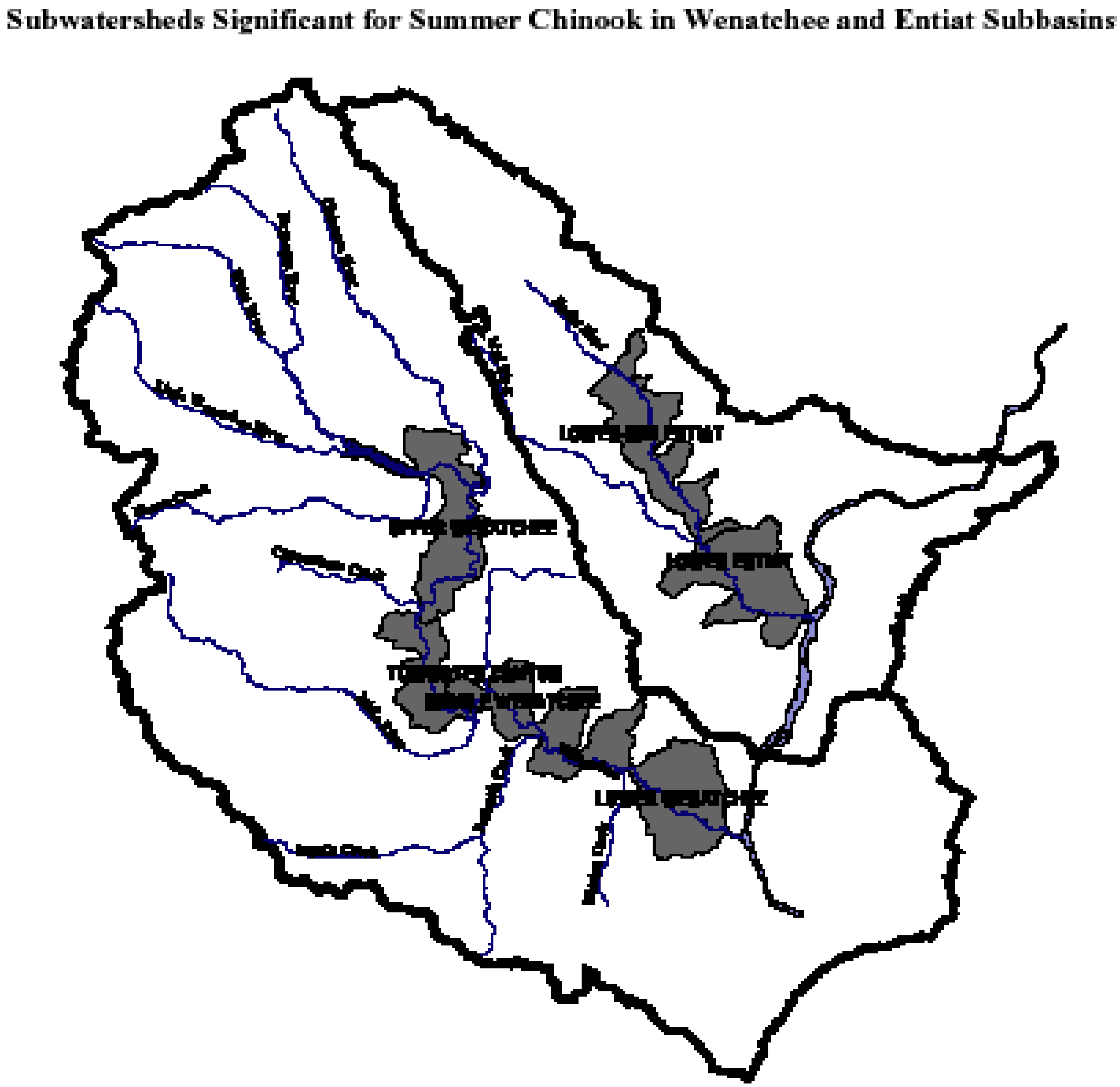

Figure 8. Significant summer chinook watersheds in Wenatchee and Entiat subbasins (RTT 2004)

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 3.7 million summer chinook, (for the entire Columbia Basin) was the best estimate of predevelopment run sizes. Late-run chinook were very abundant in upper Columbia River and tributary streams prior to the extensive resource exploitation in the 1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Peven 2003; Mullan et al. 1992).

The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, unscreened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of upper Columbia basin salmonids (Peven 2003).

Historically, the late spring and summer components of the Columbia River chinook populations were the most abundant and heavily fished (Thompson 1951, Van Hyning 1968, Chapman 1986). Overfishing in the lower Columbia River rapidly depressed summer-run chinook. Spawning and rearing habitat extirpation and destruction accelerated the decline (Peven 2003).

Decadal averages of late-run chinook escapements at Rock Island Dam from 1933 through 2002 show a rising trend. Harvest rates in the 1930s and 1940s were very high in the lower river fisheries, and no doubt had a large impact on the escapement at Rock Island (Mullan 1987). In 1951, when harvest rates in zones 1-6 (lower Columbia River) were reduced, numbers increased dramatically. Between the 1930s (starting in 1933) and 1960s (excluding 1968 and 1969). (There were no counts at Rock Island Dam between 1968 and 1972.) total (adults and jacks) decadal average numbers of late-run chinook rose from just over 7,000 to almost 28,000. Numbers remained high in the 1970s until the mid 1980s, when they declined through the 1990s and have shown a sharp increase in the 2000s (Peven 2003).

In the 1960s, dam counts became available at Rocky Reach Dam (1962) and Wells Dam (1967). These project counts of total late-run chinook show a different trend than Rock Island, which suggests the difference being the fish that spawn in the Wenatchee River were heavily affecting the trend at Rock Island Dam.

Current

Between the mid 1980s and through the 1990s, late-run chinook total numbers declined at Rock Island, Rocky Reach, and Wells dams. The magnitude of the decline increased the further upstream the counts were. This suggests that the run into the Wenatchee River remained high or increased, while runs ascending upstream of Rocky Reach, and Wells did not. The run of late-run chinook into the Wenatchee River has continued to increase since redd counts began in 1960.

The escapement into the Wenatchee River appears to be still primarily composed of naturally produced fish based on carcass sampling. The Eastbank Hatchery program releases fish in the lower Wenatchee River (near Dryden), primarily for the purpose of reseeding the lower river habitat.

Productivity

Historic

Historic production of late-run chinook is difficult to determine, it was thought to be very high. While it is known that in some years, there was drastic failure of certain year classes (primarily due to ocean conditions; see Mullan et al. 1992), it is assumed that historic production of late-run chinook was higher than current.

Current

Current productivity is affected by loss or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Mullan et al. (1992) postulated that current production may not be greatly different than historic for late-run chinook. Caveats to this postulate are that production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced (Peven 2003).

While spawning habitat does not appear to be limiting late-run chinook in the Wenatchee subbasin, potential changes to geofluvial processes may effect immediate rearing (or refuge) areas in the lower river. It is unknown what affect this has on production.

Diversity

Because some areas within the Wenatchee subbasin are in need of habitat improvements, diversity within the basin may be lower than historic. While the Wenatchee population is still believed to be an independent population increased habitat would most likely increase life history diversity.

Currently, genetic sampling has not found any differences among late-run chinook within the basin.

Table 16. Summary of late-run chinook population characterization

	Distribution	Abundance	Productivity	Diversity
Historic	Moderate	Very high	Very high	High
Current	Moderate	Moderate-High	High	Moderate-High

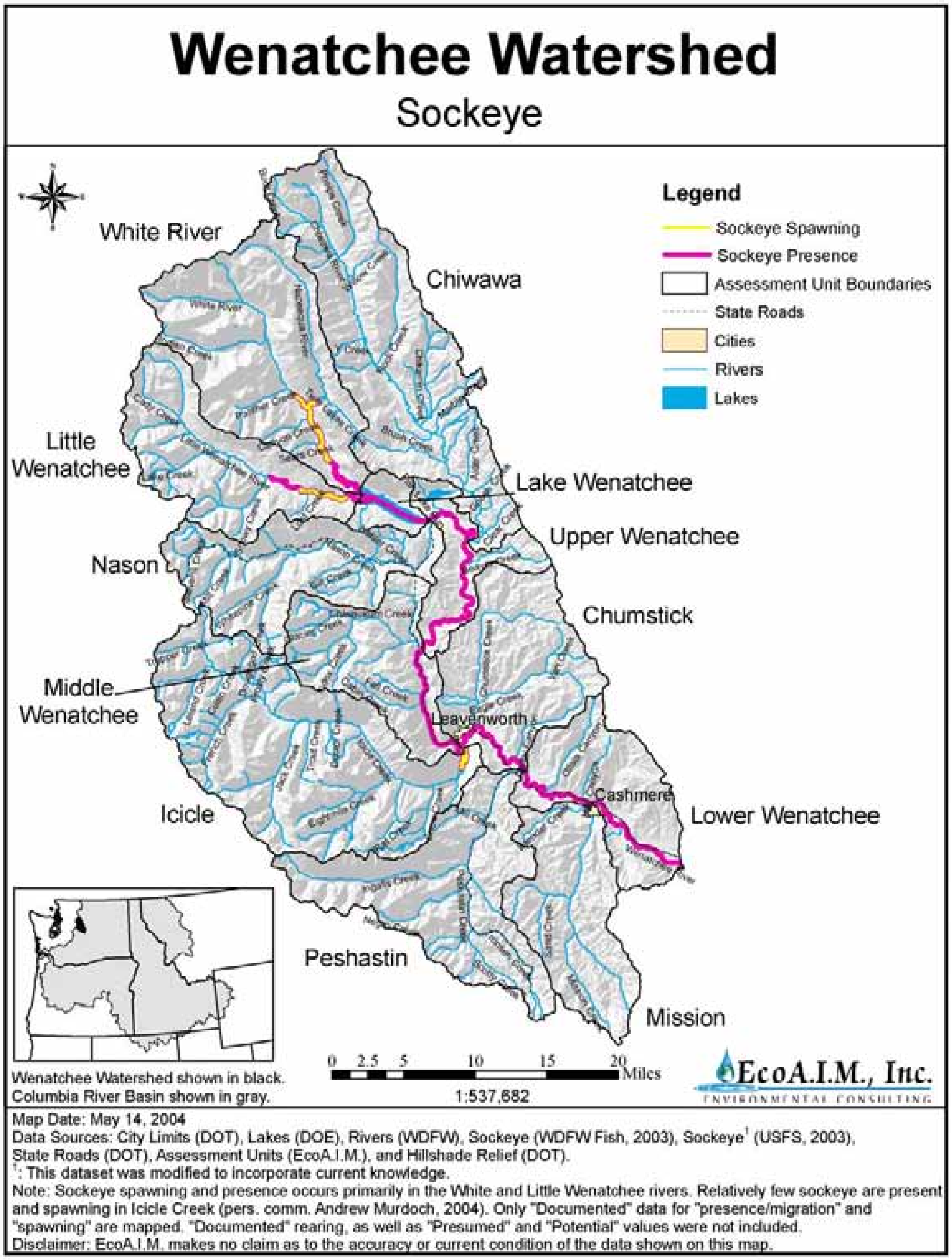

Figure 9. Sockeye distribution in the Wenatchee subbasin

4.8.4 Sockeye (*Oncorhynchus nerka*)

Rationale for Selection

The Wenatchee River supports one of only two remaining viable sockeye populations within the Columbia River, making the population of high local and regional interest. The primary spawning occurs in both White and Little Wenatchee rives, and rearing occurs primarily in Lake Wenatchee (Figure 9). Sockeye provide a good biological indicator of the ecosystem health for these spawning and rearing areas.

Key Life History Strategies: Relationship to Habitat

Time of entry and spawning

Adult sockeye begin entering the Wenatchee River basin in late June. Spawning takes place in September. The onset of spawning in a stream reach is temperature driven. Temperature may be influenced by riparian conditions. Conserving riparian areas in the White and Little Wenatchee rivers will help ensure that critical remaining spawning habitat stays intact.

Prespawning

Adults may hold in the deeper pools and under cover of the mainstem Wenatchee until arriving in Lake Wenatchee, where they hold prior to spawning. The availability of and number of deep pools and cover may be important to offset potential prespawning mortality, but most holding occurs in the lake. Preservation of the lake environment that ensures stratification (they appear to hold below the thermocline) is required at this stage.

Redd characteristics

Habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Depth of water does not seem to be critical for sockeye spawning (Chapman et al. 1995b). Sockeye appear to choose lower water velocity to spawn compared to other salmonids (Wydoski and Whitney 2003). Allen and Meekin (1980) found velocities over spawning areas ranging from 0.56 to 3.34 feet per second (fps), and average 1.52 fps. Conservation of remaining naturally geofluvial processes in the White and Little Wenatchee rivers, and restoration of areas that may have been affected by previous land use activities, will ensure quality spawning habitat remains (Peven 2003).

Incubation and emergence

Egg incubation usually lasts between 50-140 days, which is primarily dependent on temperature (in Chapman et al. 1995b). Emergence of sockeye occurs in the Wenatchee subbasin in March through April (Peven 2003).

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) states that siltation may be more lethal earlier in the incubation period than in later phases. Chapman et al. (1995b) compiled information for sockeye throughout their range for various life stage survivals. Incubation survival generally ranged from 25-60%, although some measurements were at both extremes (0%; 100%). Allen and Meekin reported that incubation survival for Wenatchee sockeye was 0-

100%. Egg to fry survival ranged below 10% to slightly less than 50% for sockeye throughout their range (Peven 2003).

In the Wenatchee subbasin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds. Conservation of existing conditions (e.g., riparian, old growth forest, etc.) within the upper watersheds of the Little Wenatchee and White rivers will help ensure that floods will have less impact.

Fry

After fry emerge (primarily at night), they begin their movement towards Lake Wenatchee (Chapman et al. 1995 CPb). During daylight hours, fry hide under stones and within debris, and they begin moving again at dawn. Because of the relatively short distance that fry would have to migrate to Lake Wenatchee, it is reasonable to assume that they can reach the lake within one night under most conditions. Fry appear to arrive in Lake Wenatchee between March and May.

After fry enter a lake, they may either move immediately offshore, or remain in limnetic areas to rear until zooplankton production increases offshore (Chapman et al. 1995b). In Lake Wenatchee, Chapman et al. (1995b) reported that Allen and Meekin (1980) did not find fry in near-shore areas during their surveys in the 1970s, but felt that it was reasonable to assume that this behavior occurred because of the conditions fry encounter when they enter the lake (Peven 2003).

Since fry enter Lake Wenatchee at its western shore, where there is currently minimal development, conserving this area as potential sockeye rearing habitat may help overall sockeye production. Other near-shore habitat has been and is currently affected by land use activities. However, most of the other shoreline habitats do not have large limnetic areas because of a sharp drop off to deeper waters, so restoration of these areas may not increase production to a great degree, although there may still be certain areas (primarily along the north shore) that would benefit from restoration factors.

Parr

Sockeye juveniles have complex daily vertical migration patterns to balance risk of being preyed upon to finding food. Chapman et al. (1995b) cite Brett (1980) who concluded that the vertical migration doesn't begin until the nursery lake stratifies. In general, juveniles seek cold, dark water (below the thermocline) in the day, rise towards the surface at dusk, feed, and then hold below the surface waiting for dawn when they feed again before migrating down again (Burgner 1991; Chapman et al. 1995b). Chapman et al. (1995b) noted that Lake Wenatchee does not typically develop a strong thermocline, and temperatures and dissolved oxygen conditions allow sockeye to use all depths throughout all photic regions within the lake (Peven 2003).

Lake Wenatchee is an oligotrophic lake; cold and well-oxygenated, but infertile. Historically, many septic systems may have leaked into the lake. The overall effect may have been increases in zooplankton, which may have had a positive affect on sockeye production. Recently, the formation of a waste water system may have reduced the production of sockeye, although this hypothesis is speculative.

Bull trout have evolved with sockeye. Historically, bull trout numbers were reduced from fishing pressure. Since they were listed as threatened in 1998, fishing pressure has been reduced. An increase of bull trout have been observed on the spawning grounds and has probably had an effect on the production of sockeye in the lake.

Maintaining the high quality functionality of Lake Wenatchee, while minimizing the impacts of current land use practices are the factors that may either maintain or increase sockeye productivity. Adding nutrients to Lake Wenatchee in a balanced manner would undoubtedly increase the production of sockeye.

Smolt

Wenatchee River sockeye smolts begin migrating from Lake Wenatchee in April. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated.

Population Characterization

Distribution

Historic

Historically, populations of sockeye salmon spawned in the Wenatchee subbasin in the White and Little Wenatchee rivers. Some spawning may have occurred within and downstream of the lake, but evidence is inconclusive (Chapman et al. 1995b).

Current

The principal spawning areas for Wenatchee subbasin sockeye are approximately in the lower 4 miles of the Little Wenatchee River and the lower 5 miles in the White River (Peven 1992). Some fish also spawn in the Napeequa River (a tributary of the White River) Also see Figure 10.

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Subwatersheds Significant for Sockeye in Wenatchee and Entiat Subbasins

Figure 10. Significant sockeye watersheds in Wenatchee and Entiat subbasins (RTT 2004)

Abundance

Historic

Chapman (1996) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead, and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 2.6 million sockeye, (for the entire Columbia basin) for predevelopment run sizes. Sockeye were very abundant in upper Columbia River tributary streams (Yakima, Wenatchee, Okanogan, and Arrow Lakes) prior to the extensive resource exploitation in the 1860s (Peven 2003).

By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, unscreened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of upper Columbia basin salmonids (Peven 2003).

By the beginning of the twentieth century, it appears that most of the sockeye entering the Columbia River were headed to the Arrow Lakes region in British Columbia (WDF 1938). In the mid 1930s, the Washington Department of Fisheries (WDF) counted fish ascending Tumwater Dam in the Wenatchee River, and Zosel Dam in the Okanogan River. These counts suggested that 85-92% of the sockeye counted over Rock Island Dam in the same years where headed to spawning areas other than the Wenatchee and Okanogan basins (Peven 2003).

Mullan (1986) quotes Rich (1940CPa, 1940CPb), who reviewed the sockeye fishery between 1892-1938, as stating that the sockeye runs were greatly reduced as long ago as 1900, since which time there has been no marked change in the size of the catch. Mullan (1986) suggests that the landings of sockeye may suggest otherwise, but that harvest rates in the lower river were undoubtedly high during that time; Rock Island Dam counts only accounted for 16% of the fish entering the Columbia River between 1933-1937, and in 1934 over 98% of the sockeye entering the river were harvested (Pevan 2003).

Mullan (1986) points out that commercial catches of sockeye after 1938 were still extreme, where escapement past the fisheries between 1938 and 1944 was mostly below 20%, and in 1941 was only 1%. In 1945, escapement increased and remained relatively high, between 25-50%. Since 1960, escapement has exceeded catch on a regular basis (Peven 2003).

Current

Since 1938, the percentage of sockeye that has entered the Columbia River (minimum run) that have passed Rock Island Dam has varied from less than 1% (1941) to greater than 95% (1990s). The mean percentage of fish ascending the Columbia past Rock Island Dam has increased since 1938. Between 1938 and 1944, only 14.5% of the sockeye estimated to have entered the Columbia River were counted at Rock Island Dam. The percentage has steadily grown since then, approaching 100% in most recent years.

Even though there appears to be problems associated with the spawning ground counts, they may be used as an index of abundance in the two systems. In the Wenatchee, it appears the run may be stable.

Decadal averages have shown a general increase in numbers of fish ascending Rock Island Dam.

Allen and Meekin (1980) report the escapement goal of 80,000 sockeye over Priest Rapids. Currently, the escapement goal at Priest Rapids is 65,000 (Devore and Hirose 1988). The Columbia River Technical Advisory Committee (TAC) changed the goal in 1984 from 80,000 fish (1933-1966 at Rock Island and from 1967 to the present at Priest Rapids) to the current

65,000, which under most conditions equates to 75,000 sockeye over Bonneville Dam. LaVoy (1992) showed the escapement goal of the Wenatchee population as 23,000. Using the various dam counts, escapement has been met in most years since 1970. If spawning ground counts are used, however, the Wenatchee system is not meeting escapement goals in most years (Peven 2003).

Productivity

Historic

Historic production of sockeye is difficult to determine, it was thought to be very high. While it is known that in some years, there was drastic failure of certain year classes (primarily due to ocean conditions; see Mullan et al. 1992), it is assumed that historic production of sockeye was higher than current (Peven 2003).

Current

Current productivity is affected by loss or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Mullan et al. (1992) postulated that current production may not be greatly different than historic for sockeye in the Wenatchee subbasin. Caveats to this postulate are that production comes at a higher cost in terms of smolt survival through the mainstem corridor and that harvest is drastically reduced (Peven 2003).

While spawning habitat does not appear to be limiting sockeye in the Wenatchee subbasin, rearing in Lake Wenatchee is. Being a highly oligotrophic lake, production may never have been high in this particular subbasin, compared to other systems of the upper Columbia River region.

Diversity

Diversity of the Wenatchee independent population is believed to be robust, especially since the Grand Coulee Fish Maintenance Project (GCFMP), about 60 years ago, when mixed stocks were released within the basin.

Summary

Table 17. Summary of sockeye population characterization

	Distribution	Abundance	Productivity	Diversity
Historic	Moderate	High	Moderate-High	Moderate-High
Current	Moderate	Moderate	Moderate	Moderate

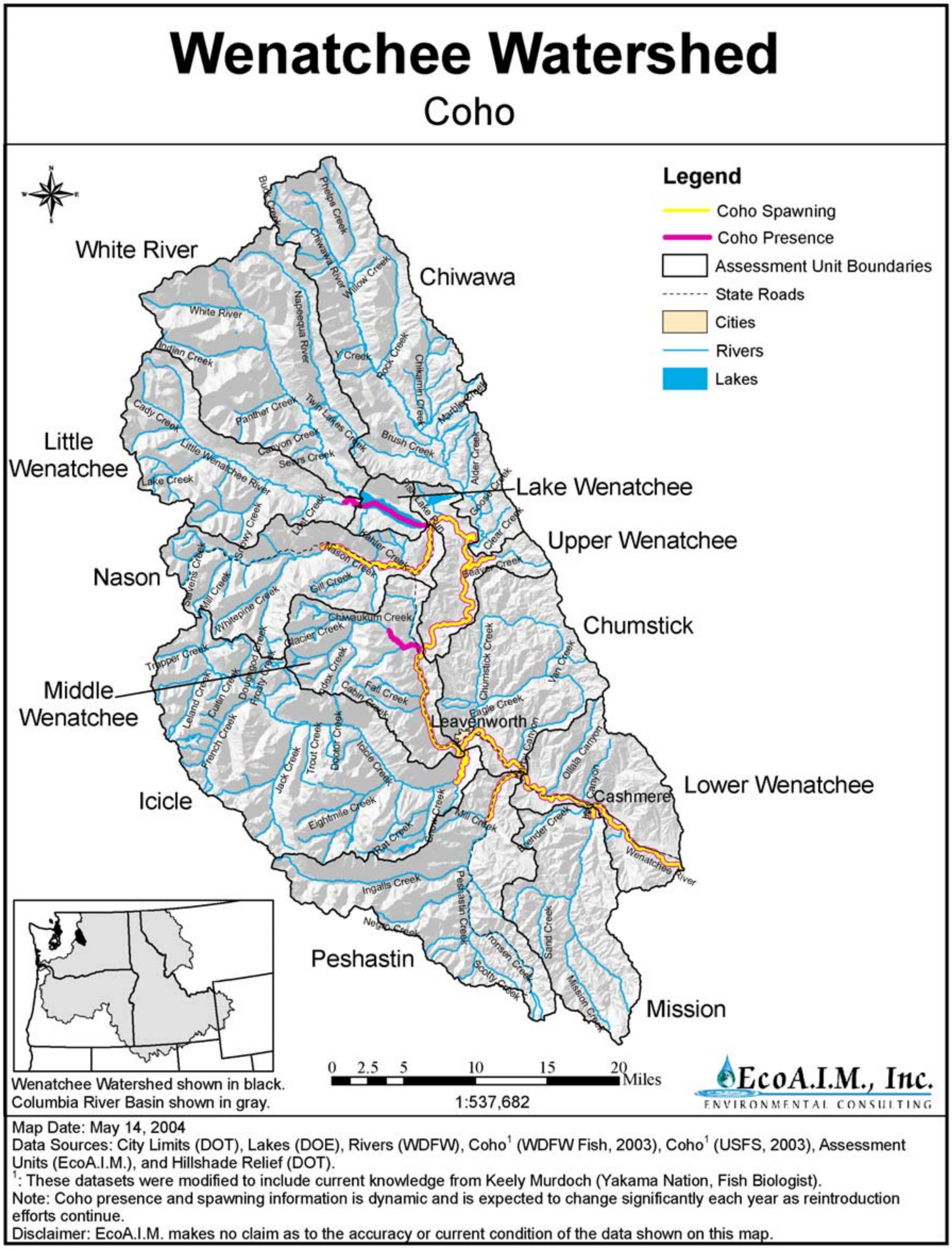

Figure 11. Coho distribution in the Wenatchee subbasin

4.8.5 Coho (*Oncorhynchus kisutch*)

Rationale for Selection

Coho salmon were once considered extinct in the mid Columbia region, but have since been reintroduced. Recent re-introduction efforts have resulted in natural reproduction occurring in the basin. Mullan (1984) estimated the historical run size at 38,000 to 51,000 adults to the Wenatchee, Entiat, and Methow rivers (Peven 2003).

Recently the Yakama Nation has begun a substantial and concerted effort to reintroduce coho into the upper Columbia, using the Wenatchee and Methow subbasins during the feasibility phase of this work. Coho salmon prefer and occupy different habitat types, selecting slower velocities and greater depths than the other focal species; Habitat complexity and off-channel habitats such as backwater pools, beaver ponds, and side channels are important for juvenile rearing making coho good biological indicators for these areas.

Key Life History Strategies: Relationship to Habitat

Time of entry and spawning

Coho salmon enter the Wenatchee River in early September through late November. Adults ascended the tributaries in the fall and spawning between mid-October and late December, although there is historical evidence of an earlier run of coho salmon (Mullan 1984). As cold Water temperatures at that time of year preclude spawning in some areas, it is likely that coho salmon spawn in areas where warmer ground water up-wells through the substrate.

Prespawning

Coho entering in September and October hold in larger pools prior to spawning, later entering fish may migrate quickly upstream to suitable spawning locations. The availability and number of deep pools and cover is important to off set potential prespawning mortality. Intact riparian habitat will increase the likelihood of in stream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat need for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Burner (1951) reported the range of depths for coho spawning to be between 8 and 51 cm. Coho salmon spawn in velocities ranging from 0.30 to 0.75 m/s and may seek out sites of groundwater seepage (Sandercock 1991).

Incubation and emergence

The length of time required for eggs to incubate in the grave is largely dependent on temperature. Sandercock (1991) reported that the total heat requirement for coho incubation in the gravel (spawning to emergence) was 1036 (±138) degree (°C) days over zero. The percentage of eggs and alevins that survive to emergence depends on stream and streambed conditions. Fall and winter flooding, low flows, freezing of gravel, and heavy silt loads can significantly reduce survival.

In the Wenatchee Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flow. Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and the conditions have improved in most watersheds. However, Nason Creek because of its location near a railroad and major highway has long term restoration needs that could most likely increase incubation success.

In the Wenatchee sub-basin, coho fry emerge from the gravel in April or May (K. Murdoch, personal communication).

Fry

Juvenile coho salmon generally distribute themselves downstream shortly after emergence and seek out suitable low gradient tributary and off channel habitats. They congregate in quiet backwaters, side channels, and shady small creeks with overhanging vegetation (Sandercock 1991). Conservation and restoration of riparian areas, and off channel habitat in natal streams within the Wenatchee Basin would increase the preferred type of habitat fry use.

Parr

Coho salmon prefer slower velocity rearing areas than chinook salmon or steelhead (Lister and Genoe 1970; Allee 1981; Taylor 1991) Recent work completed by the Yakama Nation supports these findings (Murdoch et. al. 2004). Juvenile coho tend to overwinter in riverine ponds and other off channel habitats. Overwinter survival is strongly correlated to the quantity of woody debris and habitat complexity (Quinn and Peterson 1996). Conservation of and restoration of high functioning habitat in natal tributaries along and restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Naturally produced coho smolts in the Wenatchee Basin emigrate between March and May (Murdoch et. al. 2004). Investigation of suspected or potential impediments to migraton or injury or mortality should be identified and investigated. If areas are shown to unnaturally impede migration or injure or kill fish, they should be fixed.

Population Characterization

Distribution

Historic

Coho salmon were once considered extirpated in the upper Columbia River (Fish and Hanavan 1948; Mullan 1984), but have since been reintroduced. Mullan (1984) estimated that upstream of the Yakima River, the Methow River and Spokane River historically produced the most coho, with lesser runs into the Wenatchee and Entiat. There are conflicting reports of whether the Okanogan subbasin historically produced coho (Craig and Suomela 1941; Vedan 2002). Because the indigenous stock of coho salmon no longer occur in the upper Columbia River system, the Wenatchee subbasin coho are not addressed under the ESA or by the WDFW (1994) SASSI (Peven 2003).

Information regarding the historic distribution of coho salmon within the Wenatchee River basin is limited. Based on affidavits from ‘old-time’ residents, Nason Creek was likely an important spawning area, and nearly all the smaller creeks had a run of coho salmon (Mullan 1984). The fall run of salmon in the Wenatchee River Basin continued until about 1914-1915, after which it rapidly declined (Mullan 1984).

Current

Coho salmon currently spawn in the main stem Wenatchee River (Cashmere to Lake Wenatchee), Nason Creek, Beaver Creek, Icicle Creek, Peshastin Creek, Mission Creek, and possibly Chiwakum Creek. In 2004, coho are expected to return to the Little Wenatchee River to spawn. Coho salmon rear in their natal tributaries. A portion of juvenile coho likely migrate downstream duiring the fall, presumably for overwinter habitat.

Abundance

Historic

Historically 120,000-166,500 coho were attributed to the mid-and upper Columbia tributaries (Yakima, Wenatchee, Entiat, Methow, and Spokane Rivers: Mullan 1984). Mullan (1984) estimated that the Wenatchee River supported adult returns of approximately 6,000-7,000 coho.

There were two previous attempts in the twentieth century to rebuild coho populations though these two programs were not designed or intended to rebuild upriver runs. They were for harvest augmentation. Releases did not occur in the natural production habitat areas within the watershed.. Between the early 1940s and the mid 1970s, the USFWS raised and released coho as part of their mitigation responsibilities for the construction of Grand Coulee Dam (Mullan 1984). Chelan PUD also had a coho hatchery program until the early 1990s. While some natural production may have occurred from these releases, the programs overall were not designed to re-establish naturally spawning populations, and relied on lower river stocks that were not suited to the upper Columbia (Peven 2003). All coho releases under the Chelan PUD program (197-1993) were made from the Turtle Rock Fish Hatchery, located in the middle of the Columbia River above Rocky Reach Dam. The release location likely contributed to the inability to produce a naturally spawning coho run. This reach of the Columbia River does not provide suitable coho spawning and rearing habitat.

Current

The Yakama Nation, as the lead agency, has implemented a substantial reintroduction program designed to restore naturally reproducing coho salmon through the development a locally adapted stock, while releasing acclimated smolts in natural production areas.

Since the reintroduction of coho to the Wenatchee River in 1999, the abundance of adult returns has ranged between an estimated 350 to 4000 (Murdoch et. al. 2004). Many of these fish are taken into the hatchery for broodstock development purpose, the remainder have spawned naturally. The first generation of naturally produced coho smolts emigrated from the Wenatchee River basin in 2002 with an estimated population size of 17,000 (Murdoch et al. 2004). In 2003, approximately 36,700 naturally produced coho smolts emigrated from the Wenatchee River (T. Miller, WDFW, unpublished data).

Productivity

Historic

Historic production of coho salmon is difficult to determine, although it was most likely not as high as sockeye or late-run chinook.

Current

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc). Habitats in need of restoration within the Wenatchee Basin include Nason, Icicle, Peshastin, Chumstick, and Mission Creeks. By increasing known areas in need of restoration, it is reasonable to assume that production of coho would increase.

Diversity

Because hatchery stocks were used to reintroduce coho salmon (and develop a local broodstock), spatial and life history diversity within the basin is likely lower than the historic populations of coho salmon. As increased natural production occurs, and naturally produced coho are incorporated into the broodstock, diversity will likely increase. Increased habitat would most likely increase spatial and life history diversity for coho salmon in mid-Columbia tributaries.

Table 18. Summary of coho salmon population characterization.

	Distribution	**Abundance**	**Productivity**	**Diversity**
Historic	High	Mod-high	Moderate	High
Current	Low	Low	Low	Low

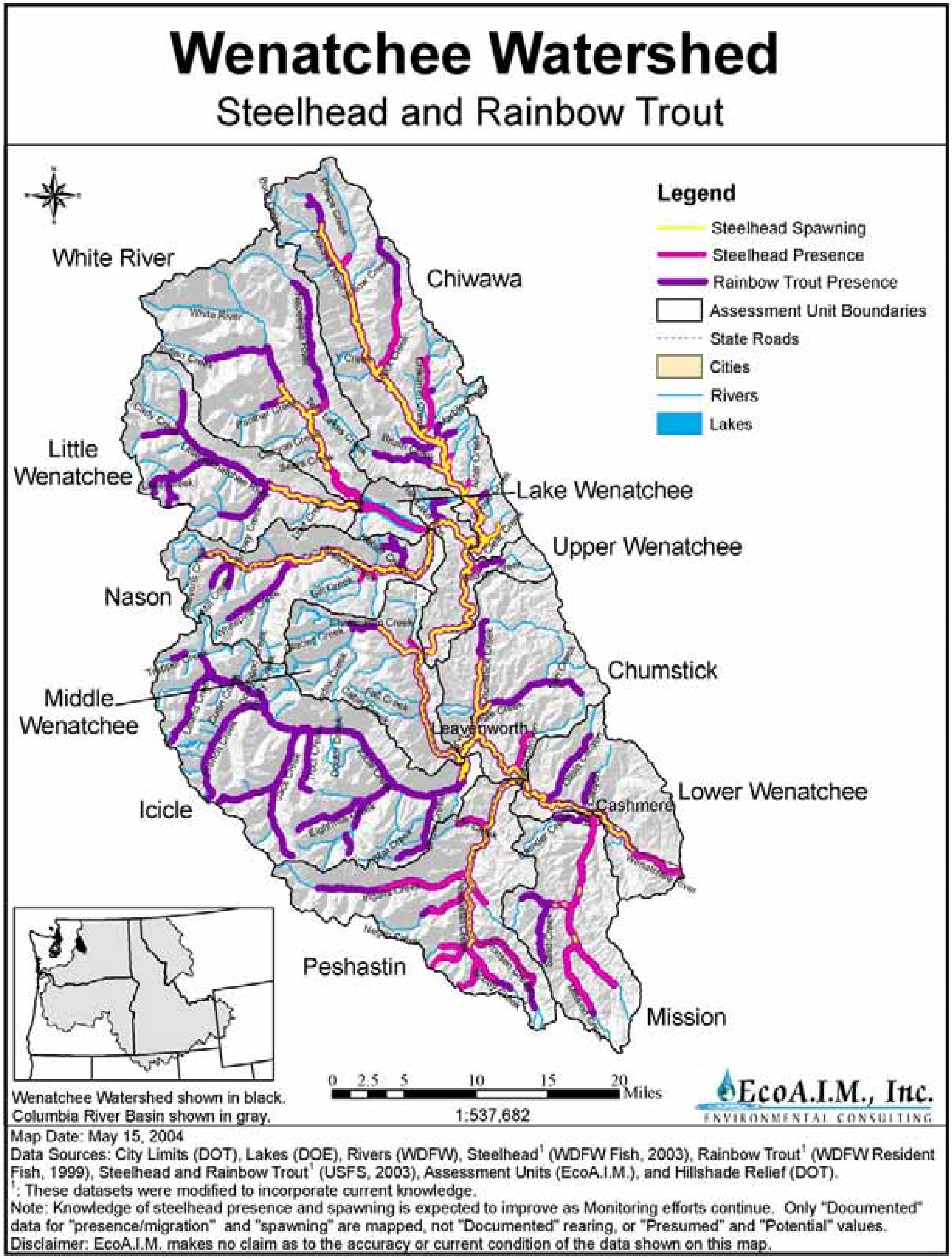

Figure 12. Steelhead and rainbow trout distribution in the Wenatchee subbasin

4.8.6 Steelhead Trout (*Oncorhynchus mykiss*)

Rationale for Selection

The Wenatchee steelhead is included by NOAA Fisheries into the upper Columbia ESU and is listed as an endangered under the ESA. Steelhead trout use all of the major tributaries of the Wenatchee subbasin except Icicle Creek due to existing barrier to passage (Figure 12). Steelhead juvenile spend two or more years in the Wenatchee mainstem and tributaries using many different habitat types making them a good biological indicator of ecosystem health.

Key Life History Strategies, Relationship to Habitat

Time of entry and spawning

Adult steelhead enter the Wenatchee River subbasin from August through the following April. Spawning begins in very late March and lasts through May, peaking in mid to late April (Murdoch and Viola 2003). Like other salmon species in the Wenatchee the onset of spawning in a stream reach is temperature driven. Other factors, such as habitat condition and stream flow may influence steelhead spawning success compared to other salmon species because of the time of year spawning occurs.

Prespawning

Adults using the Wenatchee subbasin hold in the deeper pools and under cover of the mainstem Wenatchee or natal tributaries. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Wydoski and Whitney (2003) report that spawning is usually found at a mean depth of 0.7 to 1.34 ft and water velocities of 1.8 to 2.3 fps. Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available (Peven 2003).

Incubation and emergence

Incubation success is dependent on factors such as water flow through the redds and temperature. Eggs usually hatch in 4 to 7 weeks and fry emerge 2 to 3 weeks after that (Peven 2003).

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Wenatchee subbasin, fall flooding has a high frequency of occurrence. Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the subbasin, and conditions have improved in most watersheds. However, Nason Creek because of its location near a railroad and major high way has long term restoration needs that could most likely increase incubation success, although empirical information is needed to determine if this is a need first.

Fry

In the Wenatchee River, Hillman and Chapman (1989) found most juvenile steelhead rearing in Tumwater Canyon. During daylight, age-0 (less than 1 year) steelhead used slower, shallower water than chinook, stationed individually over small boulder and cobble substrate (Hillman et al. 1989a). As they grew, they picked deeper and faster habitat over cobble and boulders. As with chinook juveniles, in winter, they concealed themselves in interstitial spaces among boulders near the stream bank, but did not cluster together. No interaction was observed between chinook and steelhead at anytime (Hillman et al. 1989a, 1989b).

During nighttime hours, steelhead moved downstream and closer to shore. At dawn, steelhead moved upstream. Most steelhead chose sand and boulder substrates, and during winter, chose deeper, larger substrate (Hillman et al. 1989b).

Hillman and Miller (2002) remarked that in ten years of surveying the Chiwawa River, age-0 steelhead most often used riffle and multiple channel habitats, but were also found associated with debris in pool and glide habitat.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Wenatchee subbasin would increase the type of habitat that fry utilize.

Parr

Downstream movement of parr from natal streams occurs within the Wenatchee subbasin (Murdoch et al. 2001). French and Wahle (1959) found that juvenile steelhead migrated past Tumwater Dam on the Wenatchee River (RM 33) from spring through late fall. Since 1992, sampling by WDFW has found steelhead emigrating from the Chiwawa River as pre-smolts beginning in spring, but primarily in the fall. In general, movement from the Chiwawa River included some yearlings leaving as early as March, extending through May, followed by subyearlings leaving through the summer and fall (until trapping ceases because of inclement weather) (Peven 2003).

Movement of juvenile steelhead from the higher-order streams in the fall appears to be a response to the harsh conditions encountered in the upper tributaries. Hillman and Chapman (1989) suggested that biotic factors, such as intraspecific interaction for available habitat with naturally and hatchery produced chinook, nocturnal sculpin predation, and interspecific interactions may accelerate movement of chinook and steelhead juveniles from the mainstem Wenatchee River.

Hillman and Chapman (1989) found that most steelhead remained in Tumwater Canyon area to rear through all seasons. The amount of habitat diversity and complexity in this reach compared to other reaches was believed to be responsible for this behavior.

Conservation of high functioning habitat in natal tributaries and Tumwater Canyon, and restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Wenatchee River steelhead smolts begin migrating in March from natal areas. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated.

Population Characterization

Distribution

Historic

Steelhead historically used all major (and some minor) tributaries within the upper Columbia basin for spawning and rearing (Chapman et al. 1994a). Fulton (1970) described steelhead using the Wenatchee River and eight of its tributaries: lower Mission, Peshastin, Icicle, Chiwaukum, Nason creeks, and the Chiwawa, Little Wenatchee, and White rivers (Peven 2003).

Current

Beginning in 2001, WDFW has been conducting spawning ground surveys for steelhead in the Wenatchee River. This effort is in conjunction with hatchery evaluations that are currently taking place within the Wenatchee River subbasin for Chelan County PUD funded mitigation efforts. Current spawning distribution in the Wenatchee subbasin, in order of importance appears to be: the Wenatchee River between the Chiwawa River and Lake Wenatchee, Nason, Chiwawa, and Icicle creeks. Other tributaries were not surveyed, such as the Little Wenatchee and White rivers, or Chiwaukum, Peshastin, or Mission creeks, but are most likely used by steelhead for possible spawning and rearing. In 2004, spawning surveys for steelhead are going to be expanded into these and other areas within the subbasin (Peven 2003). Also see Figure 13.

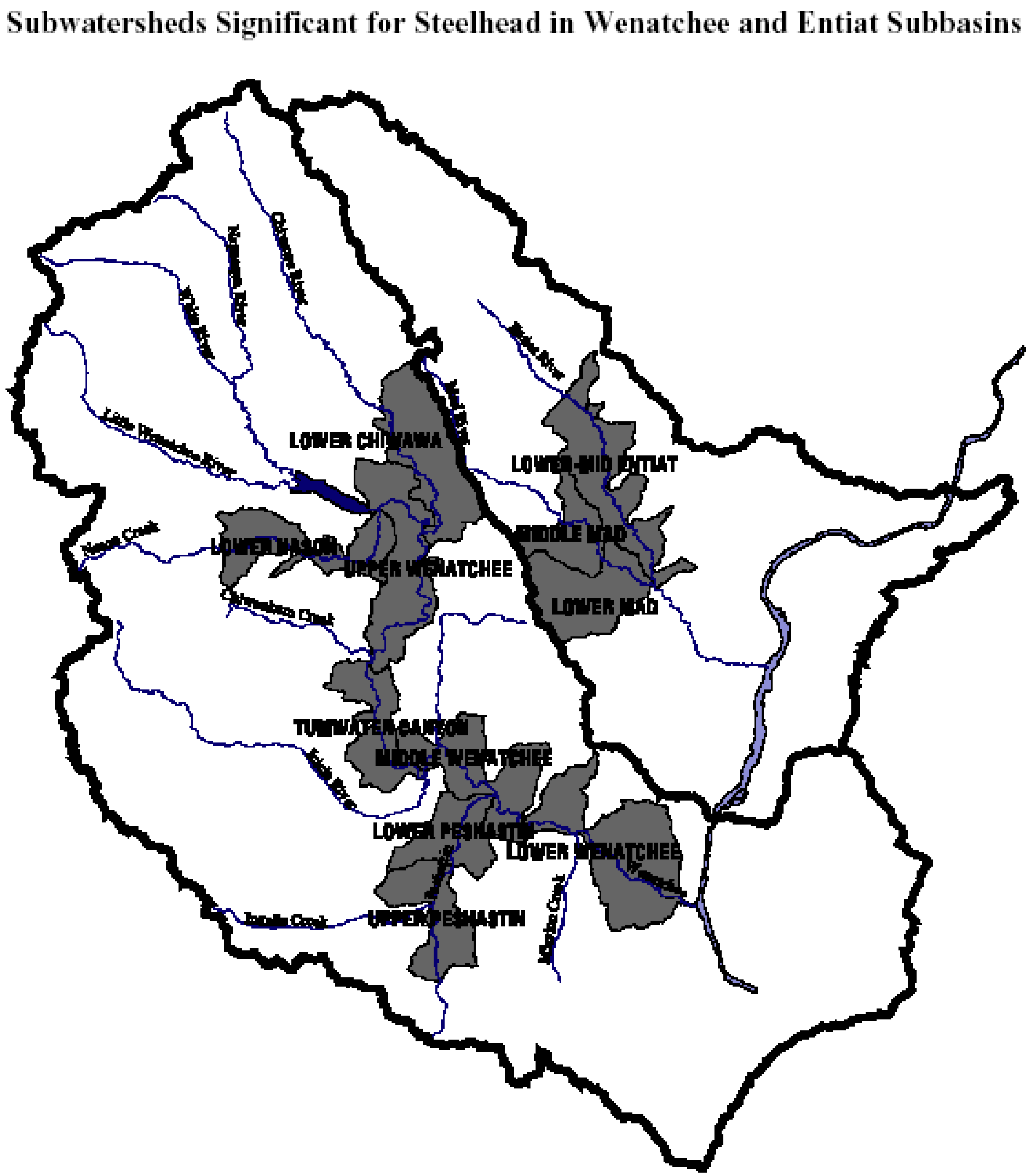

Figure 13. Significant steelhead watersheds in Wenatchee and Entiat subbasins (RTT 2004)

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead, and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 554,000 steelhead (for the entire Columbia basin) was the best estimate of predevelopment run sizes. Steelhead were relatively abundant in upper Columbia River tributary streams prior to the extensive resource exploitation in the 1860s.

By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, unscreened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of upper Columbia basin salmonids (Peven 2003).

Steelhead counts began at Rock Island Dam in 1933, and annual counts averaged 2,800 between 1933 and 1939 (these numbers do not reflect large fisheries in the lower river that took place at that time, estimated by Mullan et al. (1992) as greater than 60%). Average decadal numbers changed little in the 1940s and 1950s (2,600 and 3,700, respectively). Large hatchery releases began in the 1960s, and the average counts increased to 6,700. In the 1970s, counts averaged 5,700 and 16,500 in 1980s (record count of about 32,000 in 1985). In the 1990s, counts decreased, following a similar trend as chinook, to 7,100, while, similar to chinook, they have increased substantially so far in the 2000s, with an average of over 18,000 (a high of 28,600 in 2001).

Current

In 2002, Murdoch and Viola (2003) found a total of 475 steelhead redds upstream of Tumwater Dam, with most of them found in the Wenatchee River. Ford et al. (2001) recommended interim recovery levels of about 2,500 naturally produced spawners for the Wenatchee River (Peven 2003).

Productivity

Historic

Historic production of steelhead is difficult to determine, although it was most likely not as high as sockeye or late-run chinook. While it is known that in some years, there was drastic failure of certain year classes (primarily due to ocean conditions; see Mullan et al. 1992), it is assumed that historic production of steelhead was higher than current.

Current

Current productivity is affected by loss or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Mullan et al. (1992) postulated that current production may not be greatly different than historic for steelhead. Caveats to this postulate are that native coho are extinct, production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced. However, recent estimates of natural replacement rates for steelhead suggest that they are not replacing themselves in most years until the broods of the late 1990s (Peven 2003).

There are still habitat areas in need of restoration (e.g., Peshastin and Mission creeks) within the Wenatchee subbasin. By increasing known areas in need of restoration, it is reasonable to assume that production of steelhead would increase.

Diversity

Because some areas within the Wenatchee subbasin are in need of habitat improvements, diversity within the subbasin is believed to be lower than historic. While the Wenatchee population is still believed to be an independent population, increased habitat would most likely increase spatial and life history diversity.

Currently, genetic sampling has not found any differences among steelhead within the subbasin.

Table 19. Summary of steelhead population characterization

	Distribution	**Abundance**	**Productivity**	**Diversity**
Historic	High	High	Moderate-High	High
Current	Moderate-High	Low	Low	Moderate

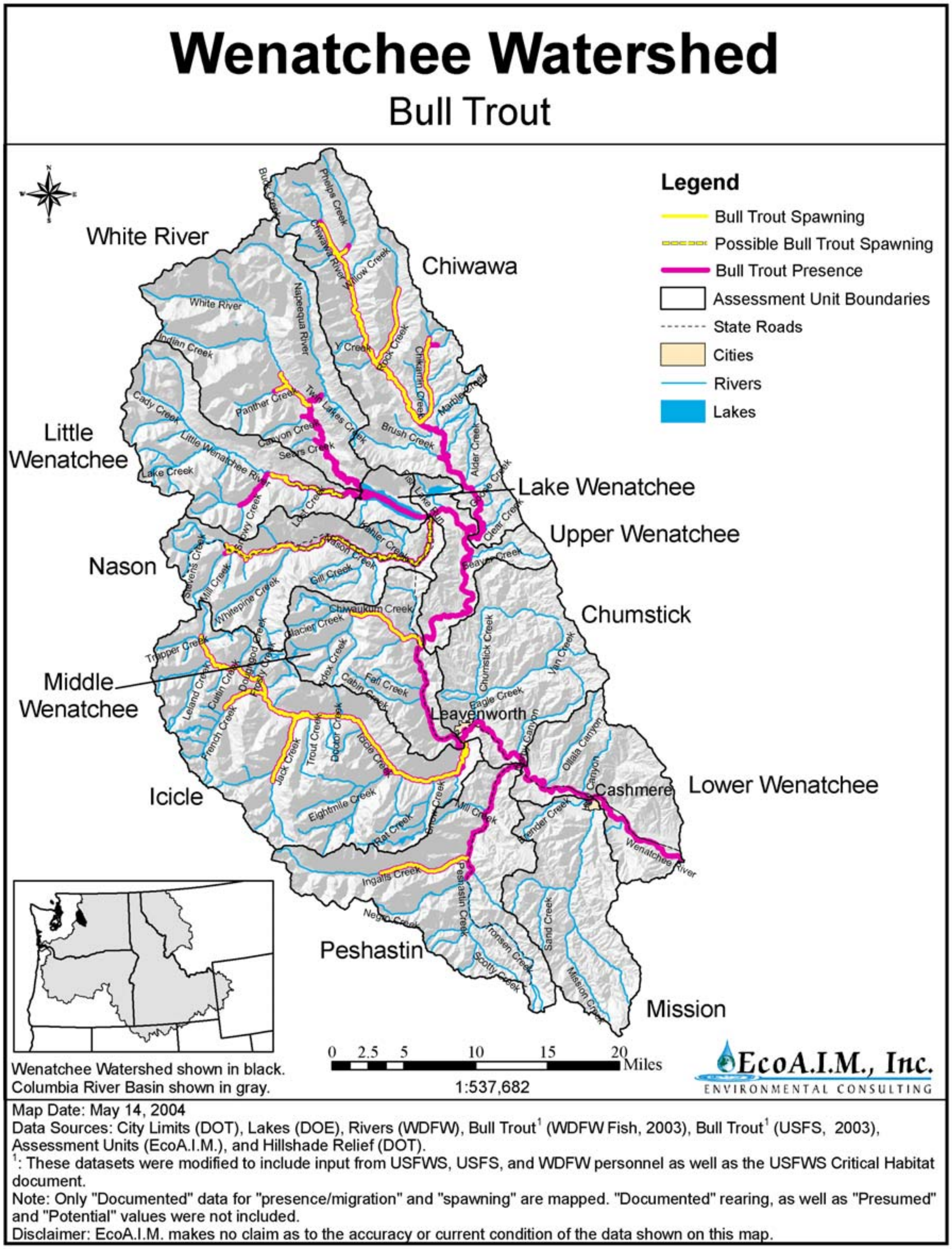

Figure 14. Bull trout distribution in the Wenatchee subbasin

4.8.7 Bull Trout (*Salvelinus confluentus*)

Rationale for Selection

Bull trout are sensitive to environmental changes, especially water temperature making them a good biological indicator of ecosystem health in the mid and upper elevations.

Key Life History Strategies, Relationship to Habitat

Spawning

Bull trout spawn in the Wenatchee River subbasin from August through October. The onset of spawning in a stream reach is temperature driven, apparently at the onset of dropping temperatures.

Prespawning

When adults are migrating upstream to spawning areas, they associate with cover: debris, deep pools, and undercut banks. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Fraley and Shepard (1989) characterized selected spawning areas as having low compaction and low gradient, and potentially near upwelling influences and proximity to cover. In general, mean velocities over redds range from 0.13-2.0 fps, with water depth ranging from 0.71-2.0 ft. Brown (1992) noted that these metrics comported well with those found within the Wenatchee subbasin. Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available (Peven 2003).

Incubation and emergence

Optimum incubation for bull trout is lower than other salmonids (36-39 °F; Brown 1992). Because of the lower temperatures, bull trout development within the redd is usually longer than other salmonids. Emergence may take another three weeks after hatching.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Wenatchee subbasin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the subbasin, and conditions have improved in most watersheds. However, Nason Creek because of its location near a railroad and major high way has long term restoration needs that could most likely increase incubation success, although empirical information is needed to determine if this is a need first.

Because bull trout development within the redd takes a long period of time, they may be more vulnerable to increases in sediments or degradation other water quality (Fraley and Shepard 1989).

Fry

Fry (< 100 mm) are usually found in shallow, slow back water side channels or eddies, in association with fine woody debris. Age-0 bull trout are consistently found near the substrate, usually over gravel-cobble areas.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Wenatchee subbasin would increase the type of habitat that fry utilize.

Parr

Hillman and Miller (2002) state that most juvenile bull trout are consistently found in multiple channels, pool, and riffles, and a few in glides. Juveniles were found in association with the stream bottom over rubble and small boulder substrate or near woody debris.

Downstream movement of juveniles (> 4 in.) from natal streams occurs within the Wenatchee subbasin (Murdoch et al. 2001). Since 1992, sampling by WDFW has found bull trout emigrating from the Chiwawa River have two modes; one in spring, and the other in the fall.

Movement of juvenile bull trout from the higher order streams in the fall may be in response to the unsuitable conditions encountered in the upper tributaries. Murdoch et al. (2001) also speculated that movement in the fall may instead be correlated to the size and age at which bull trout become piscivorous. Most of the juveniles emigrating from the Chiwawa River are likely migrating to Lake Wenatchee (Peven 2003).

Conservation of high functioning habitat in natal tributaries, restoration of riparian and geofluvial processes in or near known and potential juvenile rearing areas will have the highest likelihood of increasing parr survival.

Another factor that is limiting bull trout production in the Wenatchee subbasin is competition with brook trout. Brook trout are found in most areas that bull trout are found (Hillman and Miller 2002).

Population Characterization

Distribution

Historic

While detailed historic distribution is difficult to determine (Rieman et al. 1997), bull trout are believed to have been historically present in the Wenatchee River (Brown 1992; Mongillo 1993).

Current

All three ecotypes of bull trout currently exist in the Wenatchee River Core Area (WDFW 1998). The six migratory (Migratory bull trout are not defined within USFWS (2002). We assume they refer to ecotypes that exhibit some form of extended migration from either different order streams or between lakes and streams, and not those fish that inhabit a limited stream section (commonly known as resident.) bull trout sub populations in the Wenatchee River are found in the Chiwawa River (including Chikamin, Phelps, Rock, Alpine, Buck and James creeks), White River (including Canyon and Panther creeks), Little Wenatchee River (below the falls), Nason Creek (including Mill Creek), Chiwaukum Creek, and Peshastin Creek (including Ingalls Creek). There may also be non-migratory subpopulations within some of these streams, as well as Icicle Creek.

In the Wenatchee subbasin, the adfluvial form matures primarily in Lake Wenatchee and ascends the White and Little Wenatchee rivers, and the Chiwawa River (Kelly-Ringold and DeLavergne 2003), where the young reside for one to three years. Fluvial bull trout populations spawn in the other streams identified above.

Abundance

Historic

There is currently no information available to assess what historic abundance of bull trout was in the Wenatchee River subbasin.

Current

Recent comprehensive redd surveys, coupled with preliminary radio telemetry work suggest that remaining spawning populations within the Wenatchee River are not complete genetic isolates of one another, but rather co-mingle to some degree . It is possible that there are separate, local spawning aggregates, but more monitoring and DNA analysis is necessary to be able to empirically determine this. The chance of finding independent subpopulations within each subbasin would most likely found be in head water areas upstream of barriers, which prevents immigration from downstream recruits, but not emigration to downstream areas during high water events occasionally (Peven 2003).

Since nonmigratory fish are difficult to count, all estimates of current abundance should be considered underestimates of the true population size of bull trout within the Wenatchee subbasin. This is based on the belief that nonmigratory fish are most likely contributing to the migratory populations (like steelhead), and potentially vice versa, although there may not be very many non-migratory bull trout populations within the Wenatchee subbasin (Peven 2003).

Redd surveys have been conducted by the USFWS, USFS, and WDFW in the various streams within the Wenatchee River subbasin since the 1980s. The White and Little Wenatchee rivers have shown a fluctuating abundance of redds since 1983, averaging 34 redds.

Since 1989, the highest concentration of redds within the Wenatchee River subbasin has been observed within the Chiwawa watershed, averaging over 300 redds per year, and showing a steady increase of abundance. Lesser numbers of redds have also been observed within the Peshastin and Nason creek drainages, and in the upper mainstem Wenatchee River. Overall, the Wenatchee River subbasin has average over 250 redds since the surveys began in the Chiwawa River in 1989, and has shown a steady increase, although it should be noted that this trend may be a factor of increased effort in redd surveys in recent years (Peven 2003).

Hillman and Miller (2002) have observed between 76-900 bull trout in their snorkel surveys of the Chiwawa River between 1992 and 2002 (excluding 2000). They also state that because their surveys do not encompass areas outside of juvenile chinook salmon, or the entire lengths of all streams, so the estimates should be considered very conservative, since bull trout are known to extend beyond their survey boundaries.

Productivity

Historic

Historic productivity of bull trout within the Wenatchee subbasin is not known. However, it is reasonable to assume that it was higher, based on habitat degradation and management practices (harvest).

Current

Current productivity appears to be improving based on redd counts and other factors (see above).

Diversity

Historic diversity was most likely higher than current based on some minor losses of connectivity and potential increases in temperature. If habitat restoration occurs, there will most likely be an increase in spatial and potentially life history diversity.

Table 20. Summary of bull trout population characterization

	Distribution	Abundance	Productivity	Diversity
Historic	High	Moderate-High	Moderate	High
Current	Moderate-High	Low-Moderate	Low-Moderate	Moderate

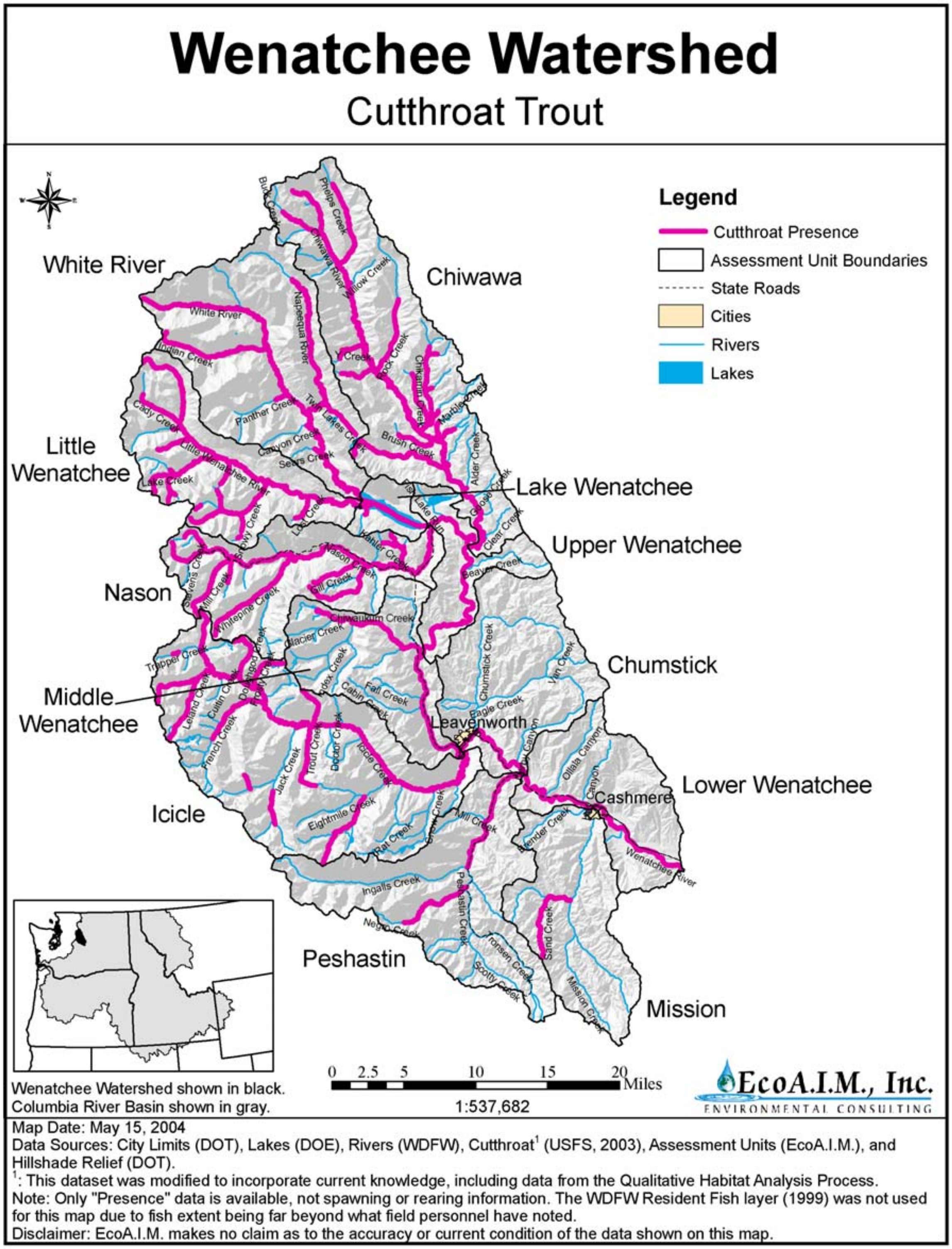

Figure 15. Cutthroat trout distribution in the Wenatchee subbasin

4.8.8 Cutthroat Trout (*Oncorhynchus clarki lewisi*)

Rationale for Selection

There are concerns about the status of this species due to genetic introgression (especially with introduced rainbow trout), depressed and fragmented populations or stocks, and loss of migratory life histories. The USFWS considers the westslope cutthroat trout a species of concern. The USFWS received a formal petition to list the westslope cutthroat trout as threatened pursuant to the ESA. A status review determined a listing of the species was not warranted at this time.

Cutthroat trout inhabit mid to high elevation streams, and may be the only salmonid species existing in various reaches. Cutthroat trout are sensitive to environmental changes, especially water temperature making them a good biological indicator of ecosystem health in the mid and upper elevations.

Key Life History Strategies, Relationship to Habitat

Spawning

Westslope cutthroat trout spawn between March and July, when water temperatures begin to warm. Spawning and rearing streams tend to be cold and nutrient poor.

Prespawning

When adults are migrating upstream to spawning areas, they associate with cover; debris, deep pools, and undercut banks. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Adult cutthroat trout need deep, slow moving pools that do not fill with anchor ice in order to survive the winter. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. USFWS (1999) state that westslope cutthroat trout redds are usually found in water that is about 0.7 ft deep with mean velocities of 1.0 to 1.3 fps.

Incubation and emergence

Eggs incubate for several weeks and emergence occurs several days after hatching (USFWS 1999).

Stream conditions (e.g., frequency of flooding) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Wenatchee subbasin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). These factors were once more prevalent than they are now in the subbasin, and conditions have improved in most watersheds. However, Nason Creek because of its location near a railroad and major high way has long term restoration needs that could most likely increase incubation success, although empirical information is needed to determine if this is a need first.

Fry

After emergence, fry are usually found in shallow, slow back water side channels or eddies, in association with fine woody debris.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Wenatchee subbasin would increase the type of habitat that fry utilize.

Parr

Juvenile cutthroat trout overwinter in the interstitial spaces of large stream substrate.

Hillman and Miller (2002) state that most juvenile westslope cutthroat trout are consistently found in multiple channels and pools.

Downstream movement of juveniles from natal streams occurs within the Wenatchee subbasin. Since 1992, sampling by WDFW has found westslope cutthroat trout emigrating from the Chiwawa River (Peven 2003).

Movement of juvenile westslope cutthroat trout within streams is most likely related to changing habitat requirements as the fish grows, or winter refuge.

Conservation of high functioning habitat in natal tributaries, restoration of riparian and geofluvial processes in or near known and potential juvenile rearing areas will have the highest likelihood of increasing parr survival.

Another factor that is limiting westslope cutthroat trout production in the Wenatchee subbasin is competition with brook trout. Brook trout are found in many areas that westslope cutthroat trout are found (Hillman and Miller 2002).

Population Characterization

Distribution

Historic

The primary historic distribution of westslope cutthroat trout occurred in the upper Columbia and Missouri River basins (USFWS 1999). Westslope cutthroat trout were originally believed to occur in three river subbasins within Washington state: Methow, Chelan, and Pend Oreille, although only abundant in the Lake Chelan subbasin (Peven 2003).

Apart from Lake Chelan and the Pend Oreille River where an abundance of relatively large cutthroat commanded the attention of pioneers, cutthroat trout in streams were obscured by their head water location and small body size . . . Accordingly, the ethnohistorical record is mostly silent on the presence or absence of cutthroat. The picture is further blurred by the early scattering of cutthroat from the first trout hatchery in Washington (Stehekin River Hatchery, 1903) by entities (Department of Fisheries and Game and county Fish Commissions) dissolved decades ago along with their planting records. The undocumented translocation of cutthroats by interested non-professionals starting with pioneers is another confusing factor that challenges determination of historical distribution.

Recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of westslope cutthroat trout in Washington state is now believed to be broader. Historic distribution now includes the head waters of the Wenatchee and Yakima River subbasins (Behnke 2002).

Overall, Behnke (1992) believed that the disjunct populations in Washington state probably were transported here through the catastrophic ice age floods.

Current

Through stocking programs that began with Washington state's first trout hatchery in the Stehekin River valley in 1903 (that targeted westslope cutthroat trout), westslope cutthroat trout have been transplanted in almost all available stream and lake habitat (Williams 1998).

Williams (1998) documented that in the Wenatchee River subbasin, westslope cutthroat trout sustain themselves in 82 streams (175 miles) and 83 alpine lakes (1,462 acres).

Abundance

Historic

There is currently no information available to assess what historic abundance of westslope cutthroat trout was in the Wenatchee River subbasin. Numerical abundance has not been documented or estimated for westslope cutthroat trout. Westslope cutthroat were not thought to have been very abundant where they occurred in the head water locations within the Methow, Entiat, and Wenatchee subbasins (Peven 2003).

Current

There are no known estimates of current abundance within the Wenatchee River subbasin

Productivity

Historic

Historic productivity of bull trout within the Wenatchee subbasin is not known. However, it is reasonable to assume that it was higher, based on habitat degradation and management practices (hatchery plants).

Current

There are no known estimates of current abundance within the Wenatchee River subbasin.

Diversity

Historic diversity was most likely higher than current based on some minor losses of connectivity and potential increases in temperature. If habitat restoration occurs, there will most likely be an increase in spatial and, potentially, life history diversity.

Table 21. Summary of westslope cutthroat trout population characterization

	Distribution	Abundance	Productivity	Diversity
Historic	Moderate	Low	Low-Moderate	Moderate
Current	Moderate-High	Low-Moderate	Low-Moderate	Moderate-High

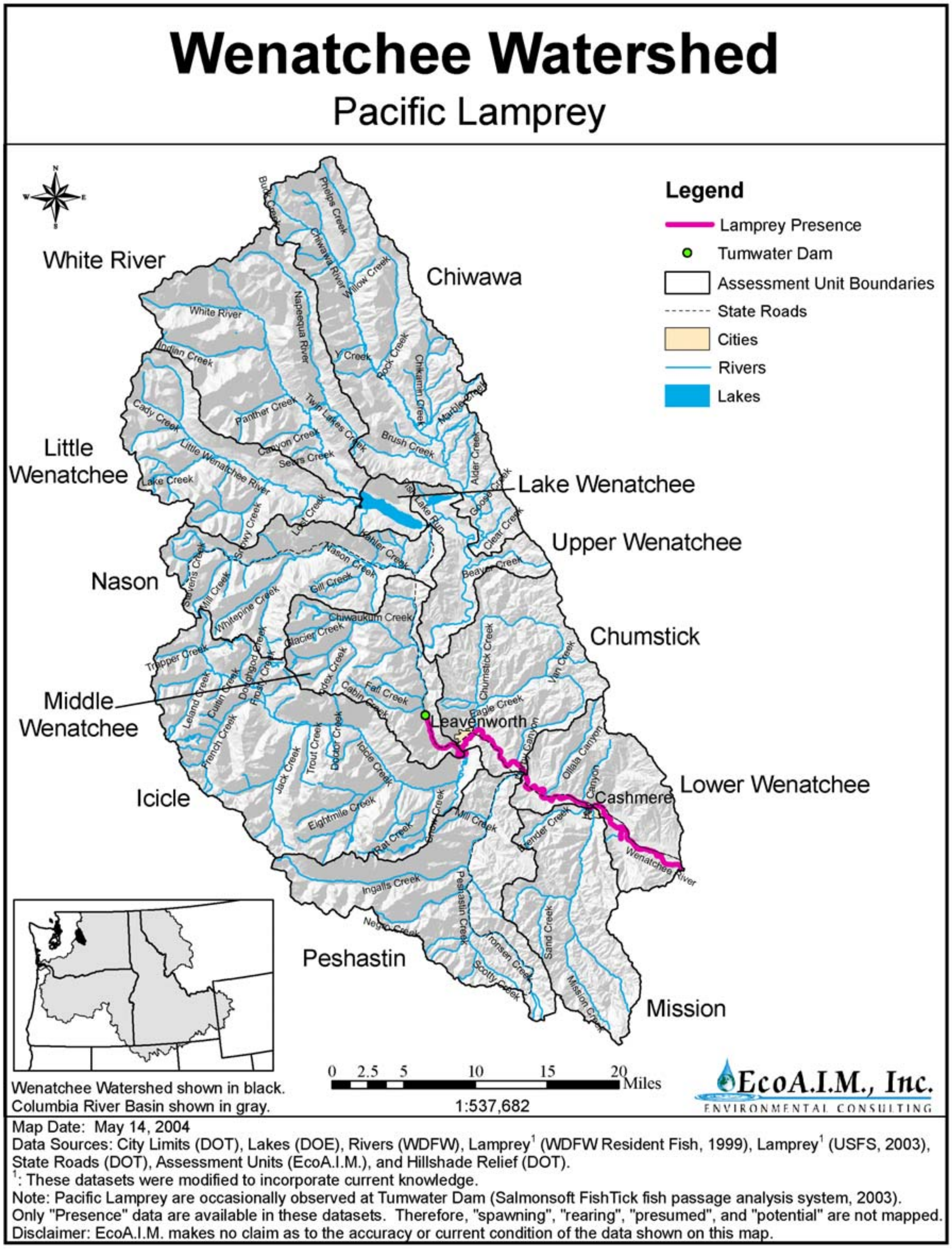

Figure 16. Presumed Pacific lamprey distribution in the Wenatchee subbasin

4.8.9 Pacific Lamprey (*Lampetra tridentate*)

Rationale for Selection

Very little is known about Pacific lamprey population or stocks in the upper Columbia and the Wenatchee River. Pacific lamprey is a culturally and commercially important species to the Yakama Nation and Confederated Tribes of the Colville Reservation.

Key Life History Strategies: Relationship to Habitat

[No information to date]

Population Characterization

Distribution

Historic

Historical distribution of Pacific lamprey in the Columbia and Snake rivers was coincident wherever salmon occurred (Simpson and Wallace 1978). It is likely that Pacific lamprey occurred historically within the Wenatchee subbasin. If it is assumed that Pacific lamprey and salmon used the same streams, it is possible to conclude that Pacific lamprey occurred in the Wenatchee River, Chiwawa River, Nason Creek, Little Wenatchee River, White River, Icicle Creek, Peshastin Creek, and Mission Creek in the Wenatchee River subbasin. (Currently, lamprey have not been observed upstream of Tumwater Canyon. There is no way to determine if they appeared there historically. This may suggest that hydraulic conditions within Tumwater Canyon are a migration barrier for lamprey and they may never have existed in the mainstem or tributaries upstream of the canyon. Another possibility is that Tumwater Dam may be limiting movement of lamprey upstream.) In 1937, WDF (1938) collected several juvenile lamprey that were bypassed from irrigation ditches in Icicle and Peshastin creeks and the lower mainstem Wenatchee River.

Current

Pacific lamprey still exist in the Wenatchee system, but the distribution is mostly unknown. BioAnalysts (2000) used anecdotal information to describe the extent of Pacific lamprey distribution Wenatchee River. However, they cautioned that the following description may be confounded by the presence of river lamprey. In most cases, observers they cited reported the occurrence of lamprey but did not identify the species. Thus, the descriptions below may apply to both species.

In the Wenatchee River subbasin, lamprey appear to occur primarily downstream from Tumwater Dam. Jackson et al. (1997) indicated that they have observed no Pacific lamprey ascending Tumwater Dam during the last decade. Because they monitored fish movement at Tumwater Dam between May through September, it is possible that they missed lamprey that migrate upstream to spawning areas during the spring (prior to May). WDFW captured no lamprey in the lower Chiwawa River during the 1992-1999 trapping period or near the mouth of Lake Wenatchee. Hillman and Chapman (1989) surveyed the entire Wenatchee River during 1986 and 1987 and found no lamprey upstream from Tumwater Dam. The lack of lamprey in the upper Wenatchee is consistent with the work of Mullan et al. (1992), who found no lamprey in the mainstem or tributaries of the upper Wenatchee River subbasin (Peven 2003).

Pacific lamprey have been observed in the lower Wenatchee River. Hillman (unpublished data) found many ammocoetes in the Wenatchee River near the town of Leavenworth and adult lamprey in the lower Wenatchee River (near RM 1.0). Kelly-Ringold (USFWS, personal communication in BioAnalysts 2000) found an adult Pacific lamprey in the Wenatchee River near the golf course in Leavenworth. Lamprey are also seen in the smolt monitoring trap in the lower Wenatchee River every year near the town of Monitor (Peven 2003). Apparently lamprey spawn in the irrigation canal just upstream from Monitor. These observations indicate that lamprey currently exist in the lower Wenatchee River (RM 0 to <27) and perhaps in the lower portions of Icicle, Peshastin, and Mission creeks.

Abundance

Historic

Historical abundance of Pacific lamprey is difficult to determine because of the lack of specific information. However, lamprey were (and continue to be) culturally significant to the Native American tribes in the Columbia basin.

Current

There are currently no abundance information except perhaps dam count differences between Rock Island and Rocky Reach. However, comparing counts among different projects is problematic because of sampling inconsistencies, the behavior of lamprey in counting stations, and the ability of lamprey to bypass counting stations undetected (Peven 2003).

Productivity

There currently is no information on historic and current productivity on Pacific lamprey. However, it is reasonable to assume that current production is lower than historic.

Diversity

Within the Wenatchee subbasin, it is not known whether Tumwater Dam is an impediment to migration. There is certainly more spawning and rearing habitat available upstream of the dam. If Tumwater is a migration blockage, then modifying that dam for passage would increase life history and spatial diversity of the Wenatchee subbasin Pacific lamprey.

Table 22. Summary of Pacific lamprey population characterization

	Distribution	Abundance	Productivity	Diversity
Historic	?	?	Higher than present	?
Current	?	?	?	?

4.8.10 Relationships of Salmonid Populations to the Ecosystem

Introduction

The biotic communities of aquatic systems in the upper Columbia basin are highly complex. Within communities, assemblages and species have varying levels of interaction with one another. Direct interactions may occur in the form of predator and prey, competitor, and disease or parasite host relationships. In addition, many indirect interactions may occur between species. For example, predation of one species upon another may enhance the ability of a third species to persist in the community by releasing it from predatory or competitive constraints. These interactions continually change in response to shifting environmental and biotic conditions. Human activities that change the environment, the frequency and intensity of disturbance, or species composition can shift the competitive balance among species, alter predatory interactions, and change disease susceptibility. All of these changes may result in community reorganization.

Community Structure

Few studies have examined the fish species assemblages within the upper Columbia basin. The available information indicates that about 41 species of fish occur within the upper Columbia basin (from the mouth of the Yakima River upstream to Chief Joseph Dam). This is an underestimate because several species of sculpins live there. Of the fish in the basin, 15 are cold-water species, 18 are cool- water species, and 8 are warm- water species. Most of the cold- water species are native to the area; only four were introduced (brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), lake whitefish (*Coregonus clupeaformis—italics*), and Atlantic salmon (*S. salar*). Four of the 18 cool- water species are exotics (pumpkinseed (*Lepomis gibbosus*), walleye (*Stizostedion vitreum*), yellow perch (*Perca flavescens*), and smallmouth bass (Micropterus dolomieu)), while all warm- water species are exotics.

About half of the resident species in the upper basin are piscivorous or fish eating. Ten cold-water species, 7 cool- water species, and 5 warm- water species are known to eat fish. About 59% of these piscivores are exotics. Before the introduction of exotics, northern pikeminnow (*Ptychocheilus oregonensis*), sculpin (*Cottus spp*.), white sturgeon, bull trout (*Salvelinus confluentus*), rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), and burbot (*Lota lota*) were the primary piscivores in the region. Presently, burbot are rare in the upper basin and probably have little effect on the abundance of juvenile salmonids in the region. The status of white sturgeon in the upper basin is mostly unknown, although their numbers appear to be quite low.

Introduced species such as walleye, smallmouth bass, and channel catfish (*Ictalurus punctatus*) are important predators of salmonids in the Columbia River. Channel catfish are rare and likely have little to no effect on abundance of salmonids. Other piscivores, such as largemouth bass (M. salmoides), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), yellow perch, and pumpkinseed are either rare or not known to prey heavily on juvenile anadromous fish.

What follows is a more detailed discussion of interactions between fish, birds, and mammals and spring chinook and summer steelhead in the upper Columbia basin.

Competition

Competition among organisms occurs when two or more individuals use the same resources and when availability of those resources is limited. That is, for competition to occur, demand for food or space must be greater than supply (implies high recruitment or that the habitat is fully seeded) and environmental stresses few and predictable. Two types of competition are generally recognized: (1) interference competition, where one organism directly prevents another from using a resource through aggressive behavior, and (2) exploitation competition, where one species affects another by using a resource more efficiently. Although competition is difficult to demonstrate, a few studies conducted within the upper Columbia basin indicate that competition may affect the production of chinook salmon and steelhead in the basin.

Chinook/steelhead

Perhaps the most likely form of interspecific competition would be between juvenile chinook and steelhead. Hillman et al. (1989) investigated the interaction between juvenile chinook and steelhead in the Wenatchee River between 1986 and 1989. They reported that chinook and steelhead used dissimilar daytime and nighttime habitat throughout the year. During the daytime in summer and autumn, juvenile chinook selected deeper and faster water than steelhead. Chinook readily selected stations associated with brush and woody debris for cover, while steelhead primarily occupied stations near cobble and boulder cover. During winter days, chinook and steelhead used similar habitat, but Hillman et al. did not find them together. At night during both summer and winter, Hillman et al. found that both species occupied similar water velocities, but subyearling chinook selected deeper water than steelhead. Within smaller streams, chinook were more often associated with pools and woody debris during the summer, while steelhead occurred more frequently in riffle habitat. Hillman et al. (1989) concluded that interaction between the two species would not strongly negatively affect production of either species, because disparate times of spawning tended to segregate the two species. This conclusion is consistent with the work of Everest and Chapman (1972) in Idaho streams.

Redside shiners

Under appropriate conditions, interspecific interaction may also occur between redside shiners and juvenile salmon and trout. Hillman (1991) studied the influence of water temperature on the spatial interaction between juvenile chinook and redside shiners in the field and laboratory. In the Wenatchee River during summer, Hillman (1991) noted that chinook and shiners clustered together and that shiners were aggressive to ward salmon. He reported that the shiners used the more energetically profitable positions, and that they remained closer than chinook to instream and overhead cover. In laboratory channels, shiners affected the distribution, activity, and production of chinook in warm (64-68°F) water, but not in cold (54-59°F) water (Hillman 1991). In contrast, chinook influenced the distribution, activity, and production of shiners in cold water, but not in warm water. Reeves et al. (1987) documented similar results when they studied the interactions between redside shiners and juvenile steelhead. Although Hillman (1991) conducted his fieldwork in the lower Wenatchee River, shiners are also present in the Entiat, Methow, and Okanogan rivers and are abundant in the mainstem Columbia River. At warmer temperatures, shiners likely negatively affect the production of chinook salmon and steelhead in the upper basin (BioAnalysts 2004).

Coho salmon

It is unknown if the re-introduction of coho salmon into the upper Columbia basin may affect the production of chinook and steelhead, although the results of extensive predation and competition studies associated with the YN's current reintroduction efforts indicate that the reintroduction of coho is unlikely to negatively affect production of chinook and steelhead. One of the first studies in the upper basin that addressed effects of coho on chinook and steelhead production was conducted by Spauling et al. (1989) in the Wenatchee River. This work demonstrated that the introduction of coho into sites with naturally produced chinook and steelhead did not affect chinook or steelhead abundance or growth. However, because chinook and coho used similar habitat, the introduction of coho caused chinook to change habitat. After removing coho from the sites, chinook moved back into the habitat they used prior to the introduction of coho. Steelhead, on the other hand, remained spatially segregated from chinook and coho throughout the study. More recent studies conducted by Murdoch et al. (2004) found that juvenile coho, chinook, and steelhead used different microhabitats in Nason Creek, and at the densities tested, coho did not appear to displace juvenile chinook or steelhead from preferred microhabitats (BioAnalysts 2004).

Various salmonids

It is possible that juvenile chinook and steelhead interact with bull trout, brook trout, and cutthroat trout if they occur together. Hillman and Miller (2002) observed chinook, bull trout, and brook trout together in several tributaries of the Chiwawa River and in the Little Wenatchee River. In tributaries of the Chiwawa River, Hillman and Miller (2002) observed chinook and juvenile bull trout in the same habitat. They report seeing bull trout and chinook nipping each other in Big Meadow, Rock, and Chickamin creeks. Usually the aggressive interactions occurred in pools near undercut banks or in woody debris. In contrast, Martin et al. (1992) investigated the interaction between juvenile bull trout and spring chinook in the Tucannon River, Washington, and found that the two species have different habitat preferences. Juvenile spring chinook occurred more often in open, slow- water habitat without complex hiding cover. Bull trout, on the other hand, more frequently used riffle and cascade habitat. Bull trout numbers inversely correlated with amounts of woody debris and the two species did not compete for food because food was not limiting in the Tucannon River (Martin et al. 1992).

Although Hillman and Miller (2002) observed juvenile chinook and brook trout together in many tributaries of the Chiwawa River and in the Little Wenatchee River, they did not see aggressive interaction between the two species. Welsh (1994), on the other hand, studied the interaction between the two species in Idaho streams and found that when chinook were introduced into a stream with brook trout, the latter was displaced into marginal habitat. Over a six-year period, Welsh (1994) notes that brook trout vanished from his study sites. No studies address the interaction between chinook and cutthroat trout. Although chinook and steelhead may interact with bull trout, brook trout, and cutthroat trout, there is no evidence that they will negatively affect the production of chinook and steelhead in the upper Columbia basin (BioAnalysts 2004).

Predation

Fish, mammals, and birds are the primary natural predators of salmonids in the upper Columbia basin. Although the behavior of various salmonids precludes any single predator from focusing exclusively on them, predation by certain species can nonetheless be seasonally and locally important. Recent changes in predator and prey populations along with major changes in the environment, both related and unrelated to development in the mid Columbia basin, have reshaped the role of predation.

Although several fish species can consume salmonids in the upper basin, northern pikeminnow, walleyes, and smallmouth bass have the potential for significantly affecting the abundance of juvenile anadromous fish (BioAnalysts 2004). These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Channel catfish also have the potential to significantly affect the abundance of juvenile salmonids, but because they are rare in the upper Columbia, they likely have a small effect on survival of juvenile salmonids there. Native species such as sculpins and white sturgeon also prey on juvenile anadromous fish. Below is a discussion on the importance of specific predators on the production of salmonids in the upper Columbia basin.

Sculpins

Sculpins are native and relatively common in the upper basin. Although sculpins are not considered a major predator of outmigrating anadromous fish, they do prey on small chinook and steelhead. In the Wenatchee River, Hillman (1989) noted that large concentrations (20 fish/11 sq. ft.) of juvenile chinook and steelhead occupied inshore, shallow, quiet- water positions on the streambed during the night. Hillman (1989) found that many sculpins moved into these areas at night and preyed heavily on chinook and steelhead fry. Predation on fry appeared to be limited to sculpins larger than 3.3 in. and ceased when prey reached a size larger than 2 in. The number of fry eaten per night appeared to be related to sculpin size, with the largest sculpins consuming the most fry per individual.

Because sculpins are abundant in upper Columbia River tributaries, they are likely an important agent of mortality of salmonid eggs and fry. As chinook and steelhead fry grow, they are released from this source of mortality. The fraction of the chinook and steelhead population removed by sculpins is unknown.

Various salmonids

Most adult salmonids within the upper basin are capable of preying on juvenile chinook and steelhead. Those likely to have some effect on the survival of chinook and steelhead include adult bull trout, rainbow/steelhead trout, cutthroat trout, brook trout, and brown trout. Because brown trout are rare in the region, they probably have little effect on the survival of other salmonids. The other salmonids often occur in the same areas as chinook and steelhead and are known to be important predators of chinook and steelhead (Mullan et al. 1992). Of these, bull trout and rainbow trout are probably the most important. These species occur together in most tributaries; hence the probability for interaction is high. The presence of both fluvial and adfluvial stocks of bull trout in the region further increases the likelihood for interaction there.

Bull trout are opportunistic feeders and will eat just about anything including squirrels, birds, ducklings, snakes, mice, frogs, fish, and insects, although adult migrant bull trout eat primarily fish. Because adult migrant bull trout occur throughout the upper basin, including the mainstem Columbia River, they likely prey on juvenile salmonids. In the upper Wenatchee subbasin, Hillman and Miller (2002) noted that juvenile chinook and steelhead were rare in areas where adult bull trout were present. Like northern pikeminnow, adult bull trout frequent the tailrace areas of upper Columbia dams. These areas provide concentrated prey items, which include juvenile chinook and steelhead. It is likely that adult bull trout prey heavily on migrant salmon and steelhead in these areas. Indeed, Stevenson et al. (2003) found bull trout staging near the Wells Hatchery outfall, apparently seeking opportunistic feeding opportunities. As the number of bull trout increase in the upper subbasin, the interaction between them and salmon and steelhead will increase (BioAnalysts 2004).

Rainbow/steelhead trout feed on chinook fry in the upper subbasin. In the Wenatchee River, for example, Hillman et al. (1989) observed both wild and hatchery rainbow/steelhead feeding on chinook fry. Predation was most intense during dawn to dusk. At that time, rainbow/steelhead occupied stations immediately adjacent to aggregations of chinook. Hillman et al. (1989) noted that within the prey cluster, the largest, light-colored chinook were closest to shelter and seldom eaten. Small, darker-colored chinook were farther from escape cover and usually eaten by predators. Hillman et al. (1989) suggest that predator-mediated interaction for shelter was strong and contributed to the rapid decline in chinook numbers in May. Although this work was done in the Wenatchee River, the results probably hold for other tributaries where the two species occur together.

Although adult salmonids prey on juvenile salmonids in the upper subbasin, the predation rate is unknown. Because of the abundance of both bull trout and rainbow/steelhead trout in the upper subbasin, it is reasonable to assume that large numbers of fry are consumed by these fish.

Birds

Currently, there is little information on the effects of bird predation on the abundance of juvenile salmon and trout in the upper subbasin. Fish eating birds that occur in the project area include great blue herons (*Ardea herodias*), gulls, osprey (*Pandion haliaetus*), common mergansers (*Mergus merganser*), American dippers (*Cinclus mexicanus*), cormorants (*Phalacrocorax spp*.), Caspian terns, belted kingfishers (*Ceryle alcyon*), common loons (*Gavia immer*), western grebes (Aechmophorus occidentalis), black-crowned night herons (*Nycticorax nycticorax*), and bald eagles (Haliaeetus leucocephalus). According to Wood (1987a, 1987b), the common merganser limited salmon production in nursery areas in British Columbia. He found during smolt migrations that mergansers foraged almost exclusively on juvenile salmonids (Wood 1987a). Maximum mortality rate declined as fish abundance increased (i.e., dispensatory mortality) and did not exceed 10% for any salmonid species. Wood (1987b) also estimated that young mergansers consumed almost one-half pound of subyearling chinook per day. Thus, a brood of ten ducklings could consume between four and five pounds of fish daily during the summer (BioAnalysts 2004).

Cormorants may take large numbers of juvenile salmon and trout in the upper subbasin. Roby et al. (1998) estimated that cormorants in the estuary consumed from 2.6 to 5.4 million smolts in 1997, roughly 24% of their diet, and most were hatchery fish. Although Caspian terns are not common in the project area, there is evidence that they consume fish from the project area. Bickford found both PIT-tags and radio tags at a Caspian Tern nesting area near Moses Lake. Tag codes indicated that consumed fish were from the upper Columbia region.

Mammals

No one has studied the influence of mammals on numbers of juvenile chinook in the upper Columbia basin. Observations by BioAnalysts indicate that river otters (*Lutra Canadensis*) occur throughout the region. BioAnalysts found evidence of otters fishing the Wenatchee, Chiwawa, Entiat, and Methow rivers, and Icicle Creek. Otters typically fished in pools with LWD. According to Hillman and Miller (2002), juvenile chinook are most abundant in these pool types, thus, the probability for an encounter is high. Dolloff (1993) examined over 8,000 otoliths in scats of two river otters during spring 1985 and found that at least 3,300 juvenile salmonids were eaten by them in the Kadashan River system, Alaska. He notes that the true number of fish eaten was much higher, as it is unlikely that searchers found all the scats deposited by the otters. Other predators, such as raccoon (Procyon lotor) and mink (Mustela vison) also occur in tributaries throughout the upper Columbia basin. Their effects on numbers of salmon and trout are unknown (BioAnalysts 2004).

Black bears (*Ursus americanus*) are relatively common in the upper Columbia basin and frequent streams used by spawning salmon during autumn. Studies have shown that salmon are one of the most important meat sources of bears and that the availability of salmon greatly influences habitat quality for bears at both the individual level and the population level. Observations by crews conducting chinook spawning surveys in the upper basin indicate that bears eat chinook, but it is unknown if the bears remove pre-spawned fish or are simply scavenging post-spawned fish. Regardless, there is no information on the roll that bears play in limiting survival and production of salmon and trout in the upper basin.

4.9 Aquatic Conditions

4.9.1 Introduction

The Wenatchee subbasin contains some of the most pristine habitat found throughout the Columbia River basin while also experiencing considerable habitat degradation in some drainages. The subbasin is very diverse in elevation and environmental conditions. For the purposes of this assessment, the Wenatchee subbasin has been dissected into 12 distinct Assessment Units, as illustrated in

In the upper Wenatchee subbasin, the Assessment Units include the Icicle Creek, Nason Creek, Little Wenatchee River, White River and Chiwawa River. These Assessment Units are all tributaries to the Wenatchee River and are characterized as being relatively high elevation, cool wet forest and relatively unaltered by human disturbances.

The Middle Wenatchee River (Tumwater Canyon to Lake Wenatchee) and Lake Wenatchee Assessment Units are also included in the upper Wenatchee subbasin. The Middle Wenatchee is primarily a steep, constrained canyon containing several smaller and highly variable tributary streams. Lake Wenatchee is a relatively large, oligtrophic (non-productive) lake that provides a unique environmental function within the Wenatchee subbasin.

The lower Wenatchee subbasin includes the mainstem of the lower Wenatchee River (mouth to Tumwater Canyon) and Mission, Peshastin and Chumstick creek assessment units. These Assessment Units are generally lower elevation, warmer dry forest types and grasslands that have been heavily altered by human disturbances.

The following describes the environmental and habitat conditions for each of the Assessment Units within the Wenatchee subbasin.

4.9.2 Assessment Methodology

The Qualitative Habitat Assessment (QHA) was developed for use by the NPCC subbasin planning process. The QHA is intended for use in stream environments at the subbasin scale. The QHA provides a structured, qualitative approach to analyzing the relationship between the focal species and habitat conditions. The assessment examines eleven environmental attributes considered important for biological productivity. Attributes are assessed for approximately 80 stream reaches within the Wenatchee subbasin.

The QHA relies on the expert knowledge of natural resource professionals and citizens with experience in a local area to describe physical conditions in the target stream. These individuals are also asked to describe how focal species may have used habitats in the past, and how fish distribution has likely changed as a result of changing habitat attributes. From this assessment, planners are able to develop hypotheses about the population and environmental relationships of the focal species. The ultimate result is a determination of the relative importance for restoration and/or protection management strategies at the watershed scale addressing specific habitat attributes.

The QHA is not viewed as a sophisticated analytical model. The QHA simply supplies a framework for reporting information and analyzing relationships between a species and its environment. It is up to local scientists, managers, and planners to interpret the results and make decisions based upon these relationships.

Rationale for Use

One of the primary objectives of the subbasin planning process is to provide a clear rationale for selecting management recommendations. Embedded in this discussion must be credible information (and assumptions) identifying key factors limiting biological productivity of focal species. The habitat characteristics used in the QHA methodology are similar to those attributes used by the federal regulatory agencies (NOAA Fisheries and USFWS) in evaluating federally funded project effects on habitat attributes important to ESA listed species. Therefore, QHA habitat attributes are intended to act as surrogates for those attributes used by the regulatory agencies to help ensure consistency and continuity between the subbasin plan and the biological assessments used by these agencies.

Currently, only the Ecosystem Diagnosis and Treatment (EDT) methodology has the power to describe biological productivity of the focal species as envisioned by the NPCC Technical Guide for Subbasin Planners. However, to adequately employ the EDT method requires a substantial commitment of time and resources necessary to develop the datasets and to run the EDT model. Due to significant constraints in budget and time, adequate resources were not available to the Wenatchee subbasin to appropriately develop a credible EDT model. Wenatchee subbasin planners chose to use the QHA because it is a simple means to organize and summarize a large amount of information and professional experience.

Development of the QHA

Subbasin planners chose to view the assessment as a tool for examining three fundament questions:

Where have significant habitat changes occurred since the historic reference condition?

What changes are thought to have most significantly affected the distribution /abundance of focal species (sub-populations within the watersheds)?

Where are the greatest opportunities to protect and / or enhance habitat attributes that will potentially provide the greatest benefits to fish populations within the subbasin?

Stream reaches and the QHA habitat rating values were described by the Habitat Technical Team and will continue to be reviewed (and modified as needed) by all interested community stakeholders. Current and historic habitat conditions were described by ranking eleven habitat attributes for each of the stream reaches. Additionally, current and historic focal species distribution was described by ranking focal species use for each of the stream reaches. The QHA values were compared to existing information to insure accuracy and consistency.

Shortcomings of the QHA

The QHA methodology has shortcomings to adequately describe environmental conditions and biological responses. One of the primary objectives of the QHA is simplicity, which is inherently contrary to the complexity of the environmental and population relationships that we are trying to describe. From the onset, it was obvious to subbasin planners that the existing definitions were inadequate and confusing. Definitions for attribute ratings were revisited on several occasions throughout the process.

There are two fundamental problems associated with the QHA approach. From a biological perspective, the habitat attribute ratings must be related to some defined quality, i.e. the attribute is good or poor compared to what species? In general, attribute ratings were related to the generic salmonid, however habitat needs are known to be very different for different species and for different life stages within a particular species.

Secondly, from a physical perspective, habitat attributes are difficult to compare between geographic areas because the inherent capacity of the habitats (geology, gradient, stream or floodplain width, etc.) are typically very different. Specifically, habitat attributes can be evaluated by their inherent capacity (in which all historic values are rated excellent) or habitat attributes are compared across a landscape (in which certain attributes for tributary steams rarely can rate high compared to mainstem reaches). In either case, simplification of the classification scheme undermines the complex and important relationships that we are striving to understand.

In spite of these problems with the QHA, the tool was useful to focus and organize the development of the assessment and provide subbasin planners with a clearer and holistic perspective of the subbasin and various Assessment Units.

Related Assessments

- U.S. Forest Service Biological Assessments (various years)
- U.S. Forest Service Watershed Assessments (various years)
- Channel Migration Zone Study (2003)
- Lake Wenatchee Storage Feasibility Study
- Regional Technical Team Biological Strategy (2004)
- Limiting Factors Analysis (2001)
- Wenatchee River Basin Watershed Assessment (August 2003)
- Subbasin Summary (October 2001)
- Aerial Surveys in the Wenatchee River Basin - Thermal Infrared and Color Videography (2003)
- USFWS Draft Bull Trout Recovery Plan, USFWS 2004: White Paper: Proposed Critical Habitat for the Mainstem Columbia River, Mid-Columbia HCP, etc.

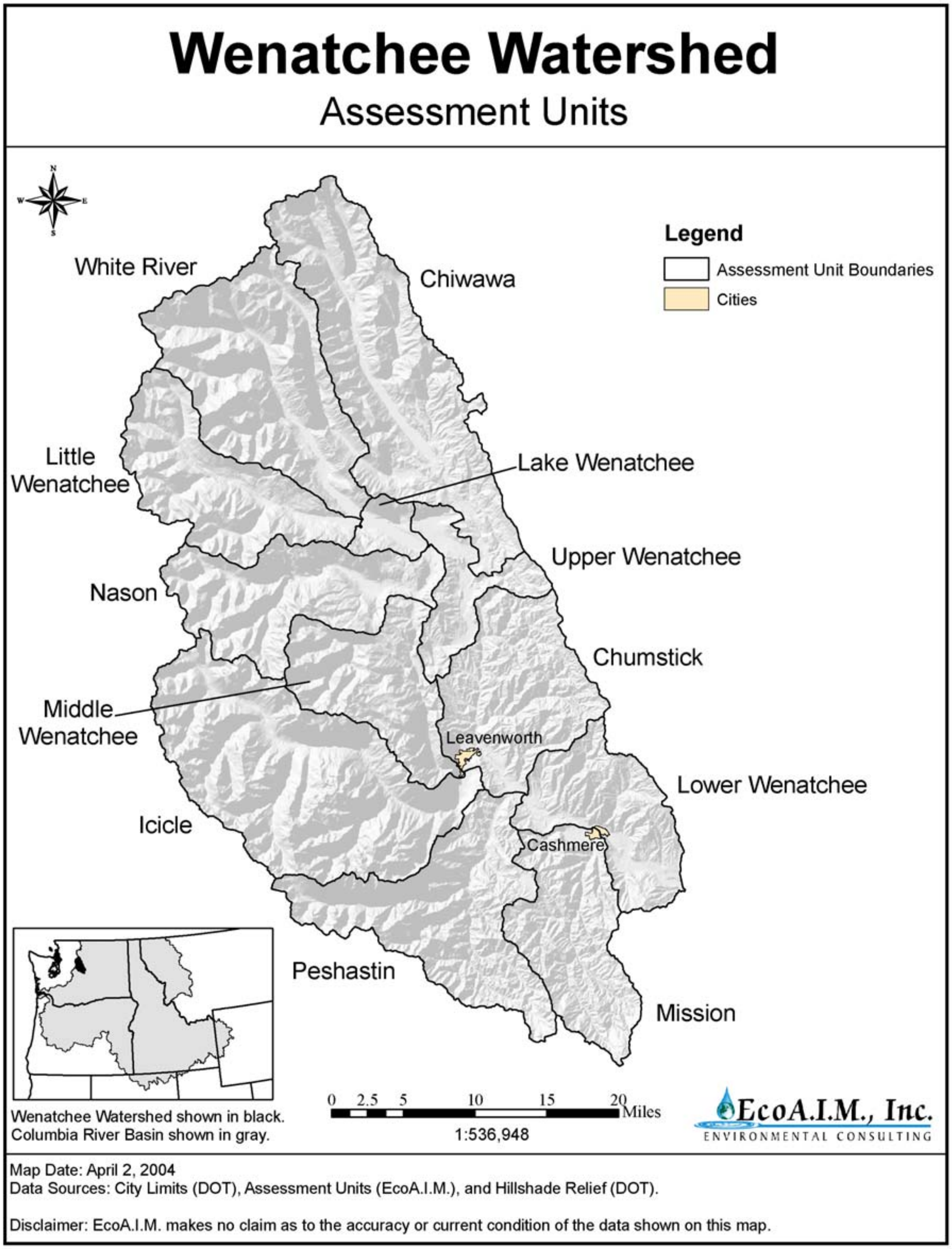

Figure 17. Assessment units in the Wenatchee subbasin

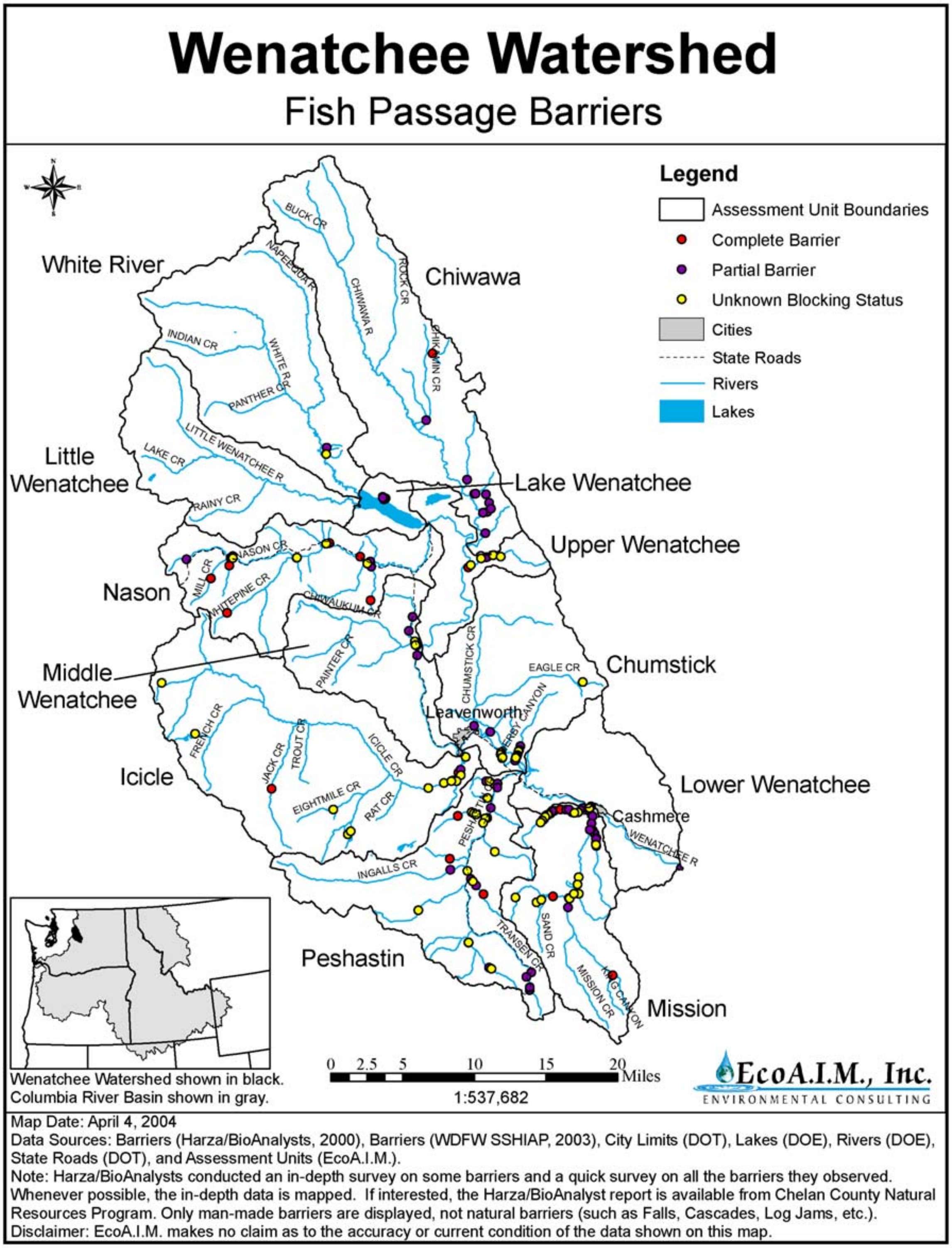

Figure 18. Fish passage barriers

4.9.3 Lower Wenatchee River Assessment Unit

Assessment Unit Description

The lower portion of the Wenatchee River begins at RM 25.6 (below Tumwater Canyon at RM 27) and flows southeasterly from the town of Leavenworth to the Columbia River. Mission, Peshastin, Chumstick and Icicle Creeks are the main tributary watersheds that join the lower mainstem (Icicle Creek will be described in the Upper Wenatchee Assessment Unit due to its ecological and geologic similarities to upper subbasin tributaries). Derby Creek, the only lesser tributary that contains anadromous fish, joins the lower Wenatchee at RM 19.0. Derby Creek contributes less than 0.1% of Wenatchee River flow (USFS 2003) The lower Wenatchee River area is within a rain shadow on the east side of the Cascades with mean annual precipitation ranging from 15 to 49 in. Most precipitation falls as snow in the winter (USFS 1999b, Andonaegui 2001).

The lower Wenatchee and the lower portions of its small tributaries including Derby, Hay, and Ollalla, have private development along the entire valley bottom with forest service ownership occurring in the upper elevations. Forest service lands are designated as matrix except for the Eagle Managed Late Successional Areas (MLSA) in the upper portion of the Chumstick and Derby creek sub watersheds (USFS 1999a).

The lower Wenatchee River flows through a floodplain formed by glacial melt waters and subsequent overbank floods. Included in the floodplain are alluvial fan sand terraces that are elevated by stream down cutting. The folded interbedded sedimentary rocks are controlling the shape of the land surface. Bedrock exposures are common. Resistant sandstone beds form predominant ridges while the stream network has downcut into weaker rock forming V-shaped valleys. The weakly cemented bedrock weathers rapidly to sand-sized grains (USFS 1999b, Andonaegui 2001).

Assessment Unit Condition

The lower Wenatchee River is rated Class A (excellent) by the State of Washington from Leavenworth to the confluence with the Columbia River. Some habitat and water quality problems have been identified and documented for this reach.

Settlement began in 1890 with the construction of the Great Northern Railroad along the Wenatchee valley bottom. This was followed by flood plain development, irrigation diversion structures, and bank armoring. Over a century of use has reduced in-stream large woody debris (LWD) and LWD recruitment, and reduced side channel/wetland habitat as well as the opportunity for development of side channel/wetland habitat. To varying degrees, the altered riparian and channel conditions have also reduced pool frequency, increased bank erosion, possibly increased channel entrenchment in localized stream reaches not naturally confined by glaciofluvial terraces, altered the sediment transport regime, and altered the natural flow regime. Stream diversions and well withdrawal from shallow aquifers in the floodplain probably have the greatest influence on low stream flows. Channel confinement, channelization, and riparian and upland land use impacts probably have the greatest influence on peak flow timing and duration. Actual identification and quantification of the causes and effects, however, are complex and problematic (USFS 1999b, Andonaegui 2001).

Depending on species needs, steelhead, spring and late-run chinook, bull trout and sockeye use the lower Wenatchee River for migration, rearing, spawning and over-wintering. The Wenatchee River provides essential connectivity for migratory bull trout traveling between Wenatchee River subbasin populations, and possibly other subbasin populations in the upper Columbia River ESU.

Riparian/Floodplain Condition and Function

Riparian Condition

As a result of riparian roads, riparian harvest, and private development and agriculture within riparian areas, Derby Creek and the lower Wenatchee River are in poor condition relative to riparian reserves.

The lower Wenatchee River riparian is in poor condition due to development of the floodplain and the presence of State Hwy. 2. The river still maintains some ponds and back water, but the presence of roads, railroads, towns, development, and agriculture have confined the lower portion and reduced the degree of accessibility.

Along its entire length 35% of the bank is confined by the railroad, 31% is entirely cleared, 19% is rip-rapped, and 16% is in a natural vegetated state. Fifty-seven percent of the bank area with little riparian vegetation is eroding, and 14% of the rip-rapped sections are eroding (USFS 1999b).

Stream Channel Conditions and Function

Channel Condition and High Flow

Channelization of some tributaries to the lower Wenatchee River and floodplain development in the mainstem corridor have degraded floodplain functions. Flood control measures in reaches not naturally confined by glaciofluvial terraces have contributed to the loss of functioning floodplain habitat. The altered riparian and channel conditions have also reduced instream LWD and recruitment, pool frequency, and side channel/wetland habitat and the opportunity for development of side channel/wetland habitat. Conditions have also increased bank erosion and possibly increased channel entrenchment instream reaches not naturally confined by glaciofluvial terraces, as well as altered the sediment transport regime the natural flow regime. Combined, these factors have likely had some of the largest impacts on the fishery resource on the mainstem Wenatchee River, limiting the use of alternate channels and access to the floodplain to disperse high flows (Andonaegui 2001).

Fine Sediment and Channel Stability

Sediment filling of pools is a problem in depositional reaches of the lower Wenatchee River, especially downstream of drainages with high sediment output. Sediment transport in the lower Wenatchee River is reduced by the back water influence of Rock Island Dam reservoir pool on the Columbia River (RM 453.4). As a result of the pooling effect caused by higher water levels upstream of Rock Island Dam, substrate in the first several hundred meter reach above the Columbia has formed a uniform stream bottom of gravel and sand, along with quiet surface water (Andonaegui 2001). In areas of the lower Wenatchee River where spawning material is available for steelhead and spring chinook, the level of fines is believed to exceed 20% (Andonaegui 2001).

Derby Creek substrate is in poor condition due to the abundance of sand in streams which may be related to the amount and location of native surface roads next to Derby Creek. Due to development and location of roads, Derby Creek is poor condition with pool-forming wood recruitment low and pool infilling occurring from high sediment loads and channel function impairment (USFS 2003).

Habitat Diversity

Off-channel habitats are severely lacking channel complexity and riparian condition has been negatively impacted over time from historic log drives and floodplain/streamside development resulting in reduced riparian and wetland connectivity. Off-channel habitats are further impacted by a loss of aquatic species connectivity through wetlands, reduced high flow refuge, reduced sinuosity and side channel development, increased bank erosion, reduced LWD and LWD recruitment, reduced pool frequency, and a reduction in channel roughness (USFS 1999b).

The lower Wenatchee refugia is in poor condition from development which has reduced channel complexity, off-channel habitat, and connectivity of minor tributaries. Private development restricts the river’s access to its historic floodplain in many areas.

The majority of the entrenchment in the lower Wenatchee is a result of post-glacial down cutting through glacial fluvial deposits, however, where the river has been encroached upon State Hwy. 2 and other development, this may have contributed to localized channel entrenchment. Overall, human land use has not been the major influence in down cutting of the channel in the lower Wenatchee River. Likewise, although bank erosion has been exacerbated by land-use activities in some reaches of the lower Wenatchee River, increased sediment loading resulting directly from eroding banks is not significant at the lower Wenatchee River level (Andonaegui 2001).

Where glacial out wash and flood deposits have created terraces in the main valley, the mainstem channel morphology is shaped by fluvial downcutting through sedimentary rocks and terraces of the Chumstick formation. The stream substrates are fairly homogenous and riffle habitat predominate. The channel is naturally constrained by alluvial fans and bedrock in a few places. Scattered sandstone outcrops occur throughout. These bedrock shelves are the primary pool forming feature. Pool formation is also naturally associated with LWD, however LWD is lacking in this portion of the river, and may result in a lower pool frequency than would exist in a functioning system. The river is confined by orchards, roads, railroads, towns and bridges. Most old floodplain areas are no longer accessible or have been heavily altered by orchards. Off channel habitats are severely lacking. This is also likely the cause of the lack of woody debris. Velocities during high flows have likely increased, and wood that could be trapped into logjams is washed through the system.

Water Quality

Temperature

The lower Wenatchee River is on the WDOE 1998 303d listing for temperature. Point measurements at Peshastin and Monitor, Washington have exceeded desired values 7 times since 1991 for steelhead trout migration and rearing. During the same time period temperatures exceeded upper limits for spring chinook spawning and incubation at least 4 times at Peshastin and Monitor. High temperatures are usually observed in the months of July and August, potentially affecting bull trout migration, as well as the migration and rearing of steelhead trout (USFS 1999b).

Oxygen/Pollutants

The lower Wenatchee River is on the WDOE 303d list for pH and dissolved oxygen.

Water Quantity

Low Flow

The lower Wenatchee River is on the 303(d) listing for instream flow. Out-of-stream water use has resulted in reduced stream flow rates and modified season runoff patterns downstream of Tumwater Canyon. Additionally, road density and location has increased the drainage network (USFS 1999).

In years of low snowpack, water withdrawals for irrigation and domestic use impact salmonid spawning and rearing habitat downstream of Dryden Dam. While the percentage of flow diverted is small in June and July, it may be significant in August through mid October of average water years, and may leave lethal impacts to juvenile salmonids in the fall of a dry year. Minimum flows have been established for the mainstem Wenatchee River however, the Columbia River Inter-Tribal Fish Commission (CRITFC) has stated that the minimum flows are not adequate to realize the spawning potential of the existing habitat (Andonaegui 2001).

From the mouth upstream to Tumwater Canyon, including tributaries to this portion of the mainstem that are not addressed as separate 5th field HUC watersheds, there are 105 surface water rights permits or certificates worth a potential total diversion of 43.8 cfs. There are 204 surface water rights claims worth a potential total diversion of 411.6 cfs. There are 11pending applications for surface water rights permits, certificates, or claims worth a potential total diversion of 5.1 cfs. There are 145 ground water rights permits or certificates worth a potential total withdrawal of 10,520 gallons per minute (gpm). There are 771 ground water rights claims worth a potential total withdrawal of 15,120 gpm. There are 13 applications for ground water rights permits, certificates or claims pending worth a potential total of 444 gpm (Montgomery et al. 1995).

Obstructions to Fish Passage

The Dryden Dam (RM 17.0), an 8-foot high irrigation diversion dam, was constructed along with the Highline Canal to provide for the water supply to the Wenatchee Reclamation District. Dryden Dam currently has a fish ladder to facilitate passage. There remains speculation if this structure currently poses a migration delay to some salmonids (Andonaegui 2001).

Derby Creek has a barrier to nearly all fish passage near the mouth, and 3 small constructed ponds that block passage upstream. Therefore (USFS 2003; USFS 1999b).

Ecological Conditions

Steelhead have been observed as far as 3 mi. up Derby Creek , although their occurrence is attributed to strong swimming individuals passing known passage barriers (BioAnalysts 2004). The sub watershed stock in Derby Creek is in poor condition, and may be nonexistent except for occasional strong swimming strays.

Environmental/Population Relationships

The lower Wenatchee is a crucial migration corridor for spring chinook, bull trout, and steelhead. Although stream conditions may not be pristine and passage may be delayed it is not impassable. Bull trout spawning populations are among the highest in the mid Columbia basin. Declines in spring chinook spawning seems linked to a larger spatial phenomenon, mirroring patterns throughout the Wenatchee subbasin. Spring migrating steelhead adults are not exposed to late summer stream temperatures. Rearing habitat for steelhead and chinook may be affected in the lower tributaries and the lowermost mile of the Chiwawa, but substantial and spatially dispersed rearing areas in the upper watershed mitigate these losses. Brook trout may displace rearing steelhead in the lower watershed.

Areas of Special Interest

- Existing riparian habitat and channel migration floodplain function is critical to maintaining focal species productivity.
- Flood-prone areas of the lower Wenatchee River, particularly from the Mission Creek confluence (RM 10.4) downstream to the Columbia River confluence provide important side-channel and off-channel habitats for many species
- Floodplain stranded by developments where access can be reestablished, and important high-flow refugia habitat in side channels and wetlands that were cut off from the river because of High way 2 placement.

Limiting Factors

- Land development, state high way and railroad affects channel migration, woody debris recruitment, and gravel recruitment
- Riparian habitat and off-channel habitat have been significantly lost or degraded
- Late summer instream flows are often critically low throughout this reach
- Floodplain function has been impaired by development, causing extremes in the peaks and nadir of the hydrograph
- Stream temperatures often exceed regulatory standards, which is contributed to by riparian habitat loss and low instream flows.
- Late summer instream flow and temperature affects salmonid juveniles
- There is a high level of concern about impacts of land development on this stream reach

Data Gaps

- The relationship between stream flows and habitat quantity on the Wenatchee River from Tumwater Canyon downstream to the mouth is important to understand potential fish use under various flow scenarios.
- The relationship between stream flow and effects on temperature in the mainstem Wenatchee River.

- The effect of high water temperatures on anadromous salmonids and bull trout migration, spawning, incubation, and rearing in the mainstem Wenatchee River.
- Contaminants are a potential limiting factor, but it is unknown to what degree these effect fish health
- Bull trout distribution and seasonal use

Functional Relationship of Assessment Unit with Subbasin

The lower Wenatchee Assessment Unit is a Category 2 watershed (see Determination of Restoration Priorities in Section 6.5 of this document) and has two significant sub- watersheds. With the exception of cutthroat and bull trout, habitat condition in the mainstem Wenatchee have very high potential to affect salmonid fish production in the Wenatchee River subbasin as a whole. In addition to providing a migratory corridor, the mainstem provides essential rearing habitat for chinook, coho and steelhead juveniles (BioAnalysts 2004).

4.9.4 Middle Wenatchee Assessment Unit

Assessment Unit Description

Tumwater Canyon

This middle portion of mainstem channel from river mile (RM) 25.6 to 35.6 has gradient less than 2%. Debris flow deposits, particularly coarse sediments, in the narrow V-shaped valley create dramatic local morphological adjustments. When cobbles and boulders are input, the river increases gradient as it cuts through the deposits. As a result the river character changes sharply between long, deep pools and cascading, rapids type riffles. Large boulders form pocket pools and step pools. Alluvial fans form at the base of some of the debris flows creating lateral or elevational channel controls and also delivering LWD. The narrow valley floor has limited floodplain development. During flood flows, material from the fans is eroded a way and raw banks are exposed.

Chiwaukum Creek

The Chiwaukum drainage is a 4th order stream with 50 sq. mi. (32,779 acres) and located northwest of Leavenworth. Chiwaukum Creek flows into the Wenatchee River near the head of Tumwater Canyon and contributes approximately 20% to the Wenatchee Rivers flow (Andonaegui 2001). Elevation at the mouth is 1,666 ft. Chiwaukum Creek is a pool-riffle channel in its lowest segments, predominantly a step-pool system in the middle sections, and cascading in its head waters (Andonaegui 2001). The only tributary known to support anadromous salmonids in the Chiwaukum Creek drainage is Skinney Creek. Skinney Creek is 6,925 acres and flows into Chiwaukum Creek at RM 0.6. Average annual precipitation in Skinney Creek ranges from 35 in. near the mouth to 50 in. at higher elevations (Andonaegui 2001). The Chiwaukum watershed is mostly located within the boundaries of the Alpine Lakes Wilderness and is managed by the USFS. Most of Skinney Creek is owned by Longview Fibre Company.

Wenatchee River above Tumwater Canyon

In the upper mainstem from the mouth of Lake Wenatchee at RM 54 down to Tumwater Canyon at RM 35.6, glaciation has created a thick mantle of till covering lower ridges and valley walls. Valley floors have glacial out wash deposits and valley bottom till contributes greatly to the formation of wetlands. Glacial till is linked to ground water storage and remnant channel locations, and the most species richness in the watershed. The upper river is meandering and only moderately confined. Ponds, marshes and overflow channels may be frequent at localized points. Subsurface flow through the landtype is relatively high, with subsurface and instream flow in continuity adjacent to streams. Primary disturbances are fire, debris slides, and seasonal flooding (Andonaegui 2001). A combination of terraces and log drives in the early part of the last century likely rendered LWD low in this reach.

Assessment Unit Condition

Tumwater Canyon

River character has been modified over time by railroad construction dam construction, log drives, and high way construction. During railroad construction in the 1800s, the canyon bottom was narrowed and large boulders were removed, possibly resulting in channel degradation (Andonaegui 2001). Tumwater Dam at RM 31, built in the early 1900s, has altered channel bed grade and substrate content above and below the structure, creating Lake Jolanda. Log drives in the early 20th century removed LWD in the channel and blasted boulders from the channel to facilitate log drives.

Chiwaukum

Chiwaukum is largely unaltered by human land use. The campground situated at the mouth of Chiwaukum Creek lies in the alluvial fan, and the stream has been channelized restricting channel migration in this reach. Spawning and rearing production in the impacted reach has likely been reduced by the channel alterations. This area supports spring chinook and steelhead spawning and rearing along with limited late-run chinook rearing while also serving as a corridor to head water spawning and rearing habitat for bull trout. The Wenatchee Watershed Assessment describes Skinney Creek as severely impacted by the railroad, high way, farming, and timber harvest. Fish barrier culverts near the mouth impede fish passage into Skinney Creek (Andonaegui 2001).

Wenatchee River above Tumwater Canyon

Channel complexity and riparian condition has been altered over time from historic log drives and floodplain and streamside development. Results of this activity include reduced riparian and wetland connectivity, a loss of aquatic species connectivity through wetlands, reduced high flow refuge, reduced sinuosity and side channel development, increased bank erosion, reduced single pieces and complexes of LWD, reduced pool frequency, and a reduction in channel roughness. Anthropogenic factors affecting the upper Wenatchee subbasin include private home building and associated private land development; timber harvest on both private and federally owned lands, farming and associated land conversion, and the construction of state high ways, county roads, and logging roads.

Riparian/Floodplain Condition and Function

As a result of railroads, roads, harvest, and private development and agriculture within riparian areas, the middle and upper Wenatchee River riparian reserves are fair condition. Function and condition has been simplified by these uses (USFS 1999). Some loss of riparian vegetation associated with Tumwater campground at the mouth and dispersed camping sites located further upstream, has increased streambank erosion locally, however the channel itself has remained relatively stable. The location of Tumwater campground limits the natural migration of Chiwaukum Creek over its floodplain, and flood control measures have been taken to protect the campground (Andonaegui 2001).

Skinney Creek, the one tributary to Chiwaukum Creek known to support steelhead and rainbow trout anadromy and spring chinook rearing, was greatly altered by the railroad during the first part of the 19th century and subsequently, by State Hwy. 2. Passage into Skinney Creek is blocked by USFS road culverts at RM 0.25 and RM 1.5. In addition, high overall road density (3.4 mi./sq. mi.) in the watershed, with a substantial portion of the roads lying in riparian areas, and private land ownership in the stream bottom, with resulting agriculture and timber harvest, has combined to limit fish habitat by decreasing woody debris input, increasing sediment input, and potentially reducing migratory corridors.

Stream Channel Conditions and Function

Channel Condition and High Flow

Flow Substrate and channel conditions are fair in Tumwater Canyon. Major channel forming elements are still intact (USFS 1999a). Narrowing by the high way, and boulder and wood removal have likely caused channel degradation and higher flow velocities (Andonaegui 2001). Tumwater Dam has changed substrate composition locally above and below the dam.

Fine Sediment and Channel Stability

Observations of the Wenatchee River indicate that boulders and bedrock are the dominant substrate in much of Tumwater canyon and the upper reach. Historic log drives and stream cleaning to facilitate the drives may have altered the substrate. Substrate in the Wenatchee River is considered to be in fair condition. Fine sediment appears to be high in Skinney Creek, and may have been historically high due to the natural geomorphology of the area (USFS 1999a). Current levels, however, are probably related to the construction of the railroad and State Hwy. 2 during the early part of the 1900s, as well as combined with agriculture and timber harvest practices (Andonaegui 2001).

Habitat Diversity

Above Tumwater Dam, there is a lack of high quality cover and refugia, and a lack of diverse habitat types especially along the stream margins (USFS 1999a). The Wenatchee River is in fair condition for refugia due to development which has reduced channel complexity, off-channel habitat, and connectivity of minor tributaries (USFS 1999a). Access to acceptable refugia areas in Tumwater Canyon, Chiwawa River, White River, Chiwaukum and possibly Ingalls Creeks is available. Tumwater Canyon is thought to be in good condition with respect to pools, since in this bedrock-controlled canyon, the dominant mechanisms of pool formation (substrate and gradient) remain largely intact (USFS 1999a). The rest of the Wenatchee River below Lake

Wenatchee is in fair condition. This reach lacks LWD, an important pool-forming agent in these channel types. This section is also confined by roads, railroads, towns and agriculture, pressure that reduces pool frequency and quality.

Water Quality

Temperature

Chiwaukum Creek is on the WDOE 1998 303d list for temperature exceedences and has had 10 recorded excursions beyond state criteria (WDOE 1998). There are presently not enough data to determine if these temperatures are significantly different than temperatures in the historic range, however, or to what extent, if any, these temperatures negatively impact salmonid migration, spawning, incubation or rearing. Most of the drainage is contained in federally designated wilderness and the channel has not been greatly exposed to solar radiation as a result of land management practices (Andonaegui 2001).

Water Quantity

Low Flow

On Chiwaukum Creek the effects of the diversions and withdrawals, both individual and cumulative, on instream habitat conditions are undetermined at this time. There are 3 surface water rights permits or certificates worth a potential total diversion of 0.5 cfs. There are 3 surface water rights claims worth a potential total diversion of 0.4 cfs. There are no pending applications for surface water rights, certificates, or claims. There is 1 ground water rights permit or certificate worth a potential total withdrawal of 50 gpm. There are 2 ground water rights claims worth a potential total withdrawal of 15 gpm. There are no applications for ground water rights permits, certificates or claims pending (Andonaegui 2001). Neither Chiwaukum nor Skinney creeks have been observed to de water in the lower 2.1 mi. (Andonaegui 2001).

Obstructions to Fish Passage

Tumwater Dam blocks the Wenatchee River and lays within the Tumwater Canyon. This dam does have a fish ladder and in the past has hindered migration at certain flows. Recent modifications to passage facilities may have relieved these passage problems.

There are multiple barriers throughout tributary streams with limited fish passage in this assessment unit. Major passage issues are listed below.

Chiwaukum Creek

From the mouth upstream to about RM 0.6, where the stream flows beside the Tumwater Campground. At low flows campers have been observed to build up small dams using the cobbles in the stream bed, to pool water. This may disrupt fish passage.

At low flows, the drop structure under the State Hwy. 2 crossing downstream of the Skinney Creek confluence at RM 0.6 may negatively impact juvenile salmon fish passage if the drop at low flow exceeds one foot in height. In the mid 1990s, a concrete drop structure was constructed at the bridge crossing to protect against bridge scour. This structure may be hindering passage. It is not certain, however, to what extent if at all, this location may be a partial barrier. In low flow years, spring chinook and migratory bull trout have been observed above the State Hwy. 2 crossing.

An old log diversion dam, two old pipes, and a water intake box, previously located at RM 0.7, were removed August 2001. The two pipes had continued to spill water back into Chiwaukum Creek. The status of this diversion is unknown.

At RM 4.3 there is a natural falls that is a barrier to spring chinook upstream passage. Bull trout have been observed above this falls up to another barrier at approximately RM 6.5 (Andonaegui 2001).

Ecological Conditions

Recent surveys in Chiwaukum Creek have found brook trout to be present. Numbers of brook trout pose a potential threat to the long term persistence of bull trout in this stream. (USFWS, 2003).Chiwaukum Creek drainage supports limited bull trout production. Anadromy on Chiwaukum Creek is naturally limited by an impassable falls at RM 4.3. Stream channel morphology limits anadromous salmonid use in the drainage to rearing in Chiwaukum and Skinney Creeks, except for some spawning in the lower 4.3 mi. of Chiwaukum Creek.

The presence of juvenile coho salmon in Chiwaukum Creek indicates that some adults originating from a reintroduction pilot project and returning in 2000 have successfully spawned either in Chiwaukum, or upstream of this tributary (USFWS 2003).

Environmental/Population Relationships

Steelhead, rainbow trout, Bull Trout and spring chinook are known to spawn and rear in Chiwaukum Creek up to a barrier falls at RM 4.3. Bull trout have been observed upstream of the RM 4.3 to the next falls at RM 6. In Skinney Creek, rainbow trout, steelhead and spring chinook rearing occurs but is restricted to the lower 0.25 mi. by an impassable culvert on USFS Road 7908. Bull trout are not present in Skinney Creek. Given its elevation and geomorphology, the habitat is more optimal for rainbow trout and steelhead than for bull trout (Andonaegui 2001).

Habitat in the watershed above Chikamin Creek (RM 13.7) is largely pristine. This portion of the watershed provides 90% of the chinook spawning, the majority of the bull trout spawning, a substantial portion of the chinook rearing, steelhead rearing, and bull trout rearing. This reach also contains the most genetically pure and possibly the strongest cutthroat populations (Andonaegui 2001; Haskins 1998).

The watershed is a crucial migration corridor for chinook, coho, sockeye, bull trout, and steelhead. Although stream conditions may not be pristine, passage in the mainstem is rarely hindered. Bull trout spawning populations are among the highest in the mid Columbia basin. The decline in spring chinook spawning seems linked to a larger spatial phenomenon, mirroring patterns throughout the Wenatchee subbasin. Spring-migrating steelhead adults are not exposed to late summer stream temperatures.

Areas of Special Interest

- The mainstem river provides key spawning and rearing habitat for chinook, coho and steelhead for this subbasin.
- The upper mainstem between Lake Wenatchee and the Chiwawa River confluence provides key habitat for most focal species (except cutthroat trout).

- Chiwaukum Creek provides a significant amount of cool water to the mainstem Wenatchee River flow, as well as key bull trout habitat.
- Beaver Creek provides steelhead/redband trout habitat and lends to structural diversity for this species

  Limiting Factors

- The state high way negatively affects riparian function and LWD recruitment, which influences habitat diversity within the mainstem channel.
- Fish passage barriers exist in tributary streams.

Data Gaps

- The effect of high water temperatures on anadromous salmonids and bull trout migration, spawning, incubation, and rearing in the mainstem Wenatchee River
- It is not understood how roughness elements placed on the Tumwater Dam apron to protect State Hwy. 2 may affect smolt outmigration.
- Distribution and abundance of Bull Trout populations have not been determined.
- Effects of Tumwater Dam on sediment transport and habitat diversity.

Functional Relationship of Assessment Unit with Subbasin

The middle Wenatchee mainstem is a Category 1 (see Determination of Restoration Priorities in Section 6.5 of this document) watershed with two significant sub- watersheds, Tumwater Canyon and Chiwakum Creek (important cutthroat and bull trout habitat). With the exception of cutthroat and bull trout, habitat condition in the mainstem Wenatchee has the very high potential to affect salmonid fish production in the Wenatchee River subbasin as a whole. In addition to providing a migratory corridor, the mainstem provides essential rearing habitat for chinook, coho and steelhead juveniles (BioAnalysts 2004).

4.9.5 Mission Creek Assessment Unit

Assessment Unit Description

The 59,712 acre Mission Creek watershed in North Central Washington is located approximately 10 mi. west of the city of Wenatchee in Chelan County. Mission Creek is the main stream course in the watershed, flowing 9.4 mi. before emptying into the Wenatchee River (RM 10.4) at the town of Cashmere. This relatively narrow drainage trends in a north-south direction, with the eastern ridge defining the edge of the Columbia River Breaks. Elevations range from 795 ft. in Cashmere to 6,887 ft. near Mission Peak in the head waters. The average annual precipitation is 19 in. with the Mission Creek watershed, contributing 1% of the average annual flow of the Wenatchee River. (Andonaegui 2001).

Topography is characterized by steep slopes, dissected by perennial and intermittent stream channels. Unstable soils derive from the native Swauk and Chumstick sandstone formations. Soils are generally shallow and light textured, except for the alluvial plain in the lower watershed. The stream is deeply incised and has an average slope in excess of 100 ft. per mile in the lower reaches, and over 300 ft. per mile in the upper reaches. The USFS manages 78 % of the watershed, with the remaining 22% in privately ownership (Andonaegui 2001).

Assessment Unit Condition

Mission Creek is considered to be the most polluted water body in the Wenatchee River subbasin.

Cumulative disruption of both stream channel and upland habitat throughout the watershed, except in the Devils Gulch reach of Mission creek, has resulted in a declining population of spring chinook and steelhead since the mid 1880s (Rife 1999). Habitat conditions that limit access and reduce rearing habitat in the watershed include de watering, low flows, and high instream temperatures. (Andonaegui 2001). Diversion dams and culverts also create fish passage barriers that reduce access to spawning and rearing habitat. Floodplains have been separated from the stream channels and channels have been altered by forest roads, urban, agricultural, and residential development. Channelized streams have eliminated or reduced woody riparian vegetation to a narrow band of mostly shrubs and with some mature trees. Conditions in this controlled stream system are aggravated by high sediment loads and soil compaction associated with timber harvest and agricultural activities (NRCS 1996, Andonaegui 2001).

Anadromous fish expected in the creek include chinook, steelhead and lampreys. Adult anadromous fish may be able to travel up Mission and Brender creeks during spring and fall flows, although several irrigation diversions block passage during the irrigation season. High sediment loads, peak flows, and pre-spawning water temperatures as well as limited adult resting habitat are problems for anadromous fish. Juvenile chinook, rainbow trout, and steelhead do rear and over-winter in Mission and Brender creeks (BioAnalysts 2004).

Riparian/Floodplain Condition and Function

Riparian Condition

Mission Creek riparian and floodplain condition is poor. Although narrow valleys constrain some mid basin stream reaches, riparian habitat on private land has been mostly converted to orchards, pasture, or hay production. A narrow band of cottonwood and shrubs adjacent to the confined channel has been left. Conversion of riparian habitat to urban/rural/residential development, also simplifies the riparian zone and separates the channel from the floodplain (Andonaegui 2001; USFS 2003).

County Road 11 and USFS Road 7100, closely parallel the lower 17.0 mi. of the creek, reducing streamside vegetation and often restricting lateral channel migration. The riparian zone along the streambanks is narrow, quickly giving way upslope to dry ponderosa pine vegetation types. Timber harvest, road building, agricultural encroachment and urban development have greatly reduced the natural vegetation, especially large conifers that might have occurred near the stream side (Andonaegui 2001).

Historically, LWD from adjacent stands was more plentiful and the riparian zone vegetation, while dominated by brush in the immediate riparian zone, had a high component of large Ponderosa pine and Douglas fir. Due to historic logging and road building, there is a lack of LWD in the mainstem streams (USFS 2003).

Off channel habitat in Mission, Sand, Little Camas Creek, and East Fork Mission creeks is lacking due to the influence of the road system and channel degradation that has stranded the floodplain. Old oxbow sections and stranded river bends are evident within the floodplain. Devils Gulch has not been artificially constrained, yet does not contain much off channel habitat.

Stream Channel Conditions and Function

Channel Condition and High Flow

Stream channel condition is poor in Mission Creek. Below the USFS boundary at RM 8.0, land use practices have altered the natural stream channels. Within the confines of the town of Cashmere, stream channels are highly confined by light industrial/urban/suburban development. Upstream of the town of Cashmere, suburban/rural/agricultural development has altered the natural stream channel (Andonaegui 2001). Floods in the 1930s, coming after decades of extensive overgrazing, caused severe erosion. Consequently, numerous channel stabilization efforts took place through the 1950s to protect property along the creek and prevent further flood damage.

Fine Sediment and Channel Stability

Given the highly erosive soils found throughout the watershed, there is naturally a high rate of sediment delivery from tributaries and a resultant high level of fines (sand) in depositional reaches of Mission Creek. After stream channelization, berming in the floodplain, riparian habitat removal, drastic decreases in LWD recruitment, LWD cleanouts, and bank stabilization, however, the sediment transport regime has been altered and channel complexity has decreased. The result is channel incision in some reaches of lower Mission Creek with heavy sediment deposition in low gradient reaches (Andonaegui 2001).

Habitat Diversity

Channel constriction resulting from development within the floodplain of Mission Creek and its tributaries has resulted in bank erosion and down cutting or incision of the channel. Woody riparian vegetation is mostly limited to a single band of trees, shrubs or grasses, and at times is replaced by orchard or hayland. The banks, however, are generally stable at this time both within the town of Cashmere and in the upstream reaches located in agricultural areas. The exception is at a head cut between RM 7.0 and RM 10.0, which has initiated as a result of channel manipulations. Bank stabilization efforts and channel incision appears to be containing recent flow conditions pending a channel-changing event resulting from high flows and sediment pulses. Decreases in the natural sinuosity of the creeks, and increases of fine sediment, have reduced the number and frequency of pools as well.

In Brender Creek, the channel has been straightened and forced into several right angle turns below the concrete flume just downstream of Evergreen Road (RM 0.1). Sand depositions in this lower reach have altered the channel flow, which now runs under Sunset High way and is then runs through the old Mill site. There is a headcut and associated bank erosion near the 7200 block of Pioneer Street. Bank stabilization efforts, channel incision, a lack of LWD, and the lack of recent channel changing events, however, have resulted in overall stable banks.

The first 1500 ft. of Yaksum Creek upstream from the mouth is altered and entrenched. The remaining 1.6 mi. of lower Yaksum Creek have been converted to a roadside ditch with some piping. The dominant vegetative cover is Reeds canary grass.

Sand and East Fork Mission creeks stream banks are vegetated with brush vegetation. The degraded riparian zone and the artificial channel confinement by roads put streambank stability at risk for erosion given a high flow, channel changing event (Andonaegui 2001).

Water Quality

Temperature

Although stream temperatures in the Mission Creek watershed are expected to be warmer during the summer months as compared to watersheds at higher elevations in the watershed, channelization and vegetation removal increase stream temperatures. The CCCD monitored instream temperatures at four sites in Brender Creek from October 1999 to September 2000, including the site at the mouth of Brender Creek previously monitored in 1992 and 1993. During this period, instream temperatures exceeded properly functioning conditions for salmonids (50-57°F) at all four sites during the month of August. Given the alterations to Brender Creek including irrigation return flows, water diversions, and channelization impacts, elevated instream temperatures are expected. Temperatures have been the lowest in Sand Creek in the portion of the stream that is perennial. Devils Gulch is considered as a baseline condition for the upper watershed because it has minimal management compared to the rest of the watershed.

Oxygen/Pollutants

Water quality in Mission Creek is poor. The watershed is included on the WDOE 1998 303d list for low dissolved oxygen, high fecal coli form and pesticides counts. Traces of toxic insecticides have been detected in samples from Mission Creek at concentrations above the water quality criteria to protect both aquatic life and wildlife. The major pesticides occurring at the detectable levels in the agricultural (primarily orchards) and urban areas of the lower valley are the chlorinated insecticides DDT and endosulfan, and the organophosphorous insecticides, cholorpyriphos and azinphos-methyl. The WDOE has stated that there are no new sources of DDT, but contamination from historical uses is an ongoing problem. DDT was heavily used on orchards prior to its ban in 1972. It is still commonly found where there is soil erosion from the orchards. DDT is detected most frequently in June, probably from storm water runoff.

Water Quantity

Low Flow

Water quantity in Mission Creek is poor. The watershed is on the WDOE 1998 list for low instream flows. watershed-wide, most 1st order channels in the Mission drainage are intermittent, drying by early summer. The mainstem goes dry in late summer. This condition may be caused in part by surface water diversions and ground water withdrawals. Information on water diversion, water withdrawals and surface water/ground water interactions is complex and not fully understood in the watershed.

Historically, Brender Creek could go dry during the late summer months. However, currently there is year-round flow in during irrigation season because the Peshastin Irrigation District uses Brender Creek as an irrigation conduit. A 1996 NRCS “Inventory and Analysis Report” states there is evidently a year-round flow from the confluence of Brisky Canyon (RM 4.3) to the mouth (Andonaegui 2001).

Basin hydrology has been altered by stream straightening, berming, road building, home building, grazing, tree removal and soil compaction. Some of these activities have resulted in faster, more intense runoff during storm events and annual snowmelt. Mission Creek is included on the WDOE 303(d) list for instream flows. Base flows have also been reduced by the removal of beaver, the loss of LWD through channel cleanouts done by the Civilian Conservation Corp (CCC), the Soil Conservation Service (SCS, now the NRCS), and the USFS (1935 – 1937 and 1954 – 1959) and channelization from road-related channel confinement. Base flows are also interrupted at times in the late summer at irrigation diversions (Andonaegui 2001, USFS 2003).

Operational spills with water diverted from Icicle Creek are delivered into Mission Creek by the Icicle Irrigation District (IID) at about RM 1.2. The influence of the spill provides somewhat of a stabilizing flow for Mission Creek below RM 1.2, although at a very low flow. Likewise, spills into Brender Creek with water diverted from Peshastin Creek by the Peshastin Irrigation District system to irrigate agriculture lands along Brender Creek, seasonally influence creek flows. There is evidence of bank erosion, probably from the sudden flush of added flow (Andonaegui 2001).

Obstructions to Fish Passage

There are numerous fish passage obstructions throughout most of this Assessment Unit. Culverts are located in the mainstem and many tributaries and irrigation diversions are located in Mission and Brender creeks. Elevated water temperature and de watering also contribute to passage problems.

Ecological Conditions

Brook trout have been introduced into this watershed and compete with resident rainbow trout and steelhead juveniles for rearing habitat. Pollutants may affect food productivity in the mainstem, as might chemical contamination residues from past agricultural practices. Habitat has been simplified to the point where productivity is limited in the middle and lower watershed. Overall, ecological conditions are fair in the upper watershed, and poor in the lower portions of the watershed.

Environmental/Population Relationships

Mission Creek today supports very low salmonid production. (Mullen et al. 1992) Small numbers of steelhead have been observed spawning in Brender, Mission, and Sand creeks. Steelhead and rainbow trout are known to rear in Mission Creek from the mouth upstream to Devils Gulch (RM 10.3). The mid Columbia mainstem Conservation Plan (MCMCP) reported that juvenile steelhead and rainbow trout also over winter in lower Mission and Brender creeks where passage is not precluded by low flows or barriers. A small fall at the mouth of Yaksum Creek prevents passage of juveniles into Yaksum Creek to rear. Steelhead/rainbow juveniles also rear in E. Fork Mission Creek and Little Camas Creek.

Currently, no spring chinook spawning occurs in the Mission Creek watershed. Juveniles do use the lower portions of Mission and Brender creeks for rearing and most likely migrate from the Wenatchee River. Rearing is limited to the first 1.2 mi. of Mission and occurs in Brender Creek up to the concrete flume fish passage barrier located immediately downstream of Evergreen Road at RM 0.7.

There is no evidence of bull trout currently occurring in the watershed. Brook trout have been located in upper Mission Creek, lower King Canyon and East Fork Mission creeks (Andonaegui 2001).

Areas of Special Interest

- Devils Gulch is in a more natural condition with some off channel areas available for use (USFS, in preparation). Potential for increased steelhead production exists in this area.
- Revegetation projects have been initiated near the mouths of Mission, Brender and Yaksum creeks within the town of Cashmere.
- Adult steelhead and adult rainbow trout spawn in reaches on USFS land
- Juvenile chinook and steelhead overwinter in lower Mission Creek

Limiting Factors

- In-channel conditions have been significantly altered by channel straightening, channelization and simplification. Resulting channel has entrenched through alluvial materials.
- Low flows and associated high instream temperatures prevent or impede access to spawning grounds for spring chinook, reduce the available rearing habitat in these areas and constrain access to rearing habitat elsewhere in the watershed.
- Diversion dams and culverts create fish passage barriers from the lower end of the watershed and progressing upstream, significantly reducing access to spawning and rearing habitat
- Stream temperatures in the Mission Creek watershed tend to be naturally elevated during the summer months and exacerbated by management activities, water diversions and habitat degradation.
- Naturally intermittent flows are exacerbated by surface water diversions and ground water withdrawals occur in the watershed
- Most of the riparian habitat in the naturally narrowing valley has been converted to orchards, pasture or hay production with thin bands of cottonwood/shrubs adjacent to the confined channel (Andonaegui 2001).

Data Gaps

- In less impacted stream reaches there is not enough data to determine if instream temperatures are significantly different than temperatures in the historic reference condition or to what extent these temperatures might negatively impact salmonid migration, spawning, incubation or rearing.

- There is no conclusive information concerning bio-accumulation of toxic materials in aquatic organisms.
- The effects of the diversions and withdrawals, both individual and cumulative, on instream habitat conditions are not fully known.
- It is not clear if sediment loads have been significantly altered in this system. A sediment budget (geomorphic potential) analysis should be completed for this watershed.

Functional Relationship of Assessment Unit with Subbasin

Mission Creek is a Category 3 watershed (see Determination of Restoration Priorities in Section 6.5 of this document); it still contains sub watersheds that support rainbow trout, steelhead and juvenile spring chinook rearing (Devils Gulch, Sand Creek, and lower Mission, respectively). In general, substantial degradation and fragmented habitat, including loss of connectivity from low flow, occurs in this watershed. Opportunities for restoring full expression of life histories for multiple populations found within the watershed are unlikely. Mission Creek does provide some high water refugia in late spring for juvenile salmonids, and small numbers of steelhead still uses the upper watershed.

4.9.6 Peshastin Creek Assessment Unit

Assessment Unit Description

Peshastin Creek originates near Swauk Pass and flows north, entering the Wenatchee downstream of the town of Peshastin at RM 20. Ingalls Creek, the largest tributary to Peshastin Creek, originates in the area around Mt. Stuart (USFS 1998). There are 14 tributaries entering Peshastin Creek and three lakes in the watershed with a total surface area of 26 acres. Although Peshastin Creek is one of the major watersheds in the Wenatchee subbasin as far as size (78,780 acres), it contributes only 4% of the summer low flow for the Wenatchee River.

Elevations in the watershed range from 9,470 ft. at Mt. Stuart to 967 ft. at the mouth. Annual precipitation levels decrease from the Cascades crest downstream to the Columbia River. Situated in the lower portion of the subbasin, Peshastin receives less precipitation than upper watersheds. Annual precipitation levels range from 80 in. in the upper elevations to 15 in. at the mouth.

The USFS manages 82% (64,600 acres) of the watershed, 29% (18,734 acres) of which is designated wilderness. The remaining 18% of the watershed (14,180 acres) is privately owned. Long View Fibre Company owns 10,000 acres.

The watershed has complex geology. Over half the landbase sits on Swauk Sandstone. Ingalls and Upper Blewett sub- watersheds are made of granite. Slopes are low to moderate gradient on much of the east side of the drainage to very steep on the west side. There is high natural surface erosion and related sedimentation level in the watershed. Valley morphology for Peshastin Creek varies from open and meandering to sharply incised and bedrock controlled. Tributary channels are dominated by steep slopes and V-shaped valleys (Andonaegui 2001).

Assessment Unit Condition

The loss of channel sinuosity, floodplain function and riparian habitat, including off channel habitat, within the channel migration zone of Peshastin Creek has had the greatest affect on salmonid production. Channel confinement resulting from the improvement of State High way 97 has reduced spring chinook, steelhead and Bull Trout spawning habitat, It has also reduced juvenile rearing habitat for all salmonid species, especially overwintering habitat for steelhead/rainbow trout. Floodplain and riparian habitat functions have also been simplified by residential and agricultural development, timber harvest and mining activity that has been active in various forms for over 100 years. Low LWD counts further reduce habitat quality.

In some years, dependent on spring runoff characteristics, reduced flow can act as a passage barrier to spawning spring chinook. During summer and fall, flows can become extremely low below the diversion, at times de watering the channel. This reduces the total amount of available rearing habitat and may lead to direct mortality of juveniles by stranding. Some tributary streams have been simplified by forest roads, mining ,and riparian harvest, which has also reduced LWD recruitment and increased sediment delivery (Berg and Lowman 2001).

Riparian/Floodplain Condition and Function

Riparian Condition

The location of State Hwy. 97 forced the abandonment of 34% of the mainstem floodplain, 194 acres out of 565 acres, from the mouth to below the Tronsen Creek confluence. During the high way construction, Peshastin creek was straightened and replaced with 19,317 ft. of new main-stem channel. Roads and mining activities along the mainstem of Peshastin, Negro, Tronsen, Scotty and Shazer creeks, further confine and entrench sections of stream channel, and consequently abandon the floodplain (USFS 1998).

From the mouth of Peshastin upstream to just below the Ingalls Creek confluence, conversion of riparian habitat to residential/urban, rural and agricultural use has heavily impacted riparian habitat. Overall, the riparian zone is reduced in size, continuity, and successional stages (Andonaegui 2001). All of these factors contribute to a lack of shade and woody debris, change in channel type, increases in temperature, lack of refugia, and a lack of connectivity (USFS 1998). From the Forest boundary downstream to the mouth, the creek has been converted from a channel that meanders (Rosgen C) into a constrained (Rosgen B) channel type.

Mill and Hansel creeks, tributaries to the lower Peshastin below Ingalls Creek, have been roaded and harvested. The lower mile of Hansel was harvested in 1975. No streamside buffer were left. Sometime after 1975, the USFS began harvesting in the head waters of Hansel Creek, which added additional regeneration units and increased roading. Additional entries were made between 1986 and 1992 in the head waters on USFS land. Harvested areas in the upper watershed are dominated by alder and other shrub species.

Upstream of Ingalls Creek, virtually all tributaries have experienced some alteration from road building, mining, timber harvest and recreational use. Ruby Creek has experienced past timber harvest practices which included tractor use that skidded logs downhill and out through tributaries.

Mining activities have reduced streamside vegetation and LWD recruitment. Other mining impacts include camps located inside riparian areas, removal of LWD and boulders for dredging access, and removal of streambank vegetation for access. Due to valley morphology in Negro Creek, mining camps are generally within 40 ft. of the creek. There is evidence of erosion from hydraulic mining scars, some of which has never re-vegetated. On the North Fork Shaser, depositional areas are visible where streamside vegetation has been cleared on both banks (Andonaegui 2001).

Stream Channel Conditions and Function

Channel Condition and High Flow

Channel type throughout much of the watershed is dominated by contained Rosgen A and B type channels, so off-channel habitat would naturally be limited in many of these perennial channels. These channels are often further contained by roads and road fill, or have been stranded from their limited floodplain due to channel down-cutting, either from channel confinement or suction dredge mining (USFS 1998). Although the ability to function under peak flow is not discussed the 1999 USFS assessment, channel simplification and confinement, combined with low wood counts and roading, likely prevents the Peshastin from attenuating peak flows.

Fine Sediment and Channel Stability

Stream survey reports describe streambank condition throughout the mainstem and many tributaries in the drainage as fair to poor. Bank integrity has been compromised by roads, mining, and riparian harvest. Streambank condition in Ingalls Creek is stable and in good condition. Overall, stream bank condition for this watershed is poor (USFS 1998).

McNeil Core samples have been collected from three sites in the watershed: below Ingalls Creek, Peshastin near Shaser Creek, and Tronsen, just above Peshastin Creek. All three of these sites had fine sediment percentages above the Forest Plan Standards. Ocular estimates of the surveyed streams indicate that a majority of segments are embedded. The exception is Ingalls Creek where the stream bed did not appear embedded. Peshastin Creek fine sediment is high, and channel bed stability is poor. High fine sediment content is likely influenced by high road densities and channel confinement, year-round suction dredge mining, and road sanding (USFS 1998). The lower reaches of Negro Creek receive pulses of sediment. At the time of the stream survey, however, embeddedness was not observed to be a problem in the lower 1.5 mi. of the stream.

The overall channel width of the lower 9.0 mi. of Peshastin Creek is increasing. The channel is becoming less entrenched, possibly in response to increases in sediment supply, decreases in riparian vegetation structure and function, and changes in the flow regime. Also, following the 1990 flood, the number of large boulders from Ingalls Creek to Negro Creek (RM 9.0 – 11.1) decreased in number, reducing channel roughness and step pool/cascades formation.

Due to historic timber harvest, mining and road building along most tributaries and Peshastin Creek, available data indicates that LWD recruitment has diminished. This has contributed to low pool frequency and poor quality in the mainstem and most tributaries. Ingalls is an exception with regard to LWD and is in good condition (Andonaegui 2001).

Habitat Diversity

Lower Peshastin Creek is of particular concern from the USFS boundary to the mouth. The normal meandering low gradient (Rosgen C type) channel in this reach has been completely modified and floodplains have been developed. Many important habitat attributes, such as large wood and cover, large pools and side channels have been significantly reduced in quality and quantity. Considering the amount of alteration in the watershed, channel condition and function is poor overall for the Peshastin watershed (USFS 1998).

Water Quality

Temperature

Peshastin Creek has been added to the current 303(d) list for failing to meet temperature and is considered to be poor by forest plan standards. In the lower reaches low flows, minimal vegetative cover, and high air temperatures contribute to high instream temperatures during late summer months (Andonaegui 2001). Temperatures above Negro Creek routinely reach the upper 60s and come close to 70°F. Between the Negro and Ingalls confluences, the temperature is decreased to the mid to lower 60s from the influence of the cooler water from Negro Creek. These reaches still exceed Forest Plan and WDOE quality standards. Directly below the Ingalls Creek confluence the stream does not exceed the one day maximum of 61°F, but does occasionally exceed the 7 day maximum temperature. It is suspected that temperatures farther downstream, in residential and agricultural portions of the creek also exceed the standard regularly. This is also true of the upper and head waters streams, including Tronsen, Shaser, North Fork Shaser, and Middle Fork Shaser. Temperatures in Negro and Ingalls creeks are considered good (USFS 1998).

The USFS does not think there is enough data to determine if instream temperatures are significantly different than temperatures in the historic range for Peshastin Creek upstream of RM 1.0 (Andonaegui 2001).

Oxygen/Pollution

Peshastin Creek did not meet dissolved oxygen standards 9 times, turbidity standards 2 times. Fecal coli form was exceeded once (CCCD 1998). The dissolved oxygen areas were throughout the watershed, while the fecal coli form was at the mouth, likely a result of the surrounding private land in the lower 8 miles. Relative to chemical contamination and nutrients Peshastin Creek is termed as functioning appropriately within USFS land and functioning at risk below the forest boundary (USFS 1998).

Water Quantity

Low Flow

Peshastin Creek is also included on the WDOE 1998 303(d) list for low instream flows. At RM 2.4, the Peshastin Irrigation District operates a water diversion dam on the eastside of the creek and a screened water diversion on the west side of the creek near the confluence of Mill Creek (RM 4.8). The channel downstream of the Peshastin Irrigation District diversion de waters approximately 100 foot section all the way to the mouth in drought years. The diversion canal intercepts several small tributaries to Peshastin Creek, two of which with the flow so completely intercepted that there is no exchange with Peshastin Creek. Although Peshastin is closed to new water diversions between June 15 and October 15, no provisions for minimum flow are in place for existing water uses (Andonaegui 2001).

There is a lack of information on flows for the Peshastin drainage. The USFS, however, considers flows in the areas above the irrigation diversions as fair. If the stream channel maintained a normalized (rather than highly modified) width to depth ration, it is likely low flow related issues would not be a significant problem. Late summer flows below the irrigation diversions during summer and early fall are considered poor due to drastic changes in flow. The effects of the diversions and withdrawals, both individual and cumulative, on instream habitat conditions are undetermined at this time (CCCD 1998). Due to lack of harvest activity and no flow diversions, Negro Creek and Ingalls Creek are termed as functioning appropriately (USFS 1998).

Obstructions to Fish Passage

At RM 2.4, the irrigation district operates a water diversion dam on the eastside of the creek. The diversion dam presents a barrier to summer and fall migration mid June through October partially blocking spring chinook salmon and migrating bull trout. The dam also precludes the movement of resident rainbows from the lower drainage into cooler waters of the upper watershed. During late summer, in years when the total water diversion exceeds instream low flows, the area directly downstream of the diversion is de watered for 100 ft., completely blocking all fish passage.

Numerous other passage obstructions, primarily culverts are located on in the tributary streams.

Ecological Conditions

Brook trout have been observed in Peshastin Creek as far upstream as RM 4.84. Reduced flows and elevated instream temperatures below a water diversion at RM 4.8 likely restricts upstream movement of migrating adult bull trout. Hatchery adult spring chinook have been released into Peshastin Creek in recent years.

Environmental/Population Relationships

Historically this WAtershed supported spring chinook, coho, bull trout, steelhead, redband trout and cutthroat trout. Steelhead were likely the more populous anadromous species spawning in this system. Before the historic stock of coho was extirpated from the region, however, they may also have been more abundant than spring chinook (MCMCP 1998). Current use is generally limited to steelhead, redband, cutthroat, and resident bull trout, although coho have been documented spawning in Peshatin Creek (C. Kamphaus, unpublished data). Current use is generally limited to steelhead, redband, cutthroat, and resident (delete and just say bull trout. We are finding sub adult bull trout rearing in Peshastin Creek via our screw trap study. Also we are uncertain as to the extent that fluvial bull trout are using Peshastin) bull trout. A barrier to summer and fall migration from mid June to October exists at RM 2.4. There a screened irrigation diversion hinders and often precludes upstream movement during mid to low flows (USFS 1998; Andonaegui 2001). Due to the timing of migration for steelhead (winter, spring), the irrigation diversion does not cause a known migration problem for steelhead in this drainage. The Bureau of Reclamation (BOR) is working with the irrigation district to design a new diversion that will not block fish passage at low flow (Kolk 2003).

Both Negro and Peshastin creeks used to maintain a population of spring chinook salmon. That population is currently very small due the many degraded conditions in lower Peshastin Creek. Steelhead use the Peshastin mainstem and associated tributaries including Negro Creek, where use would be expected mainly in the early spring. Juvenile steelhead rear in the drainage throughout the year in a variety of habitats including off-channel areas, pools, riffles, and inter-gravel spaces. Upper Negro Creek also contains westslope cutthroat trout, the only known population in the Assessment Unit.

Bull trout use Ingalls Creek and Peshastin Creek as a migration corridor from the Wenatchee River as well as for rearing .

Migratory bull trout have not been confirmed to spawn in Ingalls Creek in recent years. Outside of resident bull trout in Ingalls Creek, bull trout have been observed in the extreme lower portions of Peshastin Creek below the diversion (USFS 1998). In a recent screw trap study, USFWS have been collecting sub-adult bull trout at RM 6.25 within the mainstem of Peshastin Creek (K. Terrell May 18, 2004, personal communication to Bob Rose).

Areas of Special Interest

- The mainstem Peshastin, even though challenging, remains an important corridor for bull trout and possibly cutthroat trout rearing and migration. Ingalls Creek appears to be limited to a small population of resident bull trout.
- Peshastin Creek historically had spring chinook, although currently due to migrational barriers and temperature concerns the only known use is at the mouth for some rearing activity (USFS 1998).
- Steelhead and rainbow trout use Peshastin Creek for spawning, rearing, and as a migration corridor, although redd surveys indicate low numbers (WDFW 2003).
- Ingalls Creek is located almost entirely in wilderness and provides the one area of high water quality and fish habitat. Ingalls Creek produces the most water out of the drainage, and exceeds the flow from Peshastin Creek during most of the year.
- Negro Creek is in near pristine condition above RM 2.5 (USFS 1998) and contains the only know cutthroat population in the Peshastin watershed.

Limiting Factors

- The loss of channel sinuosity, floodplain function, and riparian habitat including off channel habitat within the channel migration zone of Peshastin Creek has had the greatest impact on salmonid production in the watershed.
- A water diversion dam presents a barrier from mid June through October partially blocking migrating spring chinook salmon, and migrating bull trout
- Low instream flows in lower Peshastin Creek impedes upstream migration, reduce rearing habitat, and likely contribute to elevated water temperature
- Elevated water temperatures exceed regulatory standards

- Loss of riparian habitat resulting from land development and state high way reduces quantity and quality of spawning and rearing habitat (Andonaegui 2001)

Data Gaps

- The effects of the diversions and withdrawals, both individual and cumulative, on instream habitat conditions are undetermined at this time
- Cumulative effects of current gold mining activities on sediment delivery, water quality, and channel conditions have not been evaluated
- The extent to which fine sediment is negatively impacting salmonid habitat and productivity in Peshastin Creek relative to historic conditions has not been evaluated (Andonaegui 2001)
- The abundance and distribution of bull trout within the Peshastin subbasin is uncertain (Upper Columbia RTT 2001)

Functional Relationship of Assessment Unit with Subbasin

Peshastin Creek is a Category 2 watershed (see Determination of Restoration Priorities in Section 6.5) based on fragmentation and habitat degradation, especially in the lower watershed (Upper Columbia RTT 2003). Peshastin has 3 significant sub-watersheds: lower Peshastin, upper Peshastin, and Ingalls. The subbasin provides spawning and rearing habitat for steelhead, although limited habitat for listed spring chinook juveniles, and resident-Deleate bull trout. Bull trout and spring chinook are at risk in this watershed. Coho spawning in lower Peshastin was noted in 2003. Connectivity among subwatersheds still exists, although it is interrupted in late summer.

4.9.7 Chumstick Creek Assessment Unit

Assessment Unit Description

The watershed is oriented in a north-south direction with tributaries entering from the north and east. Chumstick watershed can be broken into three smaller sub watersheds: mainstem Chumstick, Upper Chumstick-Little Chumstick, and Eagle Creek. Flowing south into the Wenatchee River at RM 23.5 at the east end of the town of Leavenworth, Chumstick Creek is a perennial, fish-bearing, 4th order stream (with some reaches that de water), typically flowing less than 10 cfs. It contributes 0.2% of the low flow to the Wenatchee River (USFS 2003, Andonaegui 2001).

The Chumstick drainage is 47,000 acres and located in the eastern Cascade rain shadow. Chumstick Creek and Eagle Creek (RM 1.9), a tributary to Chumstick Creek, are the only streams in the drainage known to support anadromous salmonids. Mean annual precipitation ranges from 20 in. in valley bottoms to 50 in. in the higher elevations (Andonaegui 2001). Most precipitation falls as snow in winter. The lower Wenatchee River, including Chumstick watershed, is almost wholly contained within the Swauk Sandstone Hills geologic subsection. This hilly subsection composed of folded interbedded sedimentary rocks has been modified by fluvial downcutting and mass wasting processes. Shrubsteppe and ponderosa pine dominate the lower elevations with Douglas-fir and grand fir occurring on the upper elevations (USFS 2003).

Along mainstem and major tributary valley bottoms, railroad berms, low-density housing, pastures, and agricultural development are common in the floodplain. Higher elevations are mostly in USFS ownership, although some lands are owned by the state and private landowners.

Assessment Unit Condition

The Chumstick once supported populations of summer steelhead, coho, and possibly spring chinook salmon. Land development and use occurring on both public and private land has created poor habitat condition for most stream attributes. Railroad logging began in Chumstick valley in 1910 when the Lamb-Davis Timber company finished laying 26 mi. of track from Leavenworth to Plain. In later years, the track was removed and used for the base of the high way. Many degraded habitat attributes can be linked to channel confinement resulting from road density and location, loss of floodplain connectivity, and alteration of disturbance regimes. Additionally, instream flows are very low, upstream access is blocked by multiple stream crossings and impoundments, water quality is degraded, and high fine sediments may limit spawning success and food production by macro invertebrate communities.

The Chumstick Creek drainage has been identified as one of the more problematic watersheds in the entire Wenatchee subbasin relative to land use impacts and management issues. Given restoration of fish passage, degraded habitat quality and low flow conditions will continue to limit salmonid production.

The Chumstick has most adult and all juvenile salmon passage blocked at RM 0.3 by a perched culvert under North Road. Telemetry results have shown one adult steelhead traveled 5.7 mi. up Chumstick Creek in 2000. Today, spring chinook juvenile use is limited to rearing in the first 0.3 mi. of Chumstick Creek downstream of the culvert. Brook trout have been planted throughout the drainage. Rainbow trout and steelhead are present in low numbers. Coho have been extirpated from the drainage (Andonaegui 2001).

Riparian/Floodplain Condition and Function

Riparian Condition

High way 209 and the Burlington Northern Railroad closely parallel Chumstick Creek, limiting the width of the riparian zone, and restricting channel access to the floodplain. High riparian road densities have a similar affect on tributaries. Due to the high densities of roads and restriction of the floodplain, riparian conditions in Chumstick Creek and tributaries are in poor condition (USFS 2003).

Habitat Diversity

Forty percent of the riparian vegetation along the mainstem Chumstick and Eagle creeks, in addition to other smaller tributaries, has been altered by agricultural and urban encroachment, historic railroad development, logging, and high riparian road densities, and fire suppression. Where disturbance has occurred, channels are often confined, surface erosion has increased, and channel degradation has resulted. In the disturbed areas where woody vegetation is lacking, soil is bare and an invasive weed, Reed canary grass, is abundant. High sediment levels and lack of channel roughness features such as large woody debris (LWD) are also linked to the degraded riparian habitat condition. Where woody vegetation occurs, shrubs are usually most common, with red osier dogwood the dominant woody plant. Willow, alder, snowberry, and wild rose can be found in more intact riparian areas. Cottonwood and hawthorn trees still occur on some sections of Chumstick Creek. Riparian condition is similarly poor for Eagle Creek (Andonaegui 2001).

Stream Channel Conditions and Function

Channel Condition and High Flow

As floodplain connectivity has been restricted, channel sinuosity has also decreased from the mouth to Little Chumstick Creek (RM 8.7). Coupled with high sediment rates, low LWD levels, and a flashy hydrology, Chumstick Creek may be at risk for becoming entrenched by developing a decreasing width-to-depth ratio (Andonaegui 2001).

Fine Sediment and Channel Stability

Streambank erosion associated with riparian disturbance and culvert placement has been recorded from the North Road culvert (RM 0.3) upstream to Little Chumstick Creek. Active erosion is highest from Eagle Creek (RM 1.9) to Sunitsch Canyon (Andonaegui 2001). A USFWS stream survey indicates that sand and finer substrates comprise 48-68% of the wetted channel substrate (riffles and pools). Sand and fines were the dominant substrate throughout the survey, from North Road to above Clark Canyon. Based on this data, Chumstick Creek has poor substrate (USFS 2003). Large percentages of fine sediment within the drainage can be linked to naturally erosive geology exacerbated by channel confinement, extensive native surface road network, erosion from burned areas, and possibly hill-slope erosion from historic and continued grazing (Andonaegui 2001, USFS 2003).

Instream LWD quantity throughout the watershed is lower than expected. Partially as a result of LWD deficiencies, sediment is not effectively stored in higher gradient streams, thus changing the way fine sediment is delivered to valley bottom channels (Karrer 2004. There is an acceptable amount of pool habitat in Chumstick Creek, however the depth in many pools Does not provide sufficient refuge for fish during low flow periods. Pool depth and frequency is poor in Eagle Creek (USFS 2003).

Water Quality

Temperature

The Chelan County Conservation District (CCCD) monitored water temperature at five stations in Chumstick Creek in 1999 and 2000. Most temperatures were below 57°F, although a single day high temperature of 58.5°F was recorded on August 8, 2000. Although single day measurements in summer months rarely exceed state single day standards, data does not conclusively prove state standards for temperature are met (USFS 2003).

Oxygen/Pollutants

Chumstick Creek is on the WDOE 303d list for dissolved oxygen, fecal coli form, and pH for criteria exceedences. The Wenatchee watershed ranking project documented dissolved oxygen, pH, and fecal coli form levels in violation of state water quality standards. The ranking project concluded that Chumstick was second to Mission Creek in contributing to current and future potential water quality degradation in the Wenatchee River watershed. Chumstick Creek is "functioning at an unacceptable risk" for water chemistry (USFS 2003).

Water Quantity

Low Flow

Chumstick Creek is also listed on the WDOE 303d list for instream flow for criteria exceedences. As is typical in drainages in the drier portion of the Wenatchee subbasin, stream flow is intermittent for the majority of 1st order tributaries in the drainage. Where perennial flow exists, stream flow is sometimes interrupted when the underlying water table drops low enough that surface flows go subsurface. Ground water withdrawals may influence intermittent flows on higher order mainstem channels.

Instream flow measurements showed that late summer discharge decreased going downstream, indicating Chumstick Creek has a possible loosing reach. This may be due to shallow aquifer well withdrawals throughout the valley. However, flows have been observed to go subsurface during dry summer months, sometimes reappearing when summer rains recharge the water table, then again going subsurface (Andonaegui 2001).

Given the amount of land development, high road densities, harvest, and fire suppression in relationship to Chumstick Creek peak and low flows, water quantity is in fair to poor condition in the watershed (USFS 2003). Ground water withdrawals from private wells may affect instream flows. watershed wide, there are 54 surface water rights permits or certificates worth potential total diversion of 8.2 cfs. There are 99 surface water rights claims worth a potential total diversion of 36.4 cfs. There are 103 ground water rights permits and certificates worth a potential total withdrawal of 2,194 gpm. There are 61ground water rights claims worth a potential total withdrawal of 1,215 gpm (Andonaegui 2001).

Obstructions to Fish Passage

The North Road county culvert at RM 0.3 is a full passage barrier to spring chinook juveniles and a partial passage barrier to steelhead (Andonaegui 2001). Twenty-three culverts were identified as potential migrational barriers to anadromous and resident fish species by the USFWS. Of the 23 culverts, eighteen were classified as too small to pass bank full flows and associated debris; nine exceed Washington State Administrative Code (WAC) gradient requirements and could cause low flow barriers. Many of the identified culverts are misaligned causing erosion and increased sediment loads in Chumstick Creek. Eleven of the 23 culverts have been replaced in the past three years. Funding for the remaining 12 culverts has been secured once passage at the North Road Culvert has been addressed. The culvert under North Road at RM 0.3 has received only partial funding and still awaits replacement.

Ecological Conditions

Ecological conditions are poor overall in the Chumstick Creek. In addition to state water quality listings, the Chumstick watershed no longer retains the complete fish community that was historically present. Coho reintroduced in the Wenatchee River do not use the Chumstick watershed at this time. Brook trout are present throughout most of the entire drainage (USFS 2003).

Environmental/Population Relationships

Juvenile fish access to Chumstick watershed is blocked by a perched culvert at RM 0.3, adult steelhead are occasionally able to pass this crossing. Steelhead and spring chinook juveniles would likely use more of lower mainstem Chumstick Creek for rearing and refuge if passage were restored.

Historically, steelhead and coho spawned and reared in lower Chumstick and lower Eagle creeks. Given its elevation and landtype, the Chumstick Creek drainage may have never supported spawning spring chinook and bull trout populations, even under historic conditions when water temperature, flows and substrate composition are assumed to have been in more favorable condition. Today, the North Road Culvert limits spring chinook use to the first 0.3 mi. of Chumstick Creek. Coho have been extirpated from the region and no documented bull trout use in any season exists for the drainage. Brook trout have been introduced throughout the entire drainage. Results of an ongoing radio telemetry study conducted on steelhead trout by the Douglas County PUD located adult steelhead trout in Chumstick Creek in 2000. The telemetry results tracked adult steelhead as far as 5.7 mi. upstream of the mouth of Chumstick Creek. Eagle Creek is the only tributary to Chumstick Creek that is known to support returning steelhead. The upper extent of known rainbow and steelhead trout anadromy in Eagle Creek is approximately RM 1.0 (Mullan et al. 1992, Andonaegui 2001). Rainbow and steelhead trout are present throughout the watershed.

Areas of Special Interest

- Currently spring chinook juvenile use the lower reach (the first 0.3 miles) although use is limited presumably because of the North Culvert.
- Some riparian and off-channel habitat remains in the Chumstick drainage, along with occasional beaver use.

Limiting Factors

- Channel migration is limited by state high way, the railroad, private land development, and forest roads (Andonaegui 2001, USFS 2003).
- Land development and high road density affects sediment delivery (Andonaegui 2001).
- The North Road county culvert at RM 0.3 is a full passage barrier to spring chinook and a partial passage barrier to steelhead (USFS 2003).
- Forty percent of the riparian vegetation along the mainstem Chumstick and Eagle creeks, in addition to other smaller tributaries, has been disturbed by agricultural and urban encroachment, historic railroad development, logging, and high riparian road densities.
- Given restoration of fish passage, degraded habitat quality and low flow conditions will continue to limit salmonid production.

Data Gaps

- There is insufficient data to determine if instream temperature, low dissolved oxygen and high total dissolved solids exceedences exist that affect salmonid use in Chumstick and Eagle creeks.
- The effects of the diversions and withdrawals, both individual and cumulative, on instream habitat conditions are undetermined at this time (Andonaegui 2001).

Functional Relationship of Assessment Unit with Subbasin

All habitat attributes, except pool frequency, are degraded in Chumstick Creek. In addition, Chumstick Creek experiences very low instream flows that go subsurface (2 cfs in August/September) which are exacerbated to an undetermined extent by private diversions and wells affecting surface flows. Differing reaches go dry in many years. Presently, fish passage into the drainage is blocked at RM 0.3 for all fish species except some adult steelhead trout. Given removal of fish passage barriers in the drainage, degraded habitat quality and low flow conditions will continue to limit salmonid production. The Chumstick is a low priority watershed Category 3 watershed (see Determination of Restoration Priorities in Section 6.5) and none of the three sub watersheds are considered significant.

4.9.8 Icicle Creek Assessment Unit

Assessment Unit Description

Icicle Creek originates high in a rugged portion of the Cascade Mountains and is a 5th order stream. Icicle Creek drains an area of 214 square mi. (136,960 acres) in North Central Washington. Icicle Creek main-stem flows east 31.8 river mi. (RM) before emptying into the Wenatchee River at RM 25.6) in the city of Leavenworth. There are 14 glaciers (420 acres) and 102 lakes (1,362 acres) in the watershed (Andonaegui 2001).

The watershed contains the largest tributary drainage in the Wenatchee River subbasin, providing 20% of the low season flows (Andonaegui 2001, CCCD 1996). Precipitation ranges from 120 in. at the crest of the Cascades to 20 in. at the mouth. Minimum and maximum flows recorded in Icicle Creek vary from 44 cfs to 11,600 cfs, as measured at the USGS gauging station located above Snow Creek at RM 5.4. The gauging station is upstream of all major diversions.

The main channel forming processes are glaciation and seasonal runoff. The watershed is characterized by steep valley head walls, cirques and cirque head walls which are typically bare rock or thinly soiled. The valley bottom is covered by a layer of glacial till with alluvial fans formed at the confluence of tributaries. The majority of stream channels (68%) are steep (>20% gradient) sediment/debris transport reaches with beds composed of cobble and boulder with bedrock stretches. Collapsed glacial till deposits have dammed tributary streams in the upper reaches of some west and southwest sub- watersheds (HUC 6), creating marshes, bogs, and some lakes. Historically, lower Icicle Creek below RM 3.8 was an unconfined, alluvial stream, with large areas of floodplain deposits (Andonaegui 2001)

Public ownership accounts for 87% (119,155 acres) of the watershed with 74% (88,175 acres) within the Alpine Lakes Wilderness (Andonaegui 2001, USFS 1995). Private ownership accounts for 13% with most of this land in the lower watershed below RM 6.0. East Icicle Creek and Icicle Creek roads roughly parallel the creek from the mouth to RM 17.5 at the USFS wilderness boundary (Andonaegui 2001).

Assessment Unit Condition

From the USFS wilderness boundary the head waters, aquatic habitat closely resembles historic conditions. Floodplain connectivity and riparian habitat below the wilderness boundary have been altered through the construction of roads, campground development, timber harvests, and private development. Habitat alterations increase dramatically below RM 2.8, primarily from stream side development and channel confinement. Bank stabilization, flood control, and loss of riparian habitat limit the streams ability to adjust to sediment, debris and high flows. This loss of function exacerbates bank destabilization in a naturally mobile stream section, which in turn contributes additional sediment to the stream channel. Decreased in-channel complexity from the loss of LWD degrades channel conditions in the lower 2.8 mi. (Andonaegui 2001; Berg and Lowman, 2001).

The watershed has a long history of human use beginning with sheep herding and mining in the late 1800s. More recent uses include water withdrawal, timber harvest, road building, fire suppression, campground development, private residences, and recreation. Logging has occurred on 5% of the total acreage. Road building provided access for development, recreation, and timber harvest. Over 11% of the vegetation along lower Icicle Creek has been removed from private property (USFWS 2002). Fires followed by landslides are natural disturbance events that occur at relatively frequent intervals (USFS 2004). For example, the 1994 forest fires burned 12% of the watershed in the lower part of the subbasin. In 1999, a landslide originating on a slope burned in 1994 reached Icicle just above Snow Creek.

Leavenworth National Fish Hatchery (LNFH) structures block anadromous migration beginning at RM 2.8. The LNFH intake diversion dam (RM 4.5) is a fish passage barrier at low flows. The Icicle/Peshastin Irrigation District diversion dam at RM 5.7 may also hinder upstream fish passage at low flows (Andonaegui 2001; Mullan et al. 1992; USFS 2004). The fish screens at the District and LNFH diversions do not meet current NMFS criteria and require updating. Changes in the historic channels flow regime have caused sediment accumulation and vegetation encroachment. As a result, the historic stream channel has evolved from riverine to wetland. These issues are being addressed and are slated for construction in 2006. Once completed the LNFH and Cascade irrigation withdrawal will be in compliance with NOAA-fisheries and USFWS under Section 7 of the ESA.

Brook trout, coastal rainbow trout, and lake trout are non-native species that have been introduced to the watershed. The Leavenworth NFH raises and releases hatchery fish in Icicle Creek (Andonaegui 2001, Berg and Lowman, 2001, USFWS 2002), and coho are acclimated in Icicle Creek by the Yakama Nation (Murdoch 2004). Salmon carcasses were distributed in the watershed by the USFWS in 2002 but not in 2003 (Cooper 2002; Cooper 2003).

Riparian/Floodplain Condition and Function

Lower Icicle Creek is an unconfined low gradient alluvial stream. The riparian vegetation in Icicle Creek from the mouth upstream to RM 2.8 is reduced in structures and function and is fragmented and poorly connected. Based upon analysis of aerial photographs in 1994, it was determined that 11.2% of the stream had riparian vegetation removed, principally from housing development. Homes and fields line 25% of the lower 2.8 mi. where riparian vegetation has been cleared and banks replanted with domestic grasses, trees, and shrubs. Few areas retain a narrow strip of streamside vegetation (Andonaegui 2001).

Campsites near streams throughout the watershed are thought to increase fines and bank erosion, as well as decrease riparian vegetation. Some campsites in the wilderness area are located close to stream and lake areas and have been denuded of vegetation. Loss of vegetation has contributed to erosion into these water bodies (Andonaegui 2001). Roads are a source of sediment below RM

5.7. An analysis by the US Department of Agriculture (USDA) in 1995, however, estimated that sediment from roads is at least an order of magnitude lower than the calculated background watershed sediment delivery rate (USFS 2004). Sediment from camping is relatively minimal when compared against natural delivery rates.

The riparian vegetation from RM 2.8 to 17.5, below the wilderness boundary and above the Leavenworth NFH, including the historic stream reach, is dominated by small trees 9 to 20.9 in. diameter at breast height. The quantity and quality of riparian vegetation has been reduced by campground development, road development, past timber harvests, private development, and forest fires (Andonaegui 2001, USFWS 2001). The extent of degradation to riparian habitat, however, may be more localized in nature rather than the overall degradation of the riparian habitat for the entire reach from RM 2.8 – 17.5 (Andonaegui 2001). Riparian condition above RM 5.7 is good with riparian reserves more than 80% intact. Riparian condition below RM 5.7 is poor (USFS 2004)

In areas where the Icicle Creek road is close to the stream, riparian harvest has occurred (Andonaegui 2001, USFS 1995). There are approximately 2.3 mi. of road in the watershed that are encroaching upon the stream. Outside of these areas the roads are far enough a way from the stream that direct impact is low (Andonaegui 2001).

Based on GIS mapping exercise of rip-rapped banks using GPS coordinates, 10% of the total bank length on both sides of the creek from RM 0.0 – 2.8 (3,4449 ft. [total?]) have been rip-rapped. The morphology of the historic channel reach between RM 2.8 and 3.8 has been altered considerably by the holding dams and weirs placed in the channel during construction of the Leavenworth NFH. Stream banks in the historic reach are stable (Andonaegui 2001). Upstream of RM 3.8, specific locations where riprap has been placed include the following locations provided by road mi.: 4.6 - 5.1; 9.9 – 10.1; 10.7 – 10.8; 13.6 – 14.1. The riprap placement corresponds to areas where the road is confining the stream channel. Some areas that are adjacent to streams are being degraded by heavy use with vehicles and people. This is causing localized increased bank erosion and denuding banks (Andonaegui 2001, USFS 1995). A dike has been constructed at RM 14.7 on Icicle Creek to protect the banks at the Ida Creek Campground (RM 14.7).

The majority of waters flowing into Icicle Creek originate in wilderness areas and areas that have had minimal management (Andonaegui 2001). Even in these reaches, estimates of substrate embeddedness are high at 31 ? 100% (Andonaegui 2001; USFWS 2001), the effect of naturally high sediment loads.

Delete Sediment in the substrate in upper Icicle is good condition, even though percentages are high Delete. Most important, upper reaches have extensive beaver dam development, which has slowed flow, raised water levels, and killed trees that have fallen into the channel. Sediment retention is expected under these conditions (USFS 2004). However, for stream reaches in the lower watershed affected by land management activities, the extent of increased sediment delivery coupled with channel, flow, floodplain and riparian impacts, sediment and channel stability is considered fair (USFS 2004).

Stream reaches in Icicle Creek upstream at RM 3.8 do not meet federal Forest Plan standards for LWD (Andonaegui 2001, USFWS 2001). For stream reaches within the Alpine Lakes Wilderness, observed LWD levels, which are below Forest Plan standards, are the result of natural influences. For stream reaches downstream of the wilderness boundary, residential and commercial development, road construction and timber harvest, both within the channel migration zone of Icicle Creek and within drainages potentially contributing LWD to Icicle Creek, have negatively affected LWD levels (Andonaegui 2001).

Stream Channel Conditions and Function

Channel Condition and High Flow

Peak flows are likely affected below RM 5.7. Heightened peak flows result from urbanization, flood control channels, bank hardening, roads, and urbanization (USFS 2004). Channel width-to-depth ratios in Icicle Creek downstream of RM 2.8 are increasing in response to increases in sediment supply and bank instability, decreases in riparian function and structure, and changes in flow regime. Increased width-to-depth ratios are causing the channel to become wider and shallower, thus altering the historic channel morphology considerably.

Peak flows likely have not been affected in the upper watershed as development is minor compared to the vast acreage that remains in a natural condition (USFS, 2004). Width-to-depth ratios for Icicle Creek upstream of the historic channel (RM 3.8) are probably similar to historic conditions based on stream measurement taken during USFS stream surveys, with the exception of areas where roads and bridges confine the stream channel and where riprap has been placed (Andonaegui 2001).

Jack Creek: In the mid 1970s, an avulsion occurred on the lower reach of Jack Creek, shortening the stream length (Andonaegui 2001; USFS 1995). During the 1990 flood event, the pre-flood channel was blocked by a large wood complex and a new channel again cut through the alluvial soils (Andonaegui 2001).

Fine Sediment and Channel Stability

The majority of waters flowing into Icicle Creek originate in wilderness areas and areas that have had minimal management (Andonaegui 2001). Even in these reaches, estimates of substrate embeddedness are high at 31 – 100% (Andonaegui 2001; USFWS 2001), the effect of naturally high sediment loads. Sediment in the substrate in upper Icicle is good condition, even though percentages are high. Most important, upper reaches have extensive beaver dam development, which has slowed flow, raised water levels, and killed trees that have fallen into the channel. Sediment retention is expected under these conditions (USFS 2004). However, for stream reaches in the lower watershed affected by land management activities, the extent of increased sediment delivery coupled with channel, flow, floodplain and riparian impacts, sediment and channel stability is considered fair (USFS 2004).

Habitat Diversity

Connectivity between Icicle Creek and its off-channel, wetland, floodplain, and riparian areas has been reduced due to development, road building, water diversions, and flood damage control (Andonaegui 2001). Below the Leavenworth NFH, the channel bed is less stable as Icicle Creek adjusts to natural and human impacts. Channel confinements confound this process. Reaches in upper Icicle Creek are in good condition except in areas where roads and bridges confine the stream channel and riprap has been placed. There are several side channels along East Leavenworth Road that are cut off from the stream. In several areas, riprap has been placed on stream banks and berms have been built to confine the stream and limit flood damage. Additionally, in several areas wetlands have been reduced either through draining and/or filling.

In the lower 2.8 mi. of Icicle Creek there are few back water areas and low energy off-channel areas. From RM 3.8 upstream, 1994 USFS stream survey data shows that 72% of upper Icicle Creek contains an adequate and diverse amount of off-channel habitat. Many side-channels, back water areas, ponds, wetlands, and oxbows occur (Andonaegui 2001).

Water Quality

Temperature/Oxygen/Pollutants

The WDOE 303d list has several water quality concerns for Icicle Creek, including temperature, pH, and dissolved oxygen. The USFS 1994 stream survey recorded instream temperatures as high as 64°F between RM 4.8 – 17.0 on Icicle Creek. This exceeds federal Forest Plan standards. There is presently not enough data, however, to determine if these temperatures are significantly different than temperatures in the historic range or to what extent, if any, these temperatures negatively impact salmonid migration, spawning, incubation or rearing (Andonaegui 2001; USFS 2004).

Turbidity

A landslide on a draw that descends from Icicle Ridge occurred in June 1999. The affected area was approximately 120 ft. wide and 300 ft. long with a depth of approximately 10-15 ft. (USFWS 2002).

Eightmile Creek: Timber harvest and fire have changed the vegetation and increased the exposed soils. Sediment that reaches the mainstem is transported to the alluvial fan at the mouth and into Icicle Creek. The Eightmile Road (USFS Road 7601) is a major contributor of sediment (USFS 1995).

Water Quantity

Low Flow

Icicle Creek Does not meet instream flow standards and has been included on the WDOE 303d list.

There are 23 surface water rights permits or certificates in the assessment unit that can divert a potential total of 205.4 cfs. There are 13 surface water rights claims worth a potential of 9.5 cfs. There are 5 pending applications for a surface water right permit, certificate, or claim worth 8.8 cfs. There are 5 ground water rights permits or certificates worth a potential total withdrawal of 5,178 gpm. There are 16 ground water rights claims worth a potential withdrawal of 369 gpm. There are 4 applications pending for ground water rights permits, certificates or claims worth a potential total of 135 gpm (Montgomery Water Group et al. 1995).

The effects of the diversions and withdrawals, both individual and cumulative, on instream habitat conditions are undetermined at this time. The status of the diversions and screens associated with the surface water rights are unknown at this time.

The Leavenworth NFH and the Cascade Orchards Irrigation District Company (privately owned, not an irrigation district) divert water at RM 4.5. The upstream-most water diversion occurs at

RM 5.7 on Icicle Creek by the Icicle/Peshastin Irrigation District (District) and the city of Leavenworth. Screens on all these diversions do not meet NMFS requirements.

Without releases of water (50 cfs) from Upper Snow Lake, the downstream reaches of Icicle Creek would go dry in some years (Andonaegui 2001, Mullan et al. 1992; USFWS, 2002). Low flows in the lower reach (RM 0.0 – 5.7) are the result of natural conditions compounded by public water supply needs, irrigation diversions, and the fish hatchery diversions.

Obstructions to Fish Passage

Fish passage in the upper portions of Icicle Creek remains similar to the historic reference condition. In the lower six miles of the mainstem Icicle Creek, the USFWS Leavenworth National Fish Hatchery and several irrigation diversions block fish passage. At RM 5.6, there is a natural boulder field, which creates a substantial velocity and gradient barrier.

This identifies the boulder field as the first potential natural fish passage barrier (partial barrier at some flows) on Icicle Creek (Andonaegui 2001).. LNFH is required to pass any un-spawned steelhead, that enters the holding ponds, above the hatchery.

Adult bull trout have also been observed below the LNFH spillway dam (Andonaegui 2001). In 2003, two fluvial bull trout were identified above the boulder field (Judy DeLaVergne, personal communication)

Ecological Conditions

Eastern brook trout, non-native rainbow trout, and lake trout have been introduced in the Icicle watershed (USFWS, 2002). The introduction of non-native species can impact native fish through competition, predation, and genetic hybridization.

Interactions between hatchery and wild salmonids is covered under Hatchery Management in the Wenatchee subbasin, in Section 4.

Environmental/Population Relationships

The majority of the fish habitat in the Icicle Creek between RM 24 and RM 30 and within associated tributaries is in highly functional condition. Spring chinook, steelhead and fluvial bull trout, however, are blocked at RM 2.8 at the Leavenworth NFH spill way and Dam 5 and headgate and weirs from hatchery operations in the historic channel between RM 2.8 and RM 3.8 (Andonaegui 2001, USFWS 2001). Historically, anadromous fish were able to access Icicle Creek to RM 24.0, where there is a natural falls prevents upstream passage (Andonaegui 2001; Mullan et al. 1992).

The spring chinook spawners observed annually below the spill way (RM 2.8) in Icicle Creek are likely mostly of hatchery origin (Andonaegui 2001; MCMCP 1998). From 1958 to 1999, 7.69% of all redds located in the Wenatchee subbasin by the Chelan County PUD were found in Icicle Creek. The natural characteristics of the stream are most suitable for spring chinook; steelhead, rainbow and bull trout rearing and spawning. Late-run chinook use of Icicle Creek is limited. Sockeye salmon do spawn downstream of RM 2.8, but use is limited to strays from the Lake Wenatchee population. There were 30 redds counted in 1997 and 9 in 1999 (Andonaegui 2001, USFWS 2001). Rainbow trout occur upstream of the spillway (RM 2.8), in the mainstem, and in various tributaries. Bull trout have also been located upstream of the spill way at RM 2.8 and in

Jack, Eightmile, and French creeks. The population abundance is uncertain, but are not considered strong due to the loss of connectivity to the rest of the Wenatchee River system at the Leavenworth NFH dam, and the influences of harvest and past fish stocking management. Adult bull trout have also been observed below the Leavenworth NFH spill way dam (Andonaegui 2001).

Areas of Special Interest

- functioning floodplain and riparian habitat downstream of the wilderness boundary (RM 17.5) with emphasis on protection downstream of RM 2.8 (Andonaegui 2001).

Limiting Factors

Andonaegui (2001) identified the following Limiting Factors:

- low instream flows in the Icicle
- channel function in lower Icicle Creek
- reduce sediment delivery from roads
- the Leavenworth NFH and the Cascade Orchards Irrigation District Company divert water at RM 4.5, where the screen needs updating
- waters of Icicle Creek are diverted by the Icicle/Peshastin Irrigation District and the Leavenworth at RM 5.7, where the screen needs updating
- Leavenworth at RM 5.7, where the screen needs updating Fish passage at LNFH. Dam 5 and the head gate are being retrofitted for fish ladders in 2005 for passage of steelhead and bull trout. Spring Chinook that enter the ladder will be moved to the holding ponds or be returned to the pool below Dam 5.

Data Gaps

- Salmonid passage at the boulder area (RM 5.6) upstream of the Leavenworth NFH (Andonaegui 2001; Upper Columbia RTT 2001)
- The interaction of water diversions, water withdrawals, and return flows on instream flows and temperatures, including its affects of fish habitat and use (Andonaegui 2001)
- The extent to which Icicle Creeks ability to dissipate energy and transport bedload has been affected by human-induced changes, including the location of the impacts (Andonaegui 2001)
- The effects of the diversions and withdrawals, both individual and cumulative, on instream habitat conditions are undetermined at this time
- Bull Trout and Cutthroat population abundance and distribution remains uncertain.

Functional Relationship of Assessment Unit within Subbasin

Icicle Creek is a Category 2 watershed (see Determination of Restoration Priorities in Section 6.5) and has 4 significant subwatersheds: lower, middle, and upper Icicle, and Jack creeks. Bull trout are located in upper Icicle and tributaries; they are currently- may be stranded from migratory bull trout by Leavenworth NFH structures during certain times of the year. Listed summer steelhead and hatchery spring chinook return to the lower Icicle. Westslope cutthroat are located in the upper watershed.

4.9.9 Nason Creek Assessment Unit

Assessment Unit Description

The head waters of Nason Creek lie in the eastern slopes of the Cascade Mountains in central Washington. Nason Creek flows east out of Lake Valhalla at 4,830 ft. for approximately 21 miles and then turns north for another 5 miles before emptying into the Wenatchee River at RM 53.6 just below Lake Wenatchee (RM 54.2; USFS, 1996; Rife and Haskins 1998, Andonaegui 2001). The watershed is bounded by Nason Ridge on the north, the crest of the Cascades on the west, the Chiwaukum mountains and McCue Ridge on the south, and Natapoc Mountain on the east (USFS, 1996). Nason Creek is a 3rd order stream, contributing approximately 18% of the low flow of the Wenatchee subbasin and draining 108 sq. mi. (Rife and Haskins 1998; Andonaegui 2001).

Elevations in the 69,000 acre watershed vary from 8000 ft. at Snowgrass Mountain to 1865 ft. at the mouth of Nason Creek. Precipitation and forest vegetation vary substantially along this elevational gradient (Andonaegui 2001). Annual precipitation ranges from 30 to 90 in.; 84% of the watershed receives 50-80 in. annually. Vegetation type ranges from sub-alpine to dry forest (USFS 1996).

The Nason Creek drainage was formed by glacial scour. It is dominated by steep bedrock or rocky slopes with accumulations of talus on the lower margins and a broad, U-shaped valley floor characterized by glacial till deposits (Rife and Haskins 1998; Andonaegui 2001). There are areas of excessive scouring occurring, a result of both natural events and human alterations (MCMCP 1998).

Assessment Unit Condition

Habitat in the Nason watershed has been altered by human activities including railroad development, road building, channel straightening, timber harvest, and private development. Every habitat feature measured by the USFS has been reduced to fair or poor condition somewhere in the watershed. The lower 15 mi. of the mainstem contain the most habitat features in poor condition. This reach contains all spring chinook spawning habitat in the watershed and is a key corridor for connectivity of sub watersheds. Habitat alteration is greatest in the lower watershed. The only channel reaches which are functioning appropriately for all reach metrics are Whitepine Creek above the wilderness boundary, Smith Brook, and Nason Creek above the wilderness boundary. Tributaries in the watershed form a continuum between these two extremes, with negative impacts decreasing as one moves towards the head waters (Rife and Haskins 1998).

Moderate to high subsurface water storage capacity, steep terrain, and deep, non-cohesive valley soils result in a naturally high mass wasting hazard in the watershed. Fire and debris slides are among the primary naturally occurring disturbance processes. Roads and timber harvest are believed to be the dominant human-related sources of sediment to the stream (USFS 1996;

Andonaegui 2001). Low instream flows are common in August and September, a natural condition related to snow accumulation and snow melt patterns (Andonaegui 2001).

(Feature each of the four+ components (not climate) as well as critical habitat attributes and other major related features (hatchery facilities, etc.). This is the primary place that EDT/QHA info. is presented.)

Riparian/Floodplain Condition and Function

The mainstem below Whitepine has experienced the greatest floodplain alteration and channel confinement. Much of the floodplain of the lower mainstem is privately owned, has experienced substantial development, and is likely to see further development in the future. Mill Creek watershed, the only known bull trout spawning in the Nason Creek watershed, has been substantially impacted by powerline access, a floodplain gravel pit, timber sales, roading, and a winter recreation facility that has been expanding operations in the watershed. Future development has the potential to further impair key bull trout habitat (USFS 1998).

The lower watershed is no longer resilient to disturbance, and typical disturbance events such as a 20 year high flow can have impacts beyond what would be expected in the historic condition (Rife and Haskins 1998). Channelization and constriction of Nason Creek for high way and railroad placement have led to changes in peak flow timing and duration and down cutting of the streambed in the lower reach (USFS 1996, Andonaegui 2001). Other impacts include meanders into oxbows, increasing flow velocities, and floodplain isolation (USFS 1996; Andonaegui 2001). Elevated instream temperatures in lower Nason Creek during summer months have been recorded.

Due to extensive floodplain development, much of it on private land, riparian reserves are poor condition in Nason Creek below Whitepine, and in Kahler, Gill, Roaring, and Coulter Creeks. Nason riparian condition above Whitepine is considered to be fair, due to streambank and floodplain alterations on private land, as well as floodplain and bank impacts of railroad, high way, and powerlines. There is potential for further development along some of the riparian area near Yodelin on private property (USFS 1998).

Stream Channel Conditions and Function

Fine Sediment and Channel Stability

A significant proportion of banks in low gradient reaches upstream of the Whitepine confluence (RM 14.6) have been riprapped. Bank vegetation and natural bank processes such as channel migration have largely been eliminated (USFS 1998; Andonaegui 2001). McNeil core sediment samples taken in the lower 5 mi. of Nason Creek exceeded USFS forest plan standards. Samples indicate that the sediment is out of balance and the channel bed is in poor condition (USFS 1998; USFWS 1998). Harvest-related landslides like the large 1990 slide across from Mill Creek, and other human-related sediment sources from development like the high way, may contribute sediment above historic levels from the Nason mouth to Stevens Creek. This reach is in poor condition with high amounts of fine sediment (Rife and Haskins 1998; Andonaegui 2001). The only Nason Creek tributary for which McNeil core information is available is Kahler Creek. Kahler is in poor condition with high amounts of fine sediment (Rife and Haskins 1998).

Stream surveys indicate that Mill, Stevens, Gill, Butcher, and reach 2 of Roaring creeks have elevated sediment levels and are in fair instead of good condition. Smith Brook has abundant fine sediment in any area with lower gradient but this seems to be a natural condition since there has been very little land management or roading within the drainage. Therefore the reach is considered to be natural and in good condition (USFS 1998).

The lower 15 mi. of Nason Creek has little LWD. The channel Does not appear to retain LWD as floods within the confined channel cannot dissipate energy (Rife and Haskins 1998). Recruitment of LWD from some tributaries into Nason Creek is limited by the railroad grade and culvert crossing near tributary confluences (Andonaegui 2001). Mill, Roaring, and Kahler creeks contain marginal LWD counts (Rife and Haskins 1998).

Habitat Diversity

Nason Creek below Smith Brook is in poor condition because of extensive loss of off-channel habitat. Nason Creek above Smith Brook is in fair condition for off-channel habitat because of some degradation (Rife and Haskins 1998). Although off-channel loss has been most severe in the lowest 15 mi. of Nason Creek, it has been significant in all areas of unconfined channel, including upper Nason Creek (USFS 1998; Andonaegui 2001). All of the Nason tributaries are in good condition for off-channel habitat (Rife and Haskins 1998).

Nason Creek floodplain connectivity above Whitepine is fair. Some channel confinement by high way, railroad, and floodplain development has reduced connectivity. Nason Creek below Whitepine is in poor condition resulting from these same factors. The rest of the watershed is considered to be in good condition (USFS 1998).

Water Quality

Temperature

WDOE 1998 303d lists includes Nason Creek from the mouth to Lake Valhalla. Elevated stream temperatures during summer in Nason Creek below Whitepine create poor fish habitat conditions. Nason Creek stream temperatures between Whitepine and Stevens are fair; any slight temperature increase here could have serious consequences downstream. Gill Creek temperatures are also considered fair. No temperature data is available for Kahler Creek, but summer temperature conditions are considered fair because of reduced riparian canopy. Mill Creek, Smith Brook and Whitepine creeks may be functioning appropriately for temperature (Rife and Haskins 1998). Elevated instream temperatures in upper Nason Creek are also a concern given the degraded condition of riparian habitat associated with high way riprap and riparian vegetation removal (Andonaegui 2001).

Oxygen and Turbidity

Hindes (1994) reported that 3 of 20 values of dissolved oxygen, and 1 of 20 of pH, turbidity, and water temperature failed to meet state water quality standards in Nason Creek at Nason Creek Campground. At an upper Nason site near Berne downstream of Henry Creek, 5 of 20 DO readings and one pH reading failed to meet state water quality standards. Fecal coli form was present in most water samples at both sites, but not at levels that exceeded state water quality standards. The watershed as a whole is functioning at risk for chemical contamination based on the 1994 Hindes report (Rife and Haskins 1998).

Water Quantity

Peak Flow

The WDOE 1998 303d list did not include water quantity concerns for Nason Creek. USFS 1998 evaluations noted that the combination of channel confinement, increased drainage network, road densities, and timber harvest has likely altered timing of flows within the watershed. Therefore Nason watershed is in poor condition related to peak/base flows (Rife and Haskins 1998).

Low Flow

There are 27 surface water rights permits or certificates worth a potential total diversion of 3.5 cfs. There are 35 surface water rights claims worth a potential total diversion of 6.8 cfs. There are 3 pending application for a surface water rights permits, certificates, or claims worth 0.9 cfs. There are 11 ground water rights permits or certificates worth a potential total withdrawal of 770 gpm. There are 22 ground water rights claims worth a potential total withdrawal of 270 gpm. There are 6 applications for ground water rights permits, certificates or claims pending worth a potential total of 2,555 gpm (Montgomery et al. 1995; Andonaegui 2001). The effects of the diversions and withdrawals, both individual and cumulative, on instream habitat conditions are undetermined at this time.

Obstructions to Fish Passage

Obstructions to fish passage are located throughout much of Nason Creek and its tributaries. Most of these are culverts. Important fish habitat is blocked due to the transportation system along much of Nason Creek.

Ecological Conditions

Brook trout were planted in some of the lakes within the watershed. Brook trout are known to out-compete and cross breed with bull trout, eliminating the genetically pure bull trout population (USFS, 1996). Stocking of non-native rainbow and brook trout may have displaced westslope cutthroat from some historical habitat. Planting native westslope cutthroat in high lakes has also likely expanded the range of the species. Brook trout may displace cutthroat from reaches with moderately elevated water temperatures and gradients below 7%. This displacement could fragment the population. (Rife and Haskins 1998). Cold water temperatures in the head water drainages may prevent genetically non-native rainbow from competitively displacing cutthroat in this habitat (Rife and Haskins 1998). The Yakama Nation is attempting to reintroduce coho into the Nason Creek watershed by out-planting hatchery reared pre-smolts (Peven 2003). Salmon carcasses were distributed in the watershed in 2002 and 2003 (Cooper 2002; Cooper 2003). Nason Creek above Smith Brook is important westslope cutthroat habitat (Rife and Haskins 1998).

Environmental/Population Relationships

The baseline condition of Nason watershed indicates significant environmental degradation. There is significant risk to chinook, steelhead, and bull trout habitat and populations in the watershed (Rife and Haskins 1998).

Late-run chinook do not occur in the watershed (Andonaegui 2001). Spring chinook, steelhead, bull trout, cutthroat and redband trout spawn and rear in Nason watershed (Rife and Haskins

1998, Andonaegui 2001). Whitefish, dace, and sculpin species are also present in the watershed (Rife and Haskins 1998).

The significance of the Nason Creek watershed lies in its potential contribution to Wenatchee subbasin spring chinook production and its connectivity to upper subbasin salmonid populations, particularly bull trout (Andonaegui 2001).

Key spring chinook and bull trout habitat are in poor condition in this watershed. All chinook spawning habitat lies in a reach in which every kind of habitat measurement has been reduced to fair or poor condition (Rife and Haskins 1998). All known bull trout spawning lies in a sub watershed in which many habitat conditions are poor. Little is known about steelhead spawning, but natural passage barriers confine it to the mainstem below Smith Brook and the lower ends of several tributaries. All of these channels have at least some habitat conditions reduced to fair condition. Chinook spawning appears to be confined to the mainstem below Whitepine Creek. All of this habitat has been degraded to some degree, reducing the chance to support a strong and significant chinook population. Chinook redd counts have fallen sharply since the 1950s, with an even more definite down ward trend than in neighboring watersheds. Bull trout redd counts in the watershed range from 1to 3 redds. No data is available on steelhead redds. (Rife and Haskins 1998). All spring chinook spawning and rearing habitat in the watershed is in Nason Creek below RM 16.8 where Gaynor Falls creates a natural barrier to upstream passage for chinook and sockeye (Andonaegui 2001).

Areas of Special Interest

- Remaining functioning floodplain and riparian habitat is the first priority in the Nason Creek watershed (Andonaegui 2001; Upper Columbia RTT 2002).
- Oxbows separated from the mainstem in the lower three mi. of Nason Creek.

Limiting Factors

- Channel migration is limited, and channel structure is simplified (Upper Columbia RTT 2002; Andonaegui 2001)
- Lost fish passage from the wetlands and oxbows to Nason Creek because of State Hwy. 2 placement from Whitepine Creek (RM 14.6) downstream to Kahler Creek at RM 5.1 (Upper Columbia RTT 2002; MCMCP 1998; Andonaegui 2001)
- Obstructions to Tributary and obstructions in the tributaries.Sediment delivery from roads and minimize road building (USFS 1996; Andonaegui 2001)
- Canopy loss on harvested upland habitat (Andonaegui 2001)
- Brook trout interactions (competition and predation).

Data Gaps

Andonaegui (2001) identified the following data gaps:

- The cumulative effects of timber harvest, development, and road densities on sediment delivery, LWD levels, and stream channel function.

- Opportunities to and benefits of restoring disconnected oxbows given the existing limitations presented by the existence of the railroad grade and state high ways 2 and 207.
- Population estimates and distribution of bull trout and cutthroat trout remains undermined.

Functional Relationship of Assessment Unit with Subbasin

Nason Creek is a Category 2 watershed (see Determination of Restoration Priorities in Section 6.5) and has 3 significant sub- watersheds: lower Nason, upper Nason, and head waters of Nason. Nason Creek is a Category 2 watershed based on fragmentation and habitat degradation, especially in the lower watershed (Upper Columbia RTT 2002). It provides spawning and rearing habitat for steelhead, and habitat for listed spring chinook and bull trout. Bull trout, summer steelhead and spring chinook are listed fish still able to access this watershed. Connectivity among sub watersheds still exists, although the amount of habitat available compared to historic conditions is limited.

4.9.10 Little Wenatchee River Assessment Unit

Assessment Unit Description

The Little Wenatchee River is a 4th order stream draining a 64,794 acre watershed. It is fed by four large tributaries: Rainy, Lake, Fish, and Cady creeks (Andonaegui 2001). The head waters of the Little Wenatchee River are at lower elevation than the White River, with more lakes and fewer glaciers. Elevation in the watershed varies from 1,868 ft at the lake inlet to 6,577 ft. at Longfellow Mountain. There are 13 lakes with a total area of 232 acres in the drainage (Andonaegui 2001, Raekes 2004). The Little Wenatchee River flows southwest 25 mi. and empties into Lake Wenatchee. The majority of precipitation falls during the winter months as snow, while localized high intensity thunderstorms during summer also accounting for some precipitation. Annual precipitation varies from 30 in. at the lake to 90 in. in the head waters of the Little Wenatchee River. Runoff peaks during late May and early June as snowmelt progresses. The Little Wenatchee River watershed contributed 15% of the annual flow to the Wenatchee River for the period October 1992 to September 1993 (Andonaegui 2001; CCCD 1996).

Of the total acreage in the drainage, 97% is publicly owned and 3% is in private ownership, all in the lower three mi.. Road densities are higher in the lower portions of the drainage from Lake Creek (RM 13.1) to the mouth (USFS 1998). In Rainy Creek and other managed sub watersheds of the Little Wenatchee, debris flow frequency appears to have been accelerated above background levels (Andonaegui 2001; USFS 1998).

The main channel forming processes in the Little Wenatchee watershed are glaciation and seasonal runoff. The watershed is characterized by steep valley head walls, cirques and cirque head walls which are typically bare rock or thinly soiled. The valley bottom is covered by a layer of glacial till with alluvial fans formed at the confluence of tributaries. This land type generally has a high subsurface water storage capacity and is commonly subject to inundation during high flow events. In sections where the stream is actively migrating across its floodplain, bank erosion is common and expected at meander bends. Stream migration naturally occurs in the lower river where the valley bottom is low gradient and wide, the substrate is glacial till, and channels have naturally high sinuosities (Rosgen C type channel) (Andonaegui 2001; USFS 1998). The lower

1.3 mi. of the river are heavily influenced by the back water effects from Lake Wenatchee and have remained relatively stable (Andonaegui 2001; USFS 1998). Most of the land in the watershed is designated wilderness.

Assessment Unit Condition

The Little Wenatchee River is among the healthiest watersheds in the Columbia basin. Several moderate habitat concerns, however, exist (Andonaegui 2001, USFS 1998). Most of the concerns occur in and below areas of extensive timber harvest ;Andonaegui 2001, USFS 1998). Most timber harvest in the Little Wenatchee River corridor has occurred from the mouth upstream to Cady Creek (RM 0.0 - 16.9) and the Rainy Creek drainage. Where harvest and roading have occurred, the potential for LWD input has decreased. Increased sediment delivery and disruption debris slide delivery is also expected. Moderate road densities of 2.4 mi./sq. mile and harvest activities may also contribute to high stream temperatures in the mainstem by increasing runoff and decreasing water storage potential (Andonaegui 2001).

Rainy Creek enters the mainstem at RM 8.4 above the falls (RM 7.8). It is the only tributary known to support bull trout, although there is a natural barrier on Rainy Creek at RM 5.5. There is also a barrier falls on the Little Wenatchee River that blocks anadromy. Rainy Creek is a high energy transport stream with steep gradients and a boulder/cobble bed alternating with bedrock. Over the millennia, a large fan has accumulated at the mouth of Rainy Creek. The channel pattern on the fan has gone from three wetted channels down to one entrenched channel. It is unclear what effect land management practices have had on debris slide regimes and channel form on the fan (Andonaegui 2001; USFS 1998). A bridge was constructed near the mouth, and USFS Road 6700 follows the creek up to its head waters crossing the stream three times.

Recreation including hiking, horse-riding, camping in developed campgrounds, and dispersed camping occurs throughout the Little Wenatchee watershed. Cross country ski and snowmobile routes are not groomed and use is limited to those looking for more primitive opportunities. There are no designated Off Road Vehicle opportunities in the watershed.

Coho are being reintroduced at the Two Rivers side channel (Peven 2003). Salmon carcasses were not distributed in 2002 or in 2003 (Cooper 2002; Cooper 2003). In general, roads, campgrounds, and private lands allow humans to access and potentially disturb fish, however the actual disturbance level is low.

Riparian/Floodplain Condition and Function

Riparian Condition

In the Little Wenatchee watershed, there are 29.3 mi. of road within 300 ft. of a stream (USFS 1998). Road densities in the lower Little Wenatchee sub watershed (RM 0.0 - 11.9) and the upper Little Wenatchee sub watershed (RM 16.9 to the head waters) are both 2.4 mi./sq. mile (Andonaegui 2001; USFS 1998). This road density is moderate in comparison to NOAA Fisheries habitat standards.

Some riparian harvest has occurred along the mainstem and contributes to lowered LWD levels. Harvest also possibly contributes to elevated instream temperatures measured at the mouth (Andonaegui 2001, USFS 1998). Before 1985, most timber harvest units on USFS lands left no riparian buffer on the upper reach from RM 16.9 to the head waters, the lower reach from RM

0.0 to RM 11.9 and in Rainy Creek (Andonaegui 2001, Driscoll et al. 1998). There are some clear-cuts directly adjacent to the creek where grazing and watering occurs near the head waters and tributary channel on the south side of Rainy Creek (Andonaegui 2001; Driscoll et al. 1998). On a watershed wide basis, the length of disturbed channel is minimal. USFS analysis considered effects on fish habitat relative to shade reduction and found effects to be discountable (Andonaegui 2001). Overall, the riparian corridor is in good condition.

Stream Channel Conditions and Function

Channel Condition and High Flow

The lower river has high width-to-depth ratios, a possible indicator of a high sediment load. Other indicators of high sediment load in the low gradient reaches include high apparent embeddedness in pool tail outs, apparent filling of some pools, and extensive bar development (MacDonald et al. 1998).

In the vicinity of the Riverside campground near a dispersed campsite at RM 7.8, both banks of the river have been riprapped for structure protection at the bridge and as a result of flood damage on the opposite side of the old campground . Riprap is not considered to have a measurable affect on the reach. Overall floodplain function within the watershed is in good condition (Andonaegui 2001; Driscoll et al. 1998).

Fine Sediment and Channel Stability

Analysis of historical aerial photographs in the USFS biological assessment concluded that depositional reaches of the Little Wenatchee River between RM 1.3 and 3.5 may be at risk for increasing width-to-depth ratios. There was evidence of pool filling and spawning gravel embeddedness upstream of the falls at RM (7.8) during the 1997 USFS stream survey (Andonaegui 2001; Driscoll et al. 1998).

In some surveyed reaches, however, there is not enough information to determine if fine sediment is a concern (Andonaegui 2001).

Habitat Diversity

During the 1970s, biologists were concerned that large LWD complexes created fish passage barriers in the lower few mi. of the river. They made several attempts to remove the complexes, although wood kept accumulating in the same locations (Andonaegui 2001; Mullan et al. 1992; USFS 1998). A stream survey conducted in 2000 concluded that LWD levels below RM 7.8 had good quantities of large wood present in the channel (Andonaegui 2001). All streams in the watershed appear to be within the range of natural conditions for pools . Pool depth and pool quality is considered appropriate for streams in the drainage (Andonaegui 2001; Driscoll et al. 1998).

Water Quality

Temperature/Oxygen/Pollutants

The Little Wenatchee River below Theseus Creek (RM 11.5) does not meet state and forest plan water quality standards during the summer months for temperature (Andonaegui 2001, Driscoll et al. 1998). water temperature exceeded 61°F for several weeks in August 1997 and exceeded 61°F in 4 of 5 recorded years (Andonaegui 2001; Driscoll et al. 1998). Because the water temperature exceeded criteria on numerous sampling occasions, the Little Wenatchee River is included on the WDOE 1998 303d list for water quality concerns. Other than sediment concerns, the Little Wenatchee is not listed for oxygen or pollution concerns.

There is insufficient data to determine if these temperatures are significantly different than temperatures in the historic range or to what extent they negatively impact salmonid migration, spawning, incubation or rearing. The USFS has initiated an analysis of instream temperatures on the river to evaluate the effects on salmonids (Andonaegui 2001).

On Rainy Creek multiple visual estimates of embeddedness below the natural falls barrier at RM 5.5 increased in volume by 35%. High and possibly accelerated rates of debris flows, extensive timber harvest, and road placement may result in accelerated sediment delivery to the stream (Andonaegui 2001; Driscoll et al. 1998). Road densities in Rainy Creek are 1.5 mi./sq. mile (Andonaegui 2001; USFS 1998). There are also some clearcuts adjacent to the creek where grazing and watering is allowed near head waters and mid slope at tributary channels on the south side of Rainy Creek. These were documented during USFS 1998 photo monitoring. Based on 1998 monitoring, the USFS determined that sediment impacts from soil disturbed by grazing may contribute slight but measurable amounts of fine sediment to the channel system. The USFS has also determined this is not significant on a reach basis (Andonaegui 2001; Driscoll et al. 1998).

Water Quantity

Low Flow

The WDOE 1998 303d list Does not include water quantity concerns for the Little Wenatchee River.

Annual flow records in watershed have not been recorded until recently. Some reviewers think the river flows may be altered from historic condition because of substantial road network and timber harvest below the wilderness boundary (approximately RM 9.5). (Andonaegui 2001; Driscoll et al. 1998).

There are no known areas of de watering, natural or human-induced, in the drainage (Andonaegui 2001).

There are 3 surface water rights permits or certificates worth a potential total diversion of 1.0 cfs. There are no surface water claims or applications. There are no ground water rights permits, certificates, claims or applications (Andonaegui 2001; Montgomery Water Group et al. 1995). The limited extent of potential water diversions described above Does not have the ability to change the flow regime of the mainstem or tributaries (Andonaegui 2001).

Obstructions to Fish Passage

There are no anthropogenic fish passage barriers in the Little Wenatchee watershed (USFS 1998).

Ecological Conditions

Brook trout and non-native rainbow trout have been introduced in the Little Wenatchee watershed and occur above the falls at RM 7.8. Brook trout occur throughout the mainstem to

Meander Meadow and in Rainy Creek. Potential hybridization of bull trout with introduced brook trout is a concern (Driscoll et al. 1998).

Cold water temperatures in the head water drainages may prevent non-native rainbow from competitively displacing cutthroat in this habitat. Twin Lakes serves as a strong genetic refuge for westslope cutthroat trout and is used for high lake stocking programs which could help assure persistence. Although rainbow stocking has ceased in streams, non-native rainbow are present and are still planted in some high lakes (Driscoll et al. 1998).

Environmental/Population Relationships

The Little Wenatchee watershed contains some of the best aquatic habitat and strongest native fish populations remaining in the upper Columbia River ESU (Berg and Lowman 2001; USFS 1998). The connectivity to the rest of the subbasin, including the large, un-dammed Lake Wenatchee, adds to the potential regional importance (Berg and Lowman 2001).

Spring chinook and steelhead trout spawn and rear in the river upstream to the falls (RM 7.8), with the primary spawning area for spring chinook between RM 2.7 and RM 7.8 (Andonaegui 2001, USFS 1998). Chelan PUD spring chinook redd counts from 1958 to 1999 showed the watershed contained 7% of the total number of redds counted in the Wenatchee subbasin for that period (Andonaegui 2001). Genetically “good” redband trout have been documented below Little Wenatchee falls. Above the barrier falls, native westslope cutthroat trout, introduced rainbow trout, and introduced brook trout are found (Driscoll et al. 1998). There has been extensive planting of rainbow and brook trout in most lakes and streams in the drainage. Brook trout have become well established in the lower river, Rainy Creek and other streams in the drainage (Andonaegui 2001; USFS 1998).

The lower 8 mi. of the river is one of two main spawning areas for the Lake Wenatchee sockeye run, the other being the lower White River (Andonaegui 2001; MCMCP 1998; USFS 1998). The lower Little Wenatchee River below the falls (RM 7.8) provides important spawning habitat for approximately 25% of the Lake Wenatchee sockeye salmon run. There is spawning and rearing of adfluvial bull trout in the river below the falls (Andonaegui 2001; USFS 1998).

Areas of Special Interest

- After the White River, the Little Wenatchee provides the remainder of sockeye spawning habitat in the subbasin.
- Bull trout and spring chinook successfully spawn and reproduce in the Little Wenatchee.

Limiting Factors

Competition and Predation by brook trout in the upper watersheds of the Assessment Unit

Data Gaps

In some surveyed reaches of the Little Wenatchee River, there is not enough information to determine if fine sediment is a concern (Andonaegui 2001).

Data gaps identified in the watershed Analysis (USFS 1998) include:

- Need better fish population and community composition data.

- Need complete fish distribution presence and absence information throughout watershed.
- Need data on nongame fish.
- Need to determine the where and why of Little Wenatchee River temperature concerns.
- Need better temperature and sediment data for Rainy Creek.
- Need more information on bull trout populations throughout watershed.
- According to the 1991 USFS stream survey report for Rainy Creek, visual estimates showed a high percent embeddedness below the barrier falls (RM 5.5). High and possibly accelerated rates of debris flows from a 1996 slide survey, extensive timber harvest, and road placement may result in accelerated sediment delivery to the stream (Andonaegui 2001; Driscoll et al. 1998). Road densities in Rainy Creek are 1.5 mi./sq. mile (Andonaegui 2001; USFS 1998). It is the opinion of the TAC, however, that in the past 10 years much could have changed and a more current review and analysis of sediment conditions in Rainy Creek is needed (Andonaegui 2001).

Functional Relationship of Assessment Unit with Subbasin

The Little Wenatchee River is a Category 1 priority watershed (see Determination of Restoration Priorities in Section 6.5) and 5 significant sub- watersheds. It provides spawning for spring chinook, and is one of two rivers in the subbasin in which sockeye spawn. The subbasin provides habitat for the listed spring chinook, bull trout, and for some steelhead.

4.9.11 White River Assessment Unit

Assessment Unit Description

The White River is a 5th order stream and relative to flow, one of the two primary tributaries (USFS 2004). (The Little Wenatchee River is the other tributary.) The drainage encompasses 99,956 acres and originates in alpine glaciers and perennial snow fields. Many White river head water sources are at higher elevation than the highest elevation in the Little Wenatchee drainage. Longfellow Mountain at 6,577 ft.. Elevation in the White River drainage varies from 1,868 ft at the lake surface to 8,575 ft at Clark Mountain (Andonaegui 2001; Raekes 2004). The White receives more precipitation, and sustains higher summer flows and cooler summer temperatures than the Little Wenatchee. Precipitation ranges from 30 in. at the mouth to more than 140 in. in the head waters (Andonaegui 2001).

The White River flows south-southeast for the majority of its length (26.7 river mi.). Two large tributaries, Napeequa (RM 11.0) and Panther (RM 13.1) creeks, support anadromous salmonids. Sears (RM 7.7) and Canyon (RM 10.0) creeks, two smaller tributaries to the mainstem, support bull trout only (Andonaegui 2001; Mullan et al. 1992).

Of the total acreage in the drainage, 78% is in public ownership and 22% in private ownership, all in the lower third of the river below Panther Creek (USFS 1998, Andonaegui 2001). Over half of the watershed is contained within wilderness (USFS 2004). The upper 15 mi. of the White River are located entirely within the Glacier Peak Wilderness (Andonaegui 2001).

Alpine glaciation carved out classic U-shaped valleys in the Napeequa and White Rivers. As a result of glaciation, the main drainages have a thick mantle of till on valley walls. Where glaciers overrode ridge tops, minor till may be present in thin lenses and pockets, but much of the landscape has been scoured to bedrock (USFS 1998; Raekes 2004). While upper slopes may be devoid, valley bottoms are filled with glacial till in the form of lateral moraines and glaciofluvial out wash. Glaciofluvial out wash is particularly noticeable on the mainstem below Panther Creek. Here large floodplains with high water tables and broad riparian zones dominate the landscape. Bank erosion is common at bends as the stream actively meanders across the floodplain (USFS 2004).

Assessment Unit Condition

The White River drainage is among the healthiest in the Columbia basin. Several habitat concerns, however, exist (USFS 1998; Andonaegui 2001). The mainstem below the wilderness boundary has had some alteration and consequently many habitat indicators exist in only fair condition. The most altered area is in the lower watershed below Panther Creek. Changes have resulted from floodplain development and impacts on riparian areas from historic cedar logging and roading. On private lands development of homes and vacation retreats is occurring (USFS 2004).

The mainstem below White River Falls is a key spawning and migration corridor for spring chinook salmon, sockeye, and bull trout. (USFS 2004). Four tributaries entering the White River below RM 13 support chinook salmon, steelhead or bull trout. The tributaries are Panther Creek (RM 13.1), Napeequa (RM 11.0), Canyon Creek (RM 10.0), and Sears Creek (RM 7.7). Only the Napeequa River has had some stream channel alteration in its lower two mi. where the drainage flows west through a widening valley into the very broad floodplain of the White River (Andonaegui 2001). Channel degradation from riprapping and vegetation removal is 4% of the streambank. The degradation is considered minor, and overall, the Napeequa River is in good condition.

The watershed above Panther Creek is functioning appropriately for all habitat indicators except LWD in Reach 1 of Indian Creek where historic cedar log drives originated. Despite historic floodplain conversion and development, high quality habitat and connectivity remains among White River, Panther and Napeequa populations. Increasing floodplain development in the privately owned lower valley continues to be of concern for off-channel habitat, refugia, streambank condition, floodplain connectivity, riparian reserves, LWD, and road density/location (USFS 2004).

Under the current program the Yakama Nation is not actively reintroducing coho into the White River Watershed, but as the program expands into the future, active reintroduction remains a possibility. (Murdoch 2004). Salmon carcasses were not distributed in the WAtershed by the USFWS in 2002 or 2003 (Cooper 2002; Cooper 2003).

Riparian/Floodplain Condition and Function

White River drainage has had minimal riparian harvest from the 1950s to the present on federal land. Turn of the century settlement and land clearing, however, has impacted the riparian reserve network up to Napeequa confluence. Riparian condition in the mainstem below Panther Creek is fair (USFS 2004). In the remainder of the watershed, woody debris recruitment, shade, aquatic habitat connectivity, and riparian vegetation appear to be in natural condition, and are in good condition (USFS 2004).

Disruption of the vegetative continuity along riparian areas is a result of site conversion on both private and public lands, grazing, and road building. Noxious weeds in riparian areas are also a concern and are found in most accessible riparian areas (USFS 2004).

Land development in the lower mainstem has reduced some floodplain function. The greatest future threat to salmonid production is additional floodplain development. Additional development could restrict lateral channel migration, connectivity with associated wetlands, side channel development, and LWD input. Off-channel habitat is fair in the watershed below Panther Creek and good for the remainder of the watershed, including Panther, Indian, and Napeequa tributaries (USFS 2004).

Although the Forest Service, WDFW, and Chelan-Douglas Land Trust have combined efforts in recent years to improve floodplain function in the lower mainstem, to date changes have been minor. Therefore floodplain function below Panther Creek is still in fair condition (USFS 2004).

Roads in riparian areas also contribute to loss of riparian habitat function downstream of RM 11.0 (Andonaegui 2001). Nearly half of the road mi. are located in this floodplain (Driscoll et al. 1998; Andonaegui 2001).

Concerns are related to access, recreational use, and resulting disturbance to sites including, but not limited to, snag falling, canopy openings, compaction, and reduction in amount of course woody debris (USFS 2004). In addition, concerns regarding the reduction of floodplain connectivity, reduced channel migration with a subsequent reduction in LWD input, and reduced shade related to Napeequa campground (RM 11.0) exist (Andonaegui 2001).

Stream Channel Conditions and Function

Channel Condition and High Flow

Both the White River and lower Napeequa River have sections of riprap and bank erosion associated with roads, bridges, dispersed recreation, and other development. Two notable locations include the streambanks on private land adjacent to the White River Bridge on the Little Wenatchee road, and riprap sections between Napeequa campground and the Napeequa River. During two record flood events in 1990 and 1995/96, two sections of FS 6400 below Panther Creek confluence were washed out and subsequently reconstructed. One segment was relocated further from the river, the other county road portion was reconstructed in place with riprap on the banks. The individual riprap sites restrict stream function. These hardened locations, however, are a fraction of the entire streambank length.

There are short sections of riprap and/or bank erosion associated with roads, bridges, dispersed recreation, or other development along the lower Napeequa River, the largest tributary to the White River. Bank disturbance totals 4% for the lower two miles. of Napeequa surveyed in 1996 (MacDonald et al. 1996). These individual sites are not considered to reduce the systems functionality overall. Overall streambanks are in good condition (Andonaegui 2001; Raekes 2004). With most of the riparian, floodplain, and channel condition in good or fair condition, high flows are not a concern in the watershed.

Fine Sediment and Channel Stability

There are no apparent concerns with fine sediments or human-induced channel incision in the river. The White and Napeequa rivers are glacial and transport glacial flour in the summer. Because both the White and Napeequa, upstream of the sediment sampling locations, flow through wilderness or largely unmanaged watersheds, fine sediment appears to be due to natural processes. Fine sediment levels are in good condition. All streams in the watershed are good condition in terms of pool depth and pool quality (USFS 1998; Andonaegui 2001; Raekes 2004).

Habitat Diversity

The White River still maintains high quality, complex habitat with refuge and rearing habitat for multiple life stages and life histories. The watershed is also well connected to adjacent high-quality habitats in Lake Wenatchee and the Chiwawa River that provide refuge during disturbance events. The floodplain condition is in good condition.

Water Quality

Temperature

Since 1995, the White River has been the coldest stream monitored in the Wenatchee subbasin (USFS 2004). Andonaegui (2001) indicated that there are no apparent concerns with waters temperatures.

Oxygen/Pollutants

The WDOE 1998 303d list did not include water quality concerns for the White River. The Forest Service (USFS 2004) rates the water quality in good condition.

Water Quantity

Low Flow

The WDOE 1998 303d list did not include any water quantity concerns for the White River. There are no known areas natural or human-induced de watering in the drainage (Andonaegui 2001). There are 9 surface water rights permits or certificates worth a potential total diversion of 0.9 cfs. There are 5 surface water rights claims worth a potential total diversion of 3.4 cfs. There is one pending application for a surface water rights permit, certificate, or claim worth 0.1 cfs. There is 1 ground water rights permit or certificate worth a potential total withdrawal of 350 gpm. There are 2 ground water rights claims worth a potential total withdrawal of 18 gpm. There is 1 application for a ground water rights permit, certificate or claim pending worth a potential total of 661 gpm (Montgomery Water Group et al. 1995; Andonaegui 2001). The limited extent of potential water diversions and withdrawals described above Does not have the ability to change the flow regime of the mainstem or tributaries (Andonaegui 2001).

Obstructions to Fish Passage

Although fish passage is good overall, there are three culverts that block passage. These barriers are located on the 6403 Road system at milepost 0.3 and 0.7 where 0.75 mi. of habitat for westslope cutthroat trout is blocked, and on the 6404 Road system at Sears Creek, where 1.5 mi. of habitat is blocked for juvenile and adult bull trout, and steelhead (USFS 2004).

Ecological Conditions

Connectivity among sub watersheds and through the mainstem river corridor is good. Three species of federally listed fish occur: spring chinook, bull trout, and summer steelhead. Brook trout are present but are not dominant (USFS 2004). Westslope cutthroat trout occur in the watershed. Much of the subbasin flow in late summer months comes from the Napeequa and White rivers.

Environmental/Population Relationships

Spring chinook and steelhead subpopulations are low for all indicators. Bull trout are in fair condition for subpopulation size. Westslope cutthroat and bull trout are good condition for three of four subpopulation indicators. Westslope cutthroat are in fair condition for life history diversity (USFS 2004).

Loss of floodplain function on the White is the greatest threat to salmonid production in the watershed. The connectivity between this watershed and other good aquatic habitat in the subbasin is good. The sockeye run, the majority of which spawns in the White, is one of the strongest remaining in the lower 48 states. The run is only one of two sockeye runs remaining in the Columbia basin. Spring chinook and bull trout also spawn and rear in the mainstem. Much of the reason for the high aquatic health is that depositional reaches near the mouth are structurally complex. Both meandering channels and broad, wetland-filled floodplains remain largely undeveloped and retain their function, despite some development and considerable private land ownership (Andonaegui 2001).

Areas of Special Interest

Stream channels, floodplain, and riparian function on the lower White River from the Panther Creek confluence downstream to the mouth are in fair to good condition and important habitat for the subbasin between RM 0.0 and 13.1 (MCMCP 1998; Andonaegui 2001; Upper Columbia RTT 2002).

Analysis has determined that the White River spring chinook are genetically distinct.

Limiting Factors

- Wetland complexes in lower watershed could have better connectivity to the stream channel (Upper Columbia RTT 2002; Andonaegui 2001).
- Competition and Predation by brook trout in the upper watersheds of this Assessment Unit.

Data Gaps

- Field habitat inventory and analyses are incomplete on private lands (Andonaegui 2001).
- Population abundance and distribution of Bull Trout and Cutthroat Trout is yet to be determined.

Functional Relationship of Assessment Unit with Subbasin

The White River is a Category 1 priority watershed (see Determination of Restoration Priorities in Section 6.5) and has 5 significant sub watersheds. It provides the most spawning for sockeye salmon spawning in the subbasin, as well as habitat for the listed spring chinook, bull trout, and possibly for some steelhead.

4.9.12 Chiwawa River Assessment Unit

Assessment Unit Description

The Chiwawa River originates from 5 glaciers on the southwestern slopes of the Entiat Mountains and flows southeasterly for 37 miles to its confluence with the Wenatchee River near the town of Plain. The Chiwawa River is a 5th order stream, contributing approximately 15% of the Wenatchee Rivers mean annual flow (Andonaegui 2001; Haskins 1998).

The watershed occupies 117,000 acres draining from north to south. Eleven percent of the watershed is privately owned with most of the private land occurring below RM 4.0. Of the 89% public ownership, approximately 31% is designated as wilderness (Andonaegui 2001). Elevation varies from 1,850 ft. at the mouth to 9,082 ft. at Mt. Maude. Annual precipitation in this watershed varies from 30-140 in. Most of the watershed is in public ownership, with private land use being more prevalent downstream of Chikamin Creek (Andonaegui 2001). Much of the upper Chiwawa watershed is nearly pristine because most human use has not altered ecological functions. Accordingly, the upper Chiwawa provides some of the best spring chinook and bull trout habitat in the Wenatchee subbasin.

The Chiwawa valley is U-shaped, with glacial till deposits on the lower side walls and steep bedrock slopes. The side walls have a dense network of parallel, incised first order streams and abundant precipitation in the form of snow. Debris flows are naturally frequent in this land-type, especially in conjunction with high precipitation, or rain-on-snow events. Because of the amount of bedrock, water storage capacity is limited; rain and snowmelt cause the stream to rise rapidly. Nevertheless, summer base-flows, with contributions from high altitude snow fields and glaciers, sustain salmon spawning throughout the late-summer and autumn months (Mullan et al. 1992).

Assessment Unit Condition

Overall, the Chiwawa watershed is in good condition. Development is minimal compared to most other watersheds in the Wenatchee subbasin and is constrained to the lower areas of the watershed. The lower Chiwawa River has several activities that can potentially influence watershed condition including: high road density, road location, private land development, forest practices, and a water diversion. Road concerns occur mainly in the lower mainstem and Meadow Creek. Road density is 3.8 mi/mi2 in the lower mainstem and is 3.7 mi/mi2 in Meadow Creek (USFS 1997).

Intensive logging has occurred in 15% of the watershed and typically has been carefully controlled (Mullan et al. 1992). Two 6th field watersheds in the lower Chiwawa have had 35% and 25% of their total acres harvested, respectively. Lands in these watersheds have either naturally regenerated or been planted with coniferous trees and do not measurably alter peak and base watershed flows (USFS 2004).

In the upper watershed, there is no indication that the frequency, size, or intensity of natural disturbance events has changed, other than alteration of the fire cycle through fire suppression.

Under the current program the Yakama Nation is not actively reintroducing coho into the Chiwawa River watershed, but as the program expands into the future, active reintroduction remains a strong possibility in the plan. (Murdoch 2004). Salmon carcasses were distributed in the watershed by the YN in 2000 and 2001 (K. Murdoch, YN, pers. comm.).

Riparian/Floodplain Condition and Function

Riparian Condition

Much of the Chiwawa River, especially the middle reach, meanders across a broad, unconfined, valley floor. Along the mainstem above Goose Creek, there is excellent floodplain connectivity. Below Goose Creek (RM 5.8), much of the channel is naturally confined by terraces created as climate changed after the last ice age. Glacial till provides excellent ground water storage in the valley, wetland habitat is abundant in impoundment stretches of the floodplain, summer baseflows are high relative to other geomorphic subsections on the forest, and ground water input helps moderate winter and summer water temperature extremes.

Even though alterations have taken place, the lower Chiwawa is considered fair for riparian condition. The riparian condition of Big Meadow, Brush, Clear, Deep, Goose, Elder, Alder, and Twin Creeks, is considered fair due to riparian roading and timber harvest. The proximity of roads and harvest units to stream channel reaches in these tributary drainages has resulted in some channel confinement, and possible increases in sediment delivery (USFS 2003). At the same time, these channels are lower in the watershed, located on comparatively mild topography where they receive less precipitation.

Shoreline habitat development with associated vegetation removal has occurred along segments of the mainstem from the mouth to RM 5.0, and near the confluence of Chikamin Creek at RM 13.8 (MCMCP 1998). Much of the shoreline development actually occurs on terraces above the reach of the floodplain for those developments occurring between RM 1.0 and RM 5.0 (USFS, pers. comm. date?). The channel is naturally less constricted from RM 0.0 to 1.0, and some simplification is observable. Overall, impacts to riparian characteristics and function are localized and not problematic on a watershed scale; (USFS 2003).

Probably the greatest human disturbance in the upper watershed is due to recreation facilities and campgrounds. At the watershed scale these occurrences are relatively minor. USFS management actions are being implemented to improve areas where issues have been identified.

Stream Channel Conditions and Function

Channel Condition and High Flow

Channel conditions for much of the upper Chiwawa are presumed to be near historic references since floodplain connectivity remains intact and channel condition has had only minor alteration. In the lower river, log drives occurred until the mid 1930s. Although channel conditions have repaired considerably since that time, some evidence of in-channel degradation remains. Most of the lower Chiwawa River is naturally contained by the landform and is therefore expected to contain less large wood than a channel at lower gradient flowing through loose gravel. Logging and roading activities have reduced levels of large wood within the following tributary streams: Brush, Clear, Deep, Goose, Elder, Alder, and Twin creeks (Haskins 1998).

Fine Sediment and Channel Stability

McNeil core sediment samples have been collected in mainstem Chiwawa from Grouse Creek to Rock Creek (RM 11.7 – 21.3) over the last decade. All of these reaches have fine sediment in excess of State Timber, Fish &Wildlife management recommendations. One reach fails to meet Wenatchee Forest Plan standards as well. Some of the sediment may result from recreation sites, although this has not been empirically demonstrated (USFS 2003). Sediment may also naturally occur above management recommendation levels. Because of uncertainty, sediment levels are considered fair instead of good.

Habitat Diversity

Chiwawa wetlands and off-channel habitat in the watershed are in good condition (USFS 2003). The valley floor has an extensive network of ponds, beaver canals, side channels, abandoned oxbows and other wetlands. Abundance, diversity, connectivity and quality of these wetlands is high (USFS 1997). The floodplain remains connected to the channel in the Chiwawa watershed (USFS 2003). In the upper Chiwawa, Forest Service Road 6200 parallels the Chiwawa and ends at private property on Phelps Creek at RM 30.7. The road minimally affects watershed condition and Does not constrain floodplain function. Road 6200 has simplified Rock and Chikamin Creek alluvial fans. Roads are also built on the private parcel near Phelps Creek to access a water diversion. Pool habitat is considered to be only fair in the lower main channel of Rock Creek and the lower Chiwawa.

Pool data has not been collected for Clear, Deep, Goose, Elder, Alder, and Twin creeks. The remainder of the watershed is in good condition for pool habitat (Haskins 1998).

Water Quality

Temperature

The Chiwawa River is a cold, low-conductive (35 µmhos) stream originating from snowfields and glaciers, which sustain flows through the late summer and fall (Mullan et al. 1992). In general, water quality is at or near pristine condition, however water temperatures at the mouth of Chiwawa River failed to meet USFS and State standards of 61 °F from 1992 to 1998. Stream temperatures typically reach the low to mid 60s°F, but have not exceeded 69°F (Andonaegui 2001). Cause for relatively high temperatures has not been determined although land use, channel type and channel bearing may play a role. Most tributary streams have little or no water temperature information on record (Haskins 1998).

Oxygen/Pollutants

Historic mining occurred in much of Chiwawa head waters; however no known chemical contamination has been documented. Some mine tailings in the Red Mountain and Trinity area remain unvegetated. There is no obvious contribution of fines from the mine tailing to streams (Haskins 1998). The WDOE 1998 303d list did not include any water quality concerns for the Chiwawa River

Water Quantity

Low Flow

Stream flow and total water yield or water quantity are considered to be at or near historic reference condition for most of the watershed. The WDOE 1998 303d list did not include any water quantity concerns for the Chiwawa River.

Two water diversions occur in the watershed. A six-foot wide Chiwawa Irrigation District canal diverts 12-16 cfs (limit 30cfs) from the Chiwawa River at RM 3.6. The diversion has little or no impact on fisheries (USFS 1997; CCCD 1998). It does, however, amount to approximately 25% of the average September flow in a drought year and approximately 13% of September flow in an average year (MCMCP 1998). The Trinity diversion Federal Energy Regulatory Commission (FERC) relicensing process is nearly complete and has been approved with specified mitigations. Withdrawals are not expected to harm spring chinook or bull trout using Phelps Creek (Lewis date?). There are 13 surface water rights permits, certificates, or claims located within the watershed filed with the WDOE (Andonaegui 2001).

Obstructions to Fish Passage

Fish passage throughout the Chiwawa watershed is considered to be good. A supplementation hatchery operated by Chelan County Public Utility District (PUD) is located at the mouth of the Chiwawa River. Fish passage is controlled with a weir at RM 8.0, but fish are able to migrate past it (Andonaegui 2001). Recent USFWS bull trout telemetry data suggests that the weir may discourage or delay some individual bull trout from migrating past the weir while it is operational (USFS 2003).

The Harza/BioAnalysts 2000 culvert survey identified other barriers on tributary streams. The results include: Clear Creek has one fish passage barrier culvert at RM 0.5. Deep Creek has six fish passage barrier culverts beginning at RM 0.4. Alder Creek has one fish passage barrier culvert located at RM 0.9. Goose Creek has two fish passage barrier culverts beginning at RM 0.4. Minnow Creek has one fish passage barrier culvert at RM 0.4.

Ecological Conditions

Ecological conditions are good overall in the Chiwawa River. The watershed is characterized by a diverse and strong fish community (Andonaegui 2001). The USFWS distributed salmon carcasses in the watershed in 2002, but not in 2003 (Cooper 2002; Cooper 2003). One of the greatest threats to bull trout populations in the upper watershed is from the introduction of brook trout, which could damage existing healthy bull trout through inter-breeding and competition. To date, no brook trout have been observed in the upper watershed. Brook trout are well established in the lower watershed in Schaefer Lake, Minnow Creek, and especially in Chikamin Creek. There are no barriers to hinder brook trout access to the upper watershed (Haskins 1998). Under the current program the Yakama Nation is not actively reintroducing coho into the Chiwawa River watershed, but as the program expands into the future, active reintroduction remains a strong possibility in the plan. (Murdoch 2004). Salmon carcasses were distributed in the watershed by the YN in 2000 and 2001 (K. Murdoch, YN, pers. comm.).

Hatchery out-plants occur in the Chiwawa watershed (Berg and Lowman 2001). Roads, campgrounds, and private lands in close proximity to salmonid holding and spawning areas may encourage disturbance of salmon and bull trout (USFS 2004). The amount of disturbance taking place, however, has not been quantified.

Environmental/Population Relationships

Habitat in the watershed above Chikamin Creek (RM 13.7) is largely pristine. This portion of the watershed provides 90% of the chinook spawning, the majority of the bull trout spawning, a substantial portion of the chinook rearing, steelhead rearing, and bull trout rearing. It also contains the most genetically pure and possibly the strongest cutthroat trout populations (Andonaegui 2001; Haskins 1998).

The lower watershed is a crucial migration corridor for the migratory life histories/stages of spring chinook, bull trout, and steelhead. Bull trout spawning populations are among the highest in the mid Columbia basin. The decline in spring chinook spawning appears linked to a larger spatial phenomenon, mirroring patterns throughout the Wenatchee subbasin. Spring-migrating steelhead adults are not exposed to late summer stream temperatures. Rearing habitat for steelhead and chinook may be affected in the lower tributaries and the lowermost mile of the Chiwawa, but substantial and spatially dispersed rearing areas in the upper watershed mitigate these losses. Brook trout may displace rearing steelhead in the lower watershed (Haskins 1998).

According to redd counts, the middle reach of the Chiwawa River between Chikamin (RM 13.7) and Phelps (RM 30.7) creeks supports the strongest spring chinook spawning population in the Wenatchee subbasin. The reach is one of only two watersheds in the Wenatchee subbasin that provided the bulk or 44.16% of spring chinook redds from 1958 to 1999. Nason Creek provided 28.23% during the same period.

By redd counts, Rock Creek (RM 21.3), tributary to the Chiwawa River, is the single most productive bull trout stream in the Wenatchee subbasin. Along with Rock Creek, the mainstem Chiwawa River and its tributaries help to serve as a stronghold for the bull trout population in the Wenatchee River watershed (Andonaegui 2001).

Areas of Special Interest

Functioning floodplain, good riparian and in-channel characteristics on the Chiwawa between Chikamin and Phelps Creek confluences supports the spring chinook population in the subbasin (Andonaegui 2001; MCMCP 199?, Upper Columbia RTT 2003).

Fish passage through the lower reach of the Chiwawa River is critical to sustaining spring chinook, steelhead, and bull trout populations in the Wenatchee subbasin (Andonaegui 2001, USFS 2003).

Habitat in the Chiwawa watershed upstream from Chikamin Creek (RM 13.7) is highly functional and pristine (Andonaegui 2001; USFS 2003).

Limiting Factors

- Brook trout competition and interbreeding threatens bull trout populations in the upper watershed (USFS 2003).

Data Gaps

- Interaction between surface diversions and well- water withdrawals with mainstem flows.

- Interactions between riparian development and stream temperature (Andonaegui 2001).
- It is unknown whether the debris flow regime has changed in the lower Chiwawa watershed (Haskins 1998).
- With the exception of Phelps Creek, tributary streams have little or no water temperature information on record (Haskins 1998).
- Population abundance and distribution of bull trout and cutthroat trout is undetermined.

Functional Relationship of Assessment Unit with Subbasin

The Chiwawa River is a Category 1 (see Determination of Restoration Priorities in Section 6.5) watershed for protection of natural resource values. This watershed provides a substantial amount of cool, clean water to the Wenatchee River and is a core spawning and rearing areas for spring chinook salmon and bull trout. The Chiwawa has 6 significant sub watersheds contributing key habitat for one or more native salmonid species (MacDonald et al. 2000).

4.9.13 Lake Wenatchee Assessment Unit

Assessment Unit Description

Lake Wenatchee is a large, steep-sided lake located approximately 15 mi. north of Leavenworth in the Wenatchee National Forest. It is fed principally by the Little Wenatchee River and the White River, and drains to the Wenatchee River. A large wetland is at the western end of the lake at the deltas of the Little Wenatchee and White rivers. A terminal glacial moraine at the east end of the lake is the natural dam that formed the lake. A diverse community of submerged aquatic vegetation along the shoreline extends to a depth of about 5.0 meters (WDOE 1997). The lake normally freezes over during the winter months and strong winds keep the lake mixed during much of the other seasons. General physical characteristics of the lake are listed in Table 23.

Table 23. General physical characteristics of Lake Wenatchee

Size	2,480 acres
Maximum Depth	244 ft.
Lake Volume	364,560 acre ft.
Drainage Area	273 2s. mi.
Altitude	1,875 ft.
Shoreline Length	13.3 mi.

WDOE 1997

Lake Wenatchee is an oligotrophic lake based on relatively high water clarity and low concentrations of phosphorous (Ecology 1997). Oligotrophic lakes are generally defined as being low-nutrient systems, with <10 mg/m3 phosphorus, <200 mg/m3 nitrogen, and <2 mg/m3 chlorophyll a. Average summertime secchi depth (water transparency) in Lake Wenatchee was estimated as 20 ft. and phosphorous concentrations were 4.8 ug/L (Ecology 1997). Although there are approximately 170 homes along the shoreline of Lake Wenatchee, septic systems are no longer used and all of the houses have been attached to a sewer system since around 1989.

Recreational uses on the lake include: swimming, fishing, motor boating, jet skiing, camping, hunting, picnicking, and camping.

Relatively little information exists on the water quality and limnology of Lake Wenatchee. water temperatures collected from depths of 10 ft. and lower indicated that the lake does not strongly stratify into a distinct warmer upper layer and a cooler lower layer with associated layers of high and low DO and pH (Table 6.3-2) (Sylvester and Ruggles 1957). The data for June through October, 1955 (shown in Table 6.3-2) suggest that temperature declines gradually between 10 ft. and 60–75 ft., and is notably lower at depths ranging from 150 to 175 ft.. However, coincident measurements of DO and pH suggest that deeper waters of the lake do not received sufficient organic matter to substantially depress values of either parameter. In many other temperate lakes, the upper layer of water is warmed through the summer as it absorbs solar radiation and this layer does not mix with the lower, darker layer of water, which generally exhibits a markedly cooler water temperature and depressed DO and pH in summer through fall months. However, Lake Wenatchee is subjected to high winds that apparently keep the waters mixed throughout the year resulting in similar water temperatures and levels of dissolved oxygen and pH in the upper approximately 100 ft. of the water column.

Other water quality parameters measured in Lake Wenatchee by Sylvester and Ruggles (1957) included total alkalinity, hardness, turbidity, conductivity and several metals. Their results from June 1955 through February 1957 provide a characterization of the lake as low alkalinity, very low hardness, very clear water with little turbidity and color, and low specific conductance. A single summertime chlorophyll a value of 1.7 ug/L measured in the lake (WDOE 1997) suggests phytoplankton algae levels are very low. All these features are characteristic of an oligotrophic lake, typically with low primary (algae) and secondary (zooplankton) productivity.

Little additional water quality data are available for Lake Wenatchee since the comprehensive surveys in the 1950. Some data were collected from August 1995 monthly through July 1996 at the Lake Wenatchee bridge (WRWSC 1998). These data were assumed to represent lake surface water conditions and indicate the following: 1) the surface lake waters remain very clear and of low turbidity; 2) nitrogenous nutrients (nitrate/nitrite and ammonia) were low enough to restrict algal growth; 3) total phosphorus was generally low, except for two mid winter measurements; 4) water pH remained near 7.0 (neutral), except for 1 reading of 8.87 in February 1996; 5) dissolved oxygen was measured to be above 9.0 mg/L, except for two low values in August and September 1995 (both were above 90% of air saturation); and 6) specific conductance ranged slightly higher than in the 1950s, possible indicating a slight increase in water hardness and alkalinity. Lake surveys of water transparency, total phosphorus and chlorophyll were conducted periodically from 1989 through 1997 (WDOE 1997). The results showed that water transparency is high (secchi depths >20 ft.) and chlorophyll and total phosphorus are very low. These available data, although somewhat sparse, suggest the lake waters remain oligotrophic with little evidence of effects from land use changes and development since the 1950s.

5 Inventory

5.1 Introduction, Purpose, and Scope

The inventory of the Wenatchee subbasin summarizes the fish and wildlife protection, restoration, and artificial production projects and programs. The Inventory also identifies management programs and projects that target fish and wildlife or otherwise provide substantial benefit to fish and wildlife. The inventory includes programs and projects extant or the past five years and where possible, activities that are scheduled to be implemented within the very near future.

The inventory of programs and projects helps demonstrate current management directions, existing and imminent protections, and current strategies. However, the Council's "Technical Guide for Subbasin Planners" (2002), states that the inventory will have its greatest value when it is reviewed in conjunction with the limiting factors resulting from the assessment. This analysis helps to identify gaps between ongoing management efforts and those efforts needed to realize the vision of the subbasin plan.

A comparison of past actions with limiting factors should help assess the efficacy of current actions, indicate the areas of project gaps and guide management decisions. Please refer to the electronic reference library (NPCC ftp site) included in this subbasin plan for an inventory of programmatic activities within this subbasin.

5.2 Lower and Middle Wenatchee River Assessment Units

The follow provides an Inventory of past and ongoing actions occurring within the Wenatchee Subbasin. For each Assessment Unit, a conclusion is provided that identifies additional needs for future assessment and implementation.

The following activities have or are taking place in this Assessment Unit:

- Riparian re-vegetation projects were completed between 1999-2001 by the Chelan County Conservation District.
- Trout Unlimited provided habitat enhancement work on Blackbird Island during the years 1997-2001.
- A Channel Migration Zone study was completed in 2004 evaluating the entire mainstem Wenatchee within this Assessment Unit. Recommendations for enhancements have been advanced.
- In-stream flow assessments are on-going and expected to be completed in 2005. Recommendation for implementation are expected to be available in 2005.
- Total Daily Maximum Load (TMDL) investigations are on-going. A Pollution Cleanup Management Plan and recommendations are expected to be available for implementation in 2006.
- Evaluations for fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.
- Dryden irrigation water diversion was recently fitted with new fish screens.

Conclusions: Very little habitat restoration or enhancement work has occurred in this Assessment Unit especially considering its importance to all focal species considered in this subbasin plan. Recent and on-going investigations (will) provide a solid basis for future management actions. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Improvements in riparian and floodplain habitat conditions, particularly associated with increases in side channel and off-channel enhancement and restoration.
- Increasing habitat diversity and complexity in the main stem and side channels.
- Improvements in base flow conditions, and expected decreases in water temperature.
- Future investigations should examine the relationship between flow and water temperature. This work should also focus on the potential for late summer warm water temperatures to limit salmonid productivity and to create a thermal barrier to fish passage in the lower reaches of the Wenatchee River.

5.3 Middle Wenatchee Assessment Unit

The following activities have or are taking place in this assessment unit:

- A Channel Migration Zone study was completed in 2004 evaluating the entire mainstem Wenatchee within this Assessment Unit. Recommendations for enhancements have been advanced.
- In-stream flow assessments are on-going and expected to be completed in 2005. Recommendation for implementation are expected to be available in 2005.
- Total Daily Maximum Load (TMDL) investigations are on-going. A Pollution Cleanup Management Plan and recommendations are expected to be available for implementation in 2006.
- Evaluations for fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.

Conclusions:

Very little habitat restoration or enhancement work has occurred in this Assessment Unit especially considering its importance to all focal species considered in this subbasin plan. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Key and functional floodplains and riparian areas should be identified for providing high environmental benefit and benefit to focal fish species.
- Tumwater Dam has altered (prevented) channel substrate transport within this section of the Wenatchee River. There have been no evaluations addressing this condition.
- Northern Pike minnow may be at elevated numbers immediately below Tumwater Dam. Investigations should occur to determine the benefit of a predator control program in this area.
- Investigations should evaluate the potential or extent that riprap (and associated turbulence at high flow) along Highway 2 below Tumwater dam may be injuring juveniles that pass through this area.

5.4 Mission Creek Assessment Unit

The following activities have or are taking place in this Assessment Unit:

- Riparian re-vegetation project was completed by the Chelan County Conservation District (CCCD) in portions of several stream reaches from 1999-2001.
- The CCCD and City of Cashmere completed a storm water project (water quality improvement) in the years 2001-2002.
- The Mission Creek Pilot Project (habitat enhancement) was completed by the Chelan County Conservation District and Washington Dept. Fish and Wildlife in 1996-97.
- The Brender Creek habitat improvement project was completed by Trout Unlimited, WDFW and CCCD in between years 1997-2001.

- Evaluations for fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.
- Total Daily Maximum Load (TMDL) investigations are on-going. A Pollution Cleanup Management Plan and recommendations are expected to be available for implementation in 2006.
- In-stream work has yet to be implemented in this area but is envisioned in the near term.
- Specific efforts to control or eliminate brook trout populations within the Assessment Unit should be initiated.

Conclusion:

Recent habitat restoration or enhancement work has occurred primarily in the lower portions of this Assessment Unit. Most of the focus has been in enhancements to water quality needs, although some habitat enhancement projects have been implemented in needed areas. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Sediment budget investigations should be initiated in the Mission Assessment Unit to identify priority treatments and establish baseline monitoring.
- Channel constriction and lost habitat diversity issues have not been well addressed.
- Evaluations to improve flow conditions have not been well addressed.
- Control or eradication of un-wanted species should be considered.
- Additional water storage and conservation measures are needed in this Assessment Unit.
- Additional riparian re-vegetation projects that focus on providing shade for this narrow and shallow stream are applicable for this Assessment Unit.

5.5 Peshastin Creek Assessment Unit

The following activities have or are taking place in this Assessment Unit:

- The USFWS has recently completed investigations and implementation of in-channel erosion control structures in lower Peshastin Creek.
- The local irrigation district is evaluating options to improve fish passage past an irrigation diversion in lower Peshastin Creek. This evaluation is pending due to lack of funding.
- Evaluations for other fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.
- Total Daily Maximum Load (TMDL) investigations are on-going. A Pollution Cleanup Management Plan and recommendations are expected to be available for implementation in 2006.

- Evaluations for fish passage problems (culverts) have been on-going but are yet to be completed and projects identified and prioritized.
- Specific efforts to control or eliminate brook trout populations within the Assessment Unit should be initiated.

Conclusions:

Peshastin Creek Assessment Unit has a relatively high degree of potential to enhance salmonid resources. Aside from USFS activities associated with vegetation management, very little enhancement and restoration work has been implemented in this Assessment Unit, particularly in the lower portions. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Sediment budget investigations should be initiated in the Peshastin Assessment Unit to identify priority treatments and establish baseline monitoring.
- Stream sinuosity and habitat diversity and improving riparian conditions are key elements to future salmonid enhancement efforts.
- In-channel structural diversity projects in the lower reaches should be evaluated and implemented where practical and where they have a reasonably good chance to persist during high flow events.
- Additional investigations and projects should be implemented to re-conform the channel shape, decrease sedimentation and decrease with to depth rations in appropriate locations.
- Evaluations addressing improving low flow conditions are needed.
- Priority work to improve passage conditions throughout the assessment unit is warranted.

5.6 Chumstick Creek Assessment Unit

The following activities have or are taking place in this Assessment Unit:

- Riparian re-vegetation project was completed by the Chelan County Conservation District (CCCD) in portions of several stream reaches from 1999-2001. Approximately 12 additional culverts have been identified for future replacement.
- Eleven culverts were recently replaced (2002-2003) by the CCCD, BPA, USFWS, and Washington State Salmon Recovery funds (SRFB) , opening approximately four river miles to fish passage.
- Total Daily Maximum Load (TMDL) investigations are on-going. A Pollution Cleanup Management Plan and recommendations are expected to be available for implementation in 2006.

Conclusions:

Culvert replacement and habitat restoration projects are appropriate and needed for this Assessment Unit. Considerable work remains in both areas. Water quality has long been an issue in the lower portions of this watershed. Long term management plans are expected in the near future. A holistic evaluation of cost/benefit and sequence of projects is particularly important to this watershed due to its heavily altered environmental condition and relatively low potential for fish production. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Sediment budget investigations should be initiated in the Chumstick Assessment Unit to identify priority treatments and establish baseline monitoring.
- Additional fish passage improvements are an important consideration in this assessment unit.
- Off-channel habitat, channel complexity and habitat diversity issues have not been well addressed.
- Road density and location in many areas throughout the watersheds should be evaluated and priority projects implemented.
- Low flows and the potential for future water storage is an important consideration.
- Re-establishing riparian vegetation would provide high benefit to in-channel conditions, and other ecological benefits.

5.7 Icicle Creek Assessment Unit

The following activities have or are taking place in this Assessment Unit:

- Riparian re-vegetation project was completed by the Chelan County Conservation District (CCCD) in portions of several stream reaches from 1999-2001.
- Evaluations concerning recreation camp sites and local road conditions within riparian areas are on-going by the USFS.
- The USFWS is currently investigating low flow and water temperature issues associated with the operation of the Leavenworth Nation Fish Hatchery. Results from these studies are expected to available in 2005.
- The USFWS is continuing the Icicle Creek Restoration Project (habitat improvements; 1999-present).
- Trout Unlimited is currently sponsoring investigations into improvements in lower Icicle riparian and in-stream conditions. Results from these investigations are expected to be available in 2005.
- Evaluations for fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.

Conclusions:

Relatively few habitat improvements projects have been implemented in the lower Icicle Creek. Projects that have been implemented and on-going investigations are very appropriate to resource needs. USFS activities in the upper watersheds have focused on recreation and transportation system. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Recreation sites and road locations in riparian areas should continue to be evaluated and relocated as determined appropriate.
- Implementation of projects in the lower Icicle to improve in-channel habitat diversity and riparian characteristics that are identified as high priority from on-going assessments should begin in a timely manner.
- Key and functional floodplains and riparian areas in the lower Icicle should be identified for providing high environmental benefit and benefit to focal fish species.
- Continued evaluations and implementation of recommendation to improve water conservation would benefit flows.
- Specific efforts to control or eliminate brook trout populations within the Assessment Unit should be initiated.

5.8 Nason Creek Assessment Unit

The following activities have or are taking place in this Assessment Unit:

- Total Daily Maximum Load (TMDL) investigations are on-going. A Pollution Cleanup Management Plan and recommendations are expected to be available for implementation in 2006.
- A Channel Migration Zone study was completed in 2004 evaluating the lowest portion of Nason Creek. Recommendations for enhancements have been advanced.
- Evaluations for fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.

Conclusions:

Very little habitat improvement or restoration work has occurred in the lower Nason Creek drainage. Historically, Nason Creek provided significant habitat for anadromous salmonids and currently has a very large potential for increasing productivity of all focal species. Lower Nason Creek is in poor condition and future emphasis should be re-directed to these areas. Aside from USFS activities associated with vegetation and road management, very little enhancement and restoration work has been implemented in this Assessment Unit, particularly in the lower portions. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Sediment budget investigations should be initiated in the Nason Assessment Unit to identify priority treatments and establish baseline monitoring.
- The Channel Migration Zone study recently completed should continue throughout all of the mainstem reaches that contain anadromy.

- Investigations should occur that will identify specific and appropriate instream structures that will increase channel stability, habitat diversity and complexity and provide to increase distribution of substrates suitable for salmonid spawning.
- Investigations should occur that will identify specific actions to re-connect the mainstem river to lost side channel and off-channel habitats. Enhancement of riparian vegetation should be a component of this work.
- Key and functional floodplains and riparian areas should be identified for providing high environmental benefit and benefit to focal fish species.
- Specific efforts to control or eliminate brook trout populations within the Assessment Unit should be initiated.

5.9 Little Wenatchee River Assessment Unit

The following activities have or are taking place in this Assessment Unit:

- Evaluations for fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.
- Evaluations concerning recreation camp sites and local road conditions within riparian areas are on-going by the USFS.

Conclusions:

Most of the Little Wenatchee River Assessment Unit is managed by the USFS. Relatively few habitat improvement activities have occurred on lands not management by the USFS. Activities associated with floodplain and in-channel characteristics have and should continue to focus primarily on protection of healthy natural resources and to benefit sustained productivity of salmonids. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Specific efforts to control or eliminate brook trout populations within the Assessment Unit should be initiated.
- Identify and implement as appropriate all areas where road relocation will benefit riparian and in-channel conditions.
- Identify and initiate restoration of lost wetland complexes.
- Key and functional floodplains and riparian areas should be identified for providing high environmental benefit and benefit to focal fish species.
- Maintain existing roads in a manner that will to minimize interaction with basin hydrology.

5.10 White River Assessment Unit

The following activities have or are taking place in this Assessment Unit:

- The White River Floodplain Restoration Project (2000-2004), sponsored by the Eastern Washington Regional Fisheries Enhancement Group, SRFB and the Chelan Douglas

Land Trust will continue to protect approximately 70 acres of high quality floodplain habitat.

- Evaluations for fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.
- Specific efforts to control or eliminate brook trout populations within the Assessment Unit should be initiated.
- Evaluations concerning recreation camp sites and local road conditions within riparian areas are on-going by the USFS.
- Key and functional floodplains and riparian areas should be identified for providing high environmental benefit and benefit to focal fish species.

Conclusions:

Most of the White River Assessment Unit is managed by the USFS. Relatively few habitat improvement activities have occurred on lands not in management by the USFS. Activities associated with floodplain and in-channel characteristics have and should continue to focus primarily on protection of healthy natural resources and to benefit sustained productivity of salmonids. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Riparian areas in the lower river have been altered and habitat improvement projects would benefit floodplain function and focal species productivity.
- Evaluate the benefits/cost of replacing a bridge across the lower mainstem.
- Maintain existing roads in a manner that will to minimize interaction with basin hydrology.

5.11 Chiwawa River Assessment Unit

The following activities have or are taking place in this Assessment Unit:

- Evaluations for fish passage problems have been on-going but are yet to be completed and projects identified and prioritized.
- Specific efforts to control or eliminate brook trout populations within the Assessment Unit should be initiated.
- Evaluations concerning recreation camp sites and local road conditions within riparian areas are on-going by the USFS.

Conclusions:

Most of the Chiwawa River Assessment Unit is managed by the USFS. Relatively few habitat improvement activities have occurred on lands not in management by the USFS. Activities associated with floodplain and in-channel characteristics have and should continue to focus primarily on protection of healthy natural resources and to benefit sustained productivity of salmonids. Additional efforts are required to address Limiting Factors identified in the Key Findings of this document, which should include:

- Identify key functioning floodplains and attributes to be considered to for protection of key attributes.
- Evaluations of interactions between use of well water and surface water should proceed.
- Maintain existing roads in a manner that will to minimize interaction with basin hydrology.

6 Synthesis and Interpretation

6.1 Introduction

The synthesis and interpretation brings findings from the subbasin plan together into a holistic view of the Wenatchee subbasin's biological and environmental resources. This information in turn provides a foundation for the development of scientific hypotheses concerning ecological behavior, and most importantly, ways that human intervention might prove beneficial.

This section contains a summary of environmental/population relationships for species and a discussion of the key findings. Contained within the key findings is a summary of the key limiting factors for focal species.

The section also includes hypothesis statements that suggest how focal species are expected to respond to improved environmental conditions.

The conclusion describes restoration priorities by a) species distribution, b) across landscapes, and c) in habitat activities.

6.2 Key Findings and Hypothesis Statements

Key findings are concise statements about environmental attributes found to have a relatively high importance to the focal species existence within each assessment unit. These statements describe habitat conditions that are functioning properly as well as those that have been altered or degraded to the point that they limit the ability for the focal species to thrive or exist. These degraded attributes are called limiting factors. For the purposes of this document, a limiting factor is defined as "*a habitat element that limits the productivity and/or life history diversity of a focal species.*"

Concluding the key findings for each assessment unit are hypothesis statements. These statements assume that over time, stakeholders within the subbasin will achieve the stated goals and desired future conditions. Given that, the hypothesis statements describe the *expected change (from the current condition) in productivity (from the current condition) and/or life history diversity of a specific life stage for the focal species population inhabiting the assessment unit.* Table 24 lists definitions of elements within the hypothesis statements.

Table 24. Definitions for hypothesis statements

Key Life Stages: (Adapted from the EDT framework. For simplicity, life stages are grouped into major categories.)	
Egg Incubation	Eggs in the gravel through emergence.
Fry Colonization	Emergence through the first 6-weeks as rearing territory is established.
Summer Rearing	Period throughout the late spring through October.
Winter Rearing	Period throughout winter, general dormancy of the focal species.
Juvenile Rearing	Includes both summer and winter rearing.
Pre-Spawning Adult	Adults migrating and holding until spawning.
Adult	Includes all time periods of adult life stages.
Degree of Effect (The expected change in productivity and/or life history diversity of a specific life stage for the focal species population using the Assessment Unit.)	
Low	Some improvement in productivity and/or life history diversity for this specific life stage is reasonable to assume but would be difficult to measure.
Moderate	Productivity and/or life history diversity for this specific life stage is expected to improve and changes should be measurable.
High	Productivity and/or life history diversity of a specific life stage has significantly improved and is clearly measurable.
Level of Certainty (The confidence that improvements in habitat condition will result in increases of productivity and/or life history diversity for the specific life stage of the focal species.)	
Low	The population/habitat relationship is not well understood, but it is reasonable to conclude some beneficial response will occur.
Moderate	The population/habitat relationship is reasonably well understood, and it is likely that a beneficial response will occur.
High	The population/habitat relationship is well documented through existing literature or direct observation and a beneficial response is expected.

6.3 Summary of Key Findings

6.3.1 Terrestrial/Wildlife

Key Findings: Terrestrial

The terrestrial assessment viewed the subbasin from a perspective of key and major vegetative communities. Three community types were chosen as focal habitat for this evaluation, ponderosa pine, shrubsteppe and riparian ecosystems. Within each of these focal habitats, representative species that are directly associated with these vegetative communities are identified and will be monitored.

Factors Affecting Ponderosa Pine Habitat

- Repeated timber harvest removed large diameter ponderosa pine and snags and left the understory. This has resulted in accelerated successional advancement and increased the Douglas fir component.
- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Historically, extensive grazing by domestic sheep may have altered understory composition, resulting in loss of forbs and a decrease in shrub densities.
- Overgrazing has resulted in lack of recruitment of sapling trees, particularly pines.
- Invasion of exotic plants has altered understory conditions and increased fuel loads.
- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.
- The timing (spring/summer versus fall) of restoration/silviculture practices such mowing, thinning, and burning of understory removal may be especially detrimental to single-clutch species.
- Spraying insects that are detrimental to forest health may have negative ramifications on lepidopterans (butterflies) and other non-target bird species.

Factors Affecting Shrubsteppe Habitat

- Permanent habitat conversions of shrubsteppe/grassland habitats (e.g., approximately 60 percent of shrubsteppe in Washington to other uses (e.g., agriculture, urbanization).

Significant acreage of shrubsteppe habitat continues to be converted to residential development between Wenatchee and Monitor (USFS 1999).

- Fragmentation of remaining tracts of moderate to good quality shrubsteppe habitat.
- Degradation of habitat from intensive grazing and invasion of exotic plant species, particularly annual grasses such as cheatgrass and woody vegetation such as Russian olive.
- Degradation and loss of properly functioning shrubsteppe/grassland ecosystems resulting from the encroachment of urban and residential development and conversion to agriculture. Best sites for healthy sagebrush communities (deep soils, relatively mesic conditions) are also best for agricultural productivity; thus, past losses and potential future losses are great. Most of the remaining shrubsteppe in Washington is in private ownership with little long term protection (57 percent).
- Loss of big sagebrush communities to brush control (may not be detrimental relative to interior grassland habitats).
- Conversion of CRP lands back to cropland.
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities.
- High density of nest parasites (brown-headed cowbird) and domestic predators (cats) may be present in hostile/altered landscapes, particularly those in proximity to agricultural and residential areas subject to high levels of human disturbance.
- Agricultural practices that cause direct or indirect mortality and/or reduce wildlife productivity. There are a substantial number of obligate and semi-obligate avian/mammal species; thus, threats to the habitat jeopardize the persistence of these species.
- Fire management, either fire suppression (USFS 1999), which has resulted in succession of vegetation communities, or overuse of fire, both of which have lead to loss of shrubsteppe.
- Much of the low-elevation shrubsteppe vegetation is currently dominated by cheatgrass and other nonnative plants (USFS 1999). Invasion and seeding of crested wheatgrass and other introduced plant species reduces wildlife habitat quality and/or availability.

Factors Affecting Riparian Wetland Habitat

- Loss of habitat due to numerous factors including riverine recreational developments, inundation from impoundments, cutting and spraying of riparian vegetation for eased access to water courses, gravel mining, etc.
- Habitat alteration from 1) hydrological diversions and control of natural flooding regimes (e.g., dams) resulting in reduced stream flows and reduction of overall area of riparian habitat, loss of vertical stratification in riparian vegetation, and lack of recruitment of young cottonwoods, ash, willows, etc., and 2) stream bank stabilization which narrows stream channel, reduces the flood zone, and reduces extent of riparian vegetation.

- Habitat degradation from conversion of native riparian shrub and herbaceous vegetation to invasive exotics such as reed canary grass, purple loosestrife, perennial pepperweed, salt cedar, and indigo bush.
- Fragmentation and loss of large tracts necessary for area-sensitive species.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.
- High energetic costs associated with high rates of competitive interactions with European starlings for cavities may reduce reproductive success of cavity-nesting species such as Lewis' woodpecker, downy woodpecker, and tree swallow, even when outcome of the competition is successful for these species.
- Recreational disturbances (e.g., ORVs), particularly during nesting season, and particularly in high-use recreation areas.

6.3.2 Aquatic/Fish

Summary of Environmental/Population Relationships of the Focal Species

Spring chinook

Adult migration and holding

Spring chinook enter the Wenatchee River from May through June and hold in larger pools until spawning begins in August. Channel confinement, the loss of riparian areas, and associated large wood used as cover have reduced the abundance of pools. Mortality, stress, or displacement to adults is likely greatest in Nason and Peshastin creeks.

Spawning and egg incubation

Spawning and incubation areas within the Chiwawa, White, and Little Wenatchee rivers remain in good condition. Spawning areas in Nason and Peshastin creek have been severely altered. The remaining spawning areas in the upper Wenatchee River, which is partially altered by domestic land use practices and a very small amount in Chiwaukum Creek, and Icicle Creek. Naturally spawning populations in Icicle Creek interact with fish reared in Leavenworth NFH.

Rearing

Rearing habitat for fry and parr is considered in good condition within the Chiwawa, White, and Little Wenatchee rivers. Rearing habitat in Nason and Peshastin creeks has been compromised by loss of riparian area and subsequent large wood recruitment, off channel habitat, channel stability, and general diversity. Tumwater Canyon is also known to be an important rearing area for spring chinook. Winter rearing habitat may be limiting to spring chinook juveniles because of natural temperature regimes in spawning tributaries and reductions in habitat diversity in the lower Wenatchee River.

Conclusion

Overall, spring chinook production in the Wenatchee River could increase if habitat problems within Nason and Peshastin creeks were corrected. This is a difficult task because of existing roads, railroads, and current land use practices. Preservation of quality habitat in the Little Wenatchee, White, and Chiwawa assessment units would ensure remaining high quality habitat areas remain in tact. Potentially, increases of off channel habitat and riparian areas in the lower Wenatchee River downstream of Leavenworth would increase potential rearing habitat and life history diversity. While creating or restoring more historic habitat in areas like Peshastin Creek may not increase overall spring chinook production by a significant degree, it would increase the spatial and potential genetic diversity of spring chinook in the Wenatchee River.

Late-run chinook

Adult migration and holding

Late-run chinook enter the Wenatchee River from June through October and hold (stage) until spawning begins in October in larger pools of the mainstem Wenatchee. Loss of abundance and pools likely affect late-run chinook the same way these conditions affect spring chinook (see the discussion above). Mortality, stress, or displacement to adults is likely greatest in the lower Wenatchee River.

Spawning and egg incubation

Late-run chinook of the Wenatchee subbasin spawn in the mainstem Wenatchee River. Spawning and incubation areas upstream of Leavenworth remains highly functional and are in good condition. In the lower Wenatchee increases in sediment deposition and higher flow rates (that may displace incubation gravels at a higher than normal rate) have possibly reduced incubation success in the lower river.

Rearing

Rearing habitat for fry has been compromised by loss of riparian area and subsequent LWD recruitment, off channel habitat, channel stability, and habitat diversity in the lower Wenatchee. It is reasonable to assume that given the level of detailed information from past surveys, that increases in off channel habitat in the lower river may elevate survival rates for post-emergent fry rearing in the lower river.

Conclusion

Late-run chinook production in the Wenatchee River could increase if habitat problems within lower river were improved. Preservation of quality habitat in the upper river would ensure remaining high quality habitat areas remain intact. Potentially, increases of off channel habitat and riparian areas in the lower Wenatchee River downstream of Leavenworth would increase potential rearing adult holding habitat and genetic, spatial, and life history diversity.

Sockeye salmon

Adult migration and holding

Sockeye enter the Wenatchee River from July through August and move rapidly upstream to Lake Wenatchee where they hold until spawning begins in September. Extreme high flows have been shown to be an impediment to sockeye migration in Tumwater Canyon. This is believed to be a natural event but likely accentuated due to land management practices in the upper tributaries. Extreme low flows have shown to present migrational delays at Tumwater Dam. Collaborative efforts have improved passage at Tumwater Dam in recent years.

Spawning and egg incubation

Spawning areas within the White and Little Wenatchee rivers remains functional, where most geofluvial processes have not changed over time and spawning gravels and water flow are in good condition. Incubation of eggs is most likely not affected by human-caused factors in the White and Little Wenatchee rivers.

Rearing

Rearing habitat for fry and parr is considered to be a limiting factor in Lake Wenatchee. Since Lake Wenatchee is an oligotrophic lake, it is unlikely that increases in fry-smolt production can be obtained unless increases in nutrients are introduced into the lake. This could be accomplished by either an increase in spawning salmon upstream of the lake or by artificial means.

Conclusion

Overall, sockeye production in the Wenatchee River could increase if fry-parr survival improved. Preservation of quality habitat in the Little Wenatchee and White River basins would ensure that remaining high quality habitat areas remain intact.

Coho

Adult migration and holding

Coho salmon enter the Wenatchee River in early September through late November. Coho entering in September and October hold in larger pools prior to spawning, later entering fish may migrate quickly upstream to suitable spawning locations. Extreme high flows may be an impediment to coho migration in Tumwater Canyon. This is believed to be a natural event but is likely accentuated due to land management practices in the upper tributaries. In years with extreme low flow, coho entrance into the Wenatchee River or migration to spawning grounds may be delayed. Channel confinement, the loss of riparian areas and associated large wood used as cover have reduced the abundance of pools. Mortality, stress or displacement to adults is likely greatest in Nason and Peshastin Creeks.

Spawning and egg incubation

Spawning areas for coho salmon in Nason Creek have been compromised by loss of riparian area and subsequent large wood recruitment, off channel habitats, channel stability, and general diversity. Coho spawning areas in Peshastin Creek, Mission Creek, and Chumstick Creek have been severely altered likely resulting in reduced incubation success due to lack of suitable spawning gravel and sedimentation. Coho spawning habitat in the Little Wenatchee River remains in good condition. Coho spawning also occurs in the Wenatchee River and Icicle Creek where increases in sediment deposition, channel confinement and higher flow rates (that may displace incubation gravels a higher than normal rate) have most likely reduced incubation success. Largely unaltered coho spawning habitat exists in the Chiwawa and White Rivers.

Rearing

Rearing habitat for coho salmon in Nason Creek, Icicle Creek, and Peshastin Creek has been compromised by loss of off channel habitat, channel stability and habitat diversity. Winter rearing habitat may be limiting due to the lack of off channel habitat and large woody debris.

Conclusion

Natural coho production in the Wenatchee sub-basin could increase if habitat problems within Nason, Icicle, Peshastin, Mission, and Chumstick creeks were improved. Preservation of quality habitat areas in Chiwaukum, Little Wenatchee, White, and Chiwawa basins would ensure high quality areas remain intact. Increases of off-channel habitat in riparian areas in the lower Wenatchee River downstream of Leavenworth would increase rearing and adult holding habitat and life history diversity. Adult migration and holding

Steelhead

Adult migration and holding

Steelhead enter the Wenatchee River from August through May of the following year and hold until spawning begins in February in larger pools or deeper glides of the mainstem Wenatchee or spawning tributaries. Lost pool habitat has most likely impacted steelhead adults in Mission, Nason and Peshastin creeks.

Spawning and egg incubation

Spawning and incubation areas within the Chiwawa, White, and Little Wenatchee rivers remains functional. Spawning and incubation areas in Nason, Mission, and Peshastin creeks have been severely altered. The remaining spawning occurs throughout the mainstem Wenatchee River, but primarily in the upper Wenatchee River and a very small amount in Chiwaukum and Icicle creeks. Increases in sediment deposition channel confinement and higher flow rates (that may displace incubation gravels at a higher than normal rate) have most likely reduced incubation success.

Rearing

Rearing habitat for fry and parr is considered in good condition within Tumwater Canyon, and the Chiwawa, White, and Little Wenatchee rivers. Rearing habitat in Mission, Nason, and Peshastin creeks have been compromised by loss of riparian area and subsequent large wood recruitment, off channel habitat, channel stability, and habitat diversity. Winter rearing habitat may be limiting to steelhead juveniles because of natural temperature regimes in spawning tributaries and reductions in habitat diversity in the lower Wenatchee River.

Conclusion

Overall, steelhead production in the Wenatchee River could increase if habitat problems within Mission, Nason, and Peshastin creeks were improved. Preservation of quality habitat in the Little Wenatchee, White, and Chiwawa basins would ensure remaining high quality habitat areas remain in tact. Potentially, increases of off channel habitat and riparian areas in the lower Wenatchee River downstream of Leavenworth would increase potential rearing and adult holding habitat, and life history diversity. While creating or restoring more historic habitat in areas like Mission or Peshastin creeks may not increase overall steelhead production by a significant degree, it would increase the spatial and potential genetic diversity.

Bull trout

Adult migration and holding

Bull trout may live their entire lives within the Wenatchee River or may migrate between the Wenatchee and mainstem Columbia Rivers. During their spawning migration (either from Lake Wenatchee or the Columbia River), abundance of pools, cover and high quality, cool water is important. Loss of riparian area and associated large wood that is used as cover, reduce the abundance of pools has most likely impacted bull trout adults in Nason and Peshastin creeks. Loss of connectivity to Icicle Creek and potentially Peshastin Creek is also likely to reduce productivity of this species. Illegal harvest and harassment may still negatively affect population growth, but to an unknown degree.

Spawning and egg incubation

Spawning and incubation areas within the Icicle, Chiwawa, White, Little Wenatchee rivers, and Chiwaukum Creek are in good condition. Spawning and incubation areas in lower Nason Creek and Peshastin Creek have been severely altered. Increases in sediment deposition channel confinement and higher flow rates (that may displace incubation gravels at a higher than normal rate), have most likely reduced incubation success.

Rearing

Rearing habitat for fry and parr is considered in good condition within Tumwater Canyon, and the Icicle, Chiwawa, White, and Little Wenatchee rivers and Chiwaukum Creek. Rearing habitat in Nason and Peshastin and lower Icicle creeks has been compromised by loss of riparian area and subsequent large wood recruitment, off channel habitat, channel stability, and general diversity.

Conclusion

Bull trout production in the Wenatchee subbasin could increase if habitat problems within Nason and Peshastin creeks were improved and if connectivity to Icicle and Peshastin creeks were re-established. Preservation of quality habitat in the Chiwaukum, Little Wenatchee, White, and Chiwawa basins would ensure remaining high quality habitat areas remain in tact. Potentially increases of off channel habitat and riparian areas in the lower Wenatchee River downstream of Leavenworth, would increase potential rearing and adult holding habitat and life history diversity. While creating or restoring more habitat in areas like Peshastin Creek may not increase overall bull trout production by a significant degree, it would increase the spatial and potential genetic diversity.

Westslope Cutthroat Trout

Life History

Westslope cutthroat trout (WSCT) generally exhibit three main life histories forms; fluvial, which migrate between smaller spawning stream and larger rearing streams; adfluvial, which migrate between spawning streams and a lake, and non-migratory, which generally spend their entire lives in the stream they were born in. Much of the life history of WSCT in the Wenatchee River is unknown.

Adult migration and holding

WSCT may live their entire lives in the tributaries to the Wenatchee River or they may migrate to the mainstem and possibly to the Columbia River. When adults are migrating upstream to spawning areas, they associate with cover; debris, deep pools and undercut banks. The availability of and number of deep pools and cover is important to offset potential pre-spawning mortality. Adult cutthroat trout need deep, slow moving pools that do not fill with anchor ice in order to survive the winter. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geo-fluvial processes will increase the occurrence of deeper pools.

Spawning and egg incubation

WSCT spawn between March and July, when water temperatures begin to warm. Spawning and rearing streams tend to be cold and nutrient poor. Stream conditions (e.g. frequency of flooding, extreme low temperatures) may affect egg survival. Flood can scour eggs from the gravel by increasing sediment deposition that reduces oxygen and percolation through the redd.

In the Wenatchee Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows. Road building activities in the upper watershed may increase siltation, as well as grazing and mining activities. Nason Creek, because of its location near a railroad and major highway has long term restoration needs that could most likely increase incubation success.

Rearing

After emergence, fry are usually found in shallow, slow backwater side channels or eddies, in association with fine woody debris. Juvenile cutthroat trout overwinter in the interstitial spaces of large stream substrate. Rearing habitat in Nason, and Peshastin Creek and the mid-mainstem Wenatchee and lower Chiwawa rivers have been compromised by the loss of channel stability, habitat diversity, obstructions, temperature and riparian conditions.

Conclusion

Westslope Cutthroat Trout production in the Wenatchee subbasin could increase if habitat problems within Nason and Peshastin creeks and the mid-Wenatchee and lower Chiwawa rivers were improved. Preservation of quality habitat in upper tributaries and small streams within the watershed would ensure remaining high quality habitat areas remain in tact. Potentially increases of off channel habitat and riparian areas in the lower Wenatchee River downstream of Leavenworth, would increase potential rearing and adult holding habitat and life history diversity. Creating or restoring more habitats in the Peshastin and Nason Assessment Units will increase overall westslope cutthroat trout production and will increase the spatial and potential genetic diversity.

Pacific Lamprey

Conclusion

Currently, there is not enough information concerning this species in the Wenatchee subbasin to draw conclusions.

6.4 Key Findings by Assessment Unit

6.4.1 Lower Wenatchee River Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

Riparian and floodplain conditions have been substantially altered (70% measured) throughout the lower Wenatchee River. Developments have confined the river channel, separated much of the floodplain and side channels from the main channel, and degraded water retention, riparian shade, streambank stabilization, litter input, and recruitment of large wood. Carrying capacity and habitat diversity for juvenile rearing salmonids has been significantly reduced.

Confidence in conclusion:

- HIGH A channel migration zone study is currently under way that may suggest the degree of habitat lost due to degraded floodplain and riparian conditions. There is not enough information to indicate how much productivity would be enhanced as a result of these improvements in habitat attributes although it is reasonable to suggest it would be significant.

Key Findings: Stream Channel Conditions and Function

Habitat Diversity/Channel Stability

Habitat diversity has been significantly reduced throughout much of the lower mainstem Wenatchee River. Large pools in the mainstem provide key habitat for pre-spawning adults and juvenile salmonid rearing. Coupled with lost diversity and increased flows, channel stability is likely reduced, potentially disturbing redds and over-wintering juveniles.

Confidence in conclusion

- MODERATE It is not understood to what degree large woody debris would have contributed to in-channel conditions or how much large pool habitat was available in the historic reference condition.

Sediment

Sediment delivery to the channel has accelerated as a result of erosive processes throughout much of the Wenatchee subbasin. In lower gradient, depositional reaches, increased sediment production may be embedding cobble substrates and degraded substrates suitable for spawning and egg incubation.

Confidence in conclusion

- LOW The extent of sediment delivery to the lower Wenatchee River beyond the range of natural variation is not understood. Surveys on the mainstem have not been completed. No sediment budget has been developed for the Wenatchee River system.

In Derby Canyon channel modifications from rural development, riparian roading and riparian vegetation removal are apparent. Channel entrenchment is high in some areas as a result of these modifications and the predominant sandstone geology.

Key Findings: Water Quality

Elevated Water Temperature

The Wenatchee River is on the 303(d) list for high water temperature. Late summer water temperatures are believed to have increased moderately in low flow years from presumed historic conditions. Elevated temperatures could reduce key habitat quantity for focal species.

Confidence in conclusion

- MODERATE Temperature modeling has not been done to support this conclusion. Forward looking infrared (FLIR) information suggests some warming occurs.

Key Findings: Contaminants

Pollutants are known to enter the Wenatchee River as a result of agricultural, industrial, and urban activities. The extent to which these materials are toxic to focal species within the Wenatchee subbasin has not been determined. These materials may affect egg and fry development and have a cumulative affect on overall survival on fish that rear in the lower reaches.

Confidence in conclusion

- LOW Very little information has been collected to suggest bio-accumulation. No recorded history of fish kills as a result of contaminants exists. Potential cumulative affect is likely but unknown.

Key Findings: Water Quantity

Low Flow

Low flows (baseline flows) are presumed to have decreased moderately from historic reference condition. Lowered flows are a cumulative affect of overall watershed conditions in the tributary streams and exaggerated by irrigation withdrawal. Low flows limit habitat availability for all focal species using these waters.

Confidence in conclusion

- MODERATE Specific measurements concerning affects to hydrograph from degraded watershed conditions have not been made. Stream diversions and well withdrawals from shallow aquifers in the floodplain may cumulatively influence low stream flows, particularly during low water years.

Key Findings: Obstructions to Fish Passage

In the lower portions of Derby Canyon many culverts and residential ponds are known to restrict passage of resident fish, particularly steelhead trout.

Summary of Limiting Factors

- Key Habitat Quantity
- Habitat Diversity

- Channel Stability
- Sediment
- Low Flow
- Elevated Temperature
- Contaminants

Hypothesis Statements

Elevated Temperature

Improving low summer flow and riparian/floodplains conditions in the assessment unit and upper tributaries will decrease summer water temperatures, provide for additional key habitat, and improve habitat quality for the following focal species and life stages.

Table 25. Lower Wenatchee River hypothesis statements: elevated temperature

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Summer Rearing Pre-spawning Adults	Moderate Low	Moderate Moderate
Late-run Chinook	Summer Rearing Pre-spawning Adults	Moderate Moderate	Moderate Low
Coho	Summer Rearing	High	Moderate
Steelhead	Summer Rearing Pre-spawning Adults	Moderate Low	Moderate High
Bull Trout	Pre-spawning Adults	Low	Moderate

Low Flow

Increasing summer low flows will increase wetted channel area, increase key habitat quantity, and improve habitat quality for the following focal species and life stages.

Table 26. Lower Wenatchee River assessment unit hypothesis statements: low flow

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Summer Rearing Pre-spawning Adult	Low *(1)* Low	Moderate
Late-run Chinook	Summer Rearing Pre-spawning Adult	Low-Moderate Low	Moderate
Coho	Summer Rearing Pre-spawning Adult	Moderate High	Moderate
Steelhead	Summer Rearing	Low-Moderate	Moderate
Bull Trout	Pre-spawning Adult	Low	Moderate

(1) Spring chinook are probably limited more by elevated temperature at this time than by low flow conditions.

Riparian/Floodplain Condition

Improving and restoring riparian and floodplain habitats and functionality will contribute to decreased sediment delivery, decreased summer stream temperatures, increased in-channel structural diversity and recruitment of large wood, an increase of micro-refugia during extreme flow and temperature conditions, and increases in macro-invertebrate production. Cumulatively, these contributions will increase productivity of all focal species and life stages occupying these areas by increasing key habitat quality and quantity.

Habitat Diversity

Increasing in-channel structural diversity and complexity, large pool habitat, and the amount of side-channel habitats will increase habitat quantity and quality in the assessment unit over a wide range of flow conditions for the following focal species and life stages.

Table 27. Lower Wenatchee River hypothesis statements: habitat diversity

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Juvenile Rearing Pre-Spawning Adult	High Moderate	High High
Late-run Chinook	Egg Incubation Summer Rearing Adult	Moderate High Moderate	High High High
Coho	Juvenile Rearing Adult	High High	High High
Steelhead	Juvenile Rearing Adult	High Low-Moderate	High High
Bull Trout	Adult Migration	Low	High

Fine Sediment

Decreasing fine sediment delivery and excessive accumulation in the assessment unit will enhance macro-invertebrate productivity and increase focal species productivity for the following species and life stages.

Table 28. Lower Wenatchee River hypothesis statements: fine sediment

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Egg Incubation	Low	High
Late-run Chinook	Egg incubation	High	High
Coho	Egg Incubation	High	High
Steelhead	Egg Incubation	Low	High

(1) Spring chinook and steelhead typically spawn above this assessment unit.

Channel Stability

Increasing riparian and floodplain habitat and functionality, reducing channel confinement and increasing in-channel structural complexity will improve channel (bedload) stability and will increase productivity for the following focal species and life stages:

Table 29: Lower Wenatchee River hypothesis statements: channel stability

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Winter Rearing	Moderate	Moderate
Late-run Chinook	Egg incubation Winter Rearing	Moderate Moderate	Moderate Moderate
Coho	Egg Incubation (1) Winter Rearing	Moderate Moderate	Moderate Moderate
Steelhead	Winter Rearing	Moderate	Moderate

(1) With the successful introduction of Coho, it is assumed these fish will use these habitats for spawning and rearing.

Fish Passage

Providing full fish passage in the tributary streams of this Assessment Unit will enhance life history diversity and to a lesser degree will increase productivity for the following focal species and life stages:

Table 30: Lower Wenatchee River hypothesis statements: fish passage

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Coho	Adult Migration Juvenile Migration	Moderate Moderate	High Moderate

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Steelhead	Adult Migration Juvenile Migration*	Low Moderate	High Moderate

6.4.2 Middle Wenatchee River Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

Riparian and floodplain conditions within the middle Wenatchee River have been altered over time, but remain relatively intact. Degraded riparian conditions contribute to reduced in-channel habitat diversity important for adult holding and juvenile rearing habitats.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

Habitat Diversity/Channel Confinement

Channel confinement, primarily from the transportation system, and lost large wood recruitment have contributed to a reduction in pools and habitat diversity. Despite these intrusions, habitat diversity remains relatively good throughout much of this area.

Confidence in conclusion

- HIGH Stream surveys have been completed on many significant tributary streams to date.

Sediment

Bank hardening projects (riprap) to protect developed shorelines from erosion alter the natural processes of streambank erosion and lateral channel migration in the upper reaches (below Lake Wenatchee). These practices may be elevating sediment production in some locations (erosion-prone streambank terraces), although this relationship is not well documented.

The construction of Tumwater Dam (RM 31.0) in the early 1900s changed the character of the river upstream, creating the 0.5 mile long Lake Jolanda. This impoundment has altered the sediment transport regime of the river. Coarse sediments are trapped above the dam while fine sediments flush through. The deposition of fine sediments is localized, and not persistent throughout this area.

Confidence in conclusion

- MODERATE. Sediment condition and trend information is lacking for most of this area.

Key Findings: Water Quality

water quality has changed very little in the mainstem Wenatchee River since the historic reference condition. Slight increases in pollution and possible small decreases in dissolved oxygen are noted.

Elevated Temperature

The Middle Wenatchee River is listed on the 303d list for high water temperatures. Elevated temperatures are noted in some of the tributary streams as well. Increased water temperatures are likely the cumulative result of reduced riparian vegetation, floodplain function and channel conditions and reduced late-summer flows in the tributary streams.

Confidence in conclusion

- LOW-MODERATE Elevated temperatures may be a natural condition although it is reasonable to conclude that temperature is increased from lost riparian and floodplain function in the upper tributaries.

Key Findings: Water Quantity

None identified at this time.

Key Findings: Obstructions to Fish Passage

Tumwater Dam is known to have restricted fish migration, especially during lower flows. Structural modifications to fish passage facilities have recently been completed. It is assumed that Tumwater Dam no longer imposes a significant delay in fish passage, although this condition will be closely monitored.

Confidence in conclusion

- MODERATE Culverts under road crossings are known to limit fish passage (primarily steelhead) in Skinny and Beaver creeks.

Confidence in conclusion

- HIGH

Summary of Limiting Factors

- Riparian/Floodplain Function
- Habitat Diversity
- Sediment
- Obstructions

Hypothesis Statements

Riparian/Floodplain Condition

Improving and restoring riparian and floodplain habitats and functionality will contribute to decreased sediment delivery, decreased summer stream temperatures, an increased in-channel structural diversity and recruitment of large wood, an increase of micro-refugia during extreme flow and temperature conditions, and an increase in macro-invertebrate production. All of these contributions will increase productivity of all focal species and life stages occupying these areas by increasing key habitat quality and quantity.

Habitat Diversity

Increasing in-channel structural diversity and complexity will increase habitat quantity and quality in the assessment unit over a wide range of flow conditions for the following focal species and life stages.

Table 31: Middle Wenatchee River hypothesis statements: habitat diversity

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Egg Incubation Fry Colonization Juvenile Rearing Adult	Low High Moderate Moderate	High High High Moderate
Late-run Chinook	Egg Incubation Fry Colonization Juvenile Rearing Adult	Low High Moderate Moderate	High High High Moderate
Coho	Egg Incubation Fry Colonization Juvenile Rearing Adult	Low High Moderate Moderate	High High High Moderate
Steelhead	Egg Incubation Fry Colonization Juvenile Rearing Adult	Low High Moderate Moderate	High High High Moderate
Bull Trout	Juvenile Rearing Adult	Low Moderate	Moderate Moderate

Fish Passage

Providing full fish passage in the tributary streams of this assessment unit will enhance life history diversity and to a lesser degree will increase productivity for the following focal species and life stages.

Table 32: Middle Wenatchee River hypothesis statements: fish passage

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Coho	Juvenile Rearing Adult	Moderate Moderate	High High
Spring Chinook	Juvenile Rearing*	Moderate	Moderate
Steelhead	Juvenile Rearing* Adult	Moderate Moderate	High High
Bull Trout	Juvenile Rearing* Adult	Low Moderate	High Moderate

Delay of passage at Tumwater Dam may be detrimental to spawning and egg incubation success for all focal species passing through these waters. At this time there is not enough information to determine if lost productivity exists, but this situation should be monitored closely and timely and appropriate actions taken as needed:

Competition and Predation

Control or elimination of brook trout will improve productivity and potentially life history diversity for bull trout and cutthroat trout by reducing inter-breeding, competition and predation in the upper watersheds of this Assessment Unit.

6.4.3 Mission Creek Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

Channel constriction from roads constructed within the floodplain throughout Mission Creek watershed has reduced the accessible floodplain. Riparian characteristics are highly altered in the lower watershed. In the upper watershed, riparian roads adjacent to stream channels are similar to those in most other significant drainages.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

Habitat Diversity

Pool frequency and depth have been reduced as a result of channel simplification and lost production of LWD within the stream channel. In the lower watershed stream channels are highly confined by developments. Lost habitat diversity has severely limited habitat quality and quantity for all life stages of steelhead and juvenile rearing chinook salmon.

Confidence in conclusion

- HIGH Stream surveys have been completed in public lands.

Channel Stability

Developments have resulted in a predominance of entrenched and single channel characteristics within the watershed. In these areas, flow velocities are increased, resulting in increased bedload movement and possible disruption to incubating eggs, although these conditions have not been documented in this assessment unit. Low flows are pronounced in these simplified channels, substantially reducing habitat diversity and key habitat quantity.

Confidence in conclusion

- MODERATE-HIGH

Sediment

Various riparian and in-channel alterations throughout much of the watershed have resulted in increased sediment delivery into Mission Creek. Fine sediments have filled pools, embedded cobble and gravel substrates, reducing cover for over-winter rearing juveniles, smothering incubating eggs and reducing available habitat for macro-invertebrate production.

Confidence in conclusion

- HIGH

Key Findings: Water Quality

Increased temperatures are the cumulative result of degraded riparian conditions and decreased summer flows throughout the Assessment Unit. Elevated temperature limits habitat availability and quality for juvenile salmonids and potentially increases the likelihood for.

Confidence in conclusion

- HIGH

Contaminants

Mission Creek does not meet state water quality standards for DDT; 4, 4-DDT; 4, 4-DDE and Gunthion, as well as dissolved oxygen, fecal coli form. Currently, only Mission Creek in the Wenatchee River subbasin is listed as impaired due to pesticides in fish tissues. It is likely that survival of incubating eggs and juvenile fish is reduced as a direct affect of these pollutants, or as an indirect or cumulative affect.

Confidence in conclusion

- MODERATE Affects of these toxic materials on salmonid fishes are not well documented in the Mission watershed.

Key Findings: Water Quantity

watershed hydrology is likely altered due to variety of management activities. High flows, coupled with channel confinement and reduced habitat diversity likely displaces and/or kills juvenile salmonids. High flows also increase bedload movement which likely disrupts or destroys salmonid redds. Low flows reduce key habitat availability and quality for all life stages and in many places throughout the watershed has eliminated usable habitat.

Confidence in conclusion

- HIGH It is assumed that management activities have advanced and exaggerated the hydrograph in the Mission Creek assessment unit.

Key Findings: Obstructions to Fish Passage

Fish Passage

Access to upper Mission Creek and its tributaries is limited due to de watering of lower Mission Creek, and numerous culverts and irrigation dams, many of which are impassable for juvenile fish and several also prevent adult passage.

Confidence in conclusion

- HIGH

Summary of Limiting Factors

- Riparian/Floodplain Function
- Habitat Diversity
- Channel Stability
- Sediment
- Contaminants
- Elevated Temperature
- Flow
- Obstructions

Hypothesis Statements

Elevated Temperature

Improving low summer flow and riparian/floodplains conditions in the Assessment Unit and tributaries will decrease summer water temperatures and will provide additional key habitat and improve habitat quality for the following focal species and life stages.

Table 33: Mission Creek hypothesis statements: elevated temperature

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Coho	Summer Rearing	High	High
Steelhead	Summer Rearing	High	High

(1) Chinook juveniles that presumably move into Mission Creek from the Wenatchee River will also benefit from decreased summer temperatures.

High Flow

By normalizing the hydrograph and moderating accentuated peak flow conditions within the Assessment Unit, habitat quantity and quality will improve for the following focal species and life stages.

Table 34: Mission Creek hypothesis statements: high flow

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Coho	Egg Incubation Fry Colonization Winter Rearing Adult	High (1) High High Moderate	High High High Moderate
Steelhead	Egg Incubation Fry Colonization Winter Rearing	High (1) High High	High High High

(1) Associated with in-channel conditions and assumes that redds are scoured out during high flow events.

(2) Chinook juveniles that presumably move into Mission Creek from the Wenatchee River will also benefit from a decrease in high flows.

Low Flow

Increasing summer low flows will increase wetted channel area and will increase key habitat quantity and improved habitat quality for the following focal species and life stages.

Table 35: Mission Creek hypothesis statements: low flow

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Coho	Summer Rearing Adult	High Moderate	High Moderate
Steelhead	Summer Rearing	High	High

Note: Chinook juveniles that presumably move into Mission Creek from the Wenatchee River will also benefit from an increase in base flows.

Riparian/Floodplain Condition

Improving and restoring riparian and floodplain habitats and functionality will contribute to decreased sediment delivery, decreased summer stream temperatures, an increased in-channel structural diversity and recruitment of large wood, an increase of micro-refugia during extreme flow and temperature conditions, and an increase in macro-invertebrate production. All of these contributions will increase productivity of all focal species and life stages occupying these areas by increasing key habitat quality and quantity

Habitat Diversity

Increasing in-channel structural diversity and complexity, increasing large pool habitat and increasing the amount of side-channel habitats will increase habitat quantity and quality in the assessment unit over a wide range of flow conditions for the following focal species and life stages.

Table 36: Mission Creek hypothesis statements: habitat diversity

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Coho	All Life Stages	High	High
Steelhead	All Life Stages	High	High

Channel Stability

Increasing riparian and floodplain habitat and functionality, reducing channel entrenchment and confinement and increasing in-channel structural complexity will improve channel (bedload) stability and will increase productivity for the following focal species and life stages.

Table 37: Mission Creek hypothesis statements: channel stability

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Coho	All Life Stages	High	High

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Steelhead	All Life Stages	High	High

Fish Passage

Providing full fish passage in the mainstem and tributary streams of this assessment unit will enhance life history diversity and will increase productivity for the following focal species and life stages.

Table 38: Mission Creek hypothesis statements: fish passage

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Juvenile Rearing	High	High
Coho	Adult Juvenile Rearing	Moderate High	High High
Steelhead	Adult Juvenile Rearing	Moderate High	High High

6.4.4 Peshastin Creek Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

Riparian Floodplain Conditions

Floodplain, riparian areas and off-channel habitats have been significantly reduced as a result of State High way 97 which borders much of Peshastin Creek. Floodplain and riparian attributes within the lower nine miles have been significantly altered by residential, rural and agricultural use. Much of the area within Ingalls Creek is still in fair (lower reaches) to pristine (upper reaches) conditions.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

Habitat Diversity

Stream reaches within the mainstem of the Peshastin have been significantly channelized and hardened which has reduced habitat complexity and accelerated erosive processes. Timber harvest and mining activities in most tributary streams have altered channel conditions resulting in reduced habitat diversity. Overall pool availability and quality is low in all areas except Ingalls Creek.

Confidence in conclusion

- HIGH

Channel Stability

The overall channel width of the lower 9.0 miles of Peshastin Creek is increasing, and the channel is becoming less entrenched in response to increases in sediment supply, decreases in riparian vegetation structure and function, and changes in the flow regime.

Confidence in conclusion

- HIGH

Sediment

Visual estimates indicate that substrates within a majority of segments are embedded. Exceptions include Ingalls Creek where embeddedness is not a problem and several tributaries where mining by dredging has scoured the channel down to bedrock in many reaches.

Confidence in conclusion

- MODERATE Empirical information concerning sediment in streams is lacking. Stream surveys on public lands supports this conclusion.

Key Findings: Water Quality

Elevated Temperature

Increased stream temperatures are likely a cumulative affect from a loss of riparian vegetation/shade, lower flows due to degraded channel conditions and floodplain storage throughout the mainstem and many of the tributary streams. Elevated temperature limits habitat availability and quality for focal species and potentially increases the likelihood for disease.

Confidence in conclusion

- MODERATE Insufficient data exists to determine if instream temperatures are significantly different than the historic range of temperatures. Increased stream temperatures are likely a cumulative affect from a loss of riparian vegetation and the disrupted hydrograph throughout mainstem and many of the tributary streams.

Key Findings: Water Quantity

High flows and reduced base flows within the Peshastin Creek watershed is a cumulative result of intensive upland and floodplain vegetation management, high road densities, degraded floodplain function (storage) and entrenched stream channels. High flows increase bedload movement which disrupts or destroys salmonid redds. Low flows have reduced key habitat availability and quality for all life stages,

Peshastin Creek at RM 2.4 is de watered by an irrigation diversion for approximately 100 feet below the diversion.

Confidence in conclusion

- MODERATE-HIGH There is a lack of information on flows for the Peshastin drainage. Conclusion is based upon general watershed and channel conditions.

Key Findings: Obstructions to Fish Passage

At RM 2.4, a water diversion dam presents a barrier to summer and fall migration (mid June through October) for adult and juvenile fish. There are many other water diversions and culverts that likely act to limit fish (especially juveniles) movement throughout the watershed.

Confidence in conclusion

- HIGH

Summary of Limiting Factors

- Riparian/Floodplain Function
- Habitat Diversity
- Channel Stability
- Sediment
- Elevated Temperature
- Flow
- Obstructions

Hypothesis Statements

Elevated Temperature

Improving low summer flow and riparian/floodplains conditions in the assessment unit and tributaries will decrease summer water temperatures and will provide additional key habitat and improve habitat quality for the following focal species and life stages.

Table 39: Peshastin Creek hypothesis statements: elevated temperature

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Summer Rearing Pre-spawning Adult	Low Low	Moderate High
Coho	Summer Rearing	Low	Moderate
Steelhead	Fry Colonization Summer Rearing	Low Low	High Moderate
Bull Trout	Summer Rearing Pre-spawning Adult	Low Moderate	Moderate Low*(1)*
Cutthroat Trout	Adults	None – Low	Low*(2)*

(1) Water temperatures cool significantly at night; it is not well understood if bull trout will use this time to move through day-time thermal barriers.

(2) Migration patterns of cutthroat trout are not understood and what effect elevated temperatures in this Assessment Unit might have on these patterns.

High Flow

By normalizing the hydrograph and moderating accentuated peak flow conditions within the assessment unit, habitat quantity and quality will improve for the following focal species and life stages.

Table 40: Peshastin Creek hypothesis statements: high flow

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Egg Incubation Fry Colonization Winter Rearing	High *(1)* High Moderate	Moderate High Moderate
Coho	Egg Incubation Fry Colonization Winter Rearing	High (1) High Moderate	Moderate High Moderate
Steelhead	Winter Rearing	Moderate	Moderate
Bull Trout	Winter Rearing Fry Colonization	Moderate Moderate	Moderate Moderate
Cutthroat Trout	Egg Incubation Fry Colonization	Low*(2)* Low	Moderate Moderate

(1) Associated with poor in-channel conditions, assumes that redds are scoured out during high flow events.

(2) Cutthroat trout currently exist in one tributary within the assessment unit which remains relatively intact hydrologically.

Riparian/Floodplain Condition

Improving and restoring riparian and floodplain habitats and functionality will contribute to decreased sediment delivery, decreased summer stream temperatures, an increased in-channel structural diversity and recruitment of large wood, an increase of micro-refugia during extreme flow and temperature conditions, and an increase in macro-invertebrate production. All of these contributions will increase productivity of all focal species and life stages occupying these areas by increasing key habitat quality and quantity.

Habitat Diversity

Increasing in-channel structural diversity and complexity, increasing large pool habitat and increasing the amount of side-channel habitats will increase habitat quantity and quality in the assessment unit over a wide range of flow conditions for the following focal species and life stages.

Table 41: Peshastin Creek hypothesis statements: habitat diversity

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Egg Incubation Fry Colonization Juvenile Rearing	Moderate High High	High High High

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
	Adult	Moderate	Moderate
Coho	All Life Stages	High	High
Steelhead	Egg Incubation Fry Colonization Juvenile Rearing Adult	Moderate High High Moderate	High High High Moderate
Bull Trout	Egg Incubation Fry Colonization Juvenile Rearing Adult	Low High Moderate Moderate	High High High Moderate
Cutthroat Trout	Egg Incubation Fry Colonization Juvenile Rearing Adult	Low High Moderate Moderate	High High High Moderate

Channel Stability

Increasing riparian and floodplain habitat and functionality, reducing channel entrenchment and confinement and increasing in-channel structural complexity will improve channel (bedload) stability and will increase productivity for the following focal species and life stages:

Table 42: Peshastin Creek hypothesis statements: channel stability

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Egg Incubation Winter Rearing	Moderate Moderate	Moderate Moderate
Coho	Egg Incubation Winter Rearing	Moderate Moderate	Moderate Moderate
Steelhead	Egg Incubation Winter Rearing	Moderate Moderate	Moderate Moderate
Bull Trout	Egg Incubation Winter Rearing	Moderate Moderate	Moderate Moderate
Cutthroat Trout	Egg Incubation Winter Rearing	Moderate Moderate	Moderate Moderate

Fish Passage

Providing full fish passage in the mainstem and tributary streams of this assessment unit will enhance life history diversity and will increase productivity for the following focal species and life stages

Table 43: Peshastin Creek hypothesis statements: fish passage

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Juvenile Rearing Pre-spawning Adult	Moderate High	High High
Coho	Juvenile Rearing Adult	High High	High High
Steelhead	Juvenile Rearing	Moderate	High
Bull Trout	Pre-spawning Adult	High	Moderate
Cutthroat Trout	Juvenile Rearing Pre-spawning Adult	Unknown Unknown	Unknown Unknown

Competition and Predation

Control or elimination of brook trout will improve productivity and potentially life history diversity for bull trout and cutthroat trout by reducing inter-breeding, competition and predation in the upper watersheds of this assessment unit.

6.4.5 Chumstick Creek Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

Riparian / Floodplain Condition

A high way and railroad closely parallel Chumstick Creek, channelizing the creek, limiting the width of the riparian zone and restricting the use of its floodplain. Rural development has simplified many riparian characteristics. In disturbed areas where woody vegetation is lacking the invasive weed, reed canary grass (*Phalaris arundinacea*), is abundant.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

Channel Stability

Many of the perennial channels in the Chumstick watershed have been modified, confined or hardened. In confined areas, bedload movement is likely augmented during high flows, although this condition is not well documented. Channel instability can disrupt egg incubation and winter rearing habitat.

Confidence in conclusion

- HIGH

Habitat Diversity

The transportation system and rural developments have simplified channel characteristics. Large woody debris throughout the watershed is lacking in quantity and quality.

Confidence in conclusion

- HIGH

Sediment

Erosion associated with riparian disturbance, channel confinement, culvert placement, road placement and past logging all contribute to excessive fine sediment and substrate embeddedness throughout much of the watershed.

Confidence in conclusion

- HIGH

Key Findings: Water Quality

Contaminants

Chumstick Creek is impaired for dissolved oxygen, fecal coli form, and pH criteria. Dissolved oxygen levels may be reduced as a function of elevated temperatures, increased nutrients and increased biological oxygen demand. Coli form counts are likely a cumulative affect of livestock and failing septic systems within the mainstem reaches. Changes in pH from the historic reference condition are unknown.

Confidence in conclusion

- MODERATE-HIGH Affects of these attributes to focal species is undetermined. Fish kills have not been reported.

Key Findings: Water Quantity

Flow

Watershed conditions have changed considerably resulting in accentuation and advancement of hydrologic responses. Coupled with simplified channel conditions, refugia for juvenile salmonids from high flow events is limited. Low flows are likely reduced from the historic reference condition because of lost watershed and floodplain function (water storage) and entrenched cannel conditions.

Confidence in conclusion

- HIGH

Key Findings: Obstructions to Fish Passage

The North Road county culvert at RM 0.3 is a full passage barrier to spring chinook and a partial passage barrier to steelhead, particularly juveniles.

This barrier substantially limits the ability for fish species to use the Chumstick watershed. There are numerous obstructions located throughout the watershed that are considered to be significant and/or partial barriers to adult and/or juvenile fish.

Confidence in conclusion

- HIGH It is not understood how much habitat above the existing culvert would be used by salmon if full passage existed, although it is assumed the use would be significant.

Summary of Limiting Factors

- Riparian/Floodplain Function
- Habitat Diversity
- Channel Stability
- Sediment
- Flow
- Obstructions

Hypothesis Statements

High Flow

By normalizing the hydrograph and moderating accentuated peak flow conditions within the assessment unit, habitat quantity and quality will improve for the following focal species and life stages.

Table 44: Chumstick Creek hypothesis statements: high flow

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Steelhead	Egg Incubation Fry Colonization Winter Rearing	High High Moderate	High High Moderate
Coho*(1)*	Egg Incubation Fry Colonization Winter Rearing	High High Moderate	High High Moderate

(1) Assumes that coho are established in this assessment unit.

Low Flow

Increasing summer low flows will increase wetted channel area and will increase key habitat quantity and improved habitat quality for the following focal species and life stages.

Table 45: Chumstick Creek hypothesis statements: low flow

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Steelhead	Summer Rearing	High	High
Coho	Summer Rearing	High	High

Riparian/Floodplain Condition

Improving and restoring riparian and floodplain habitats and functionality will contribute to decreased sediment delivery, decreased summer stream temperatures, an increased in-channel structural diversity and recruitment of large wood, an increase of micro-refugia during extreme flow and temperature conditions, and an increase in macro-invertebrate production. All of these contributions will increase productivity of all focal species and life stages occupying these areas by increasing key habitat quality and quantity.

Habitat Diversity

Increasing in-channel structural diversity and complexity, increasing large pool habitat and increasing the amount of side-channel habitats will increase habitat quantity and quality in the assessment unit over a wide range of flow conditions for the following focal species and life stages.

Table 46: Chumstick Creek hypothesis statements: habitat diversity

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Steelhead	All Life Stages	High	High
Coho	All Life Stages	High	High

Channel Stability

Increasing riparian and floodplain habitat and functionality, reducing channel entrenchment and confinement and increasing in-channel structural complexity will improve channel (bedload) stability and will increase productivity for the following focal species and life stages.

Table 47: Chumstick Creek hypothesis statements: channel stability

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Steelhead	Egg Incubation Winter Rearing	High Moderate	High Moderate
Coho	Egg Incubation Winter Rearing	High Moderate	High Moderate

Fine Sediment

Decreasing fine sediment delivery and excessive accumulation in the assessment unit will enhance macro-invertebrate productivity and increase focal species productivity for the following species and life stages.

Table 48: Chumstick Creek hypothesis statements: fine sediment

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Steelhead	Egg Incubation	High	High
Coho	Egg Incubation	High	High

Fish Passage

Providing full fish passage in the mainstem and tributary streams of this assessment unit will enhance life history diversity and will increase productivity for the following focal species and life stages.

Table 49. Chumstick Creek hypothesis statements: fish passage

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Steelhead	Juvenile Rearing Pre-spawning Adult	High High	High High
Coho	Juvenile Rearing Pre-spawning Adult	High High	High High

Competition and Predation

Control or elimination of brook trout will improve productivity and potentially life history diversity for bull trout and cutthroat trout by reducing inter-breeding, competition and predation in the upper watersheds of this assessment unit.

6.4.6 Icicle Creek Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

The connectivity in upper and lower reaches between Icicle Creek and its off-channel, wetland, floodplain, and riparian areas has been reduced mainly due to development, road building, water diversions, construction of Leavenworth NFH, and flood damage control (dikes). Simplification of riparian and off-channel attributes has decreased habitat diversity in the lower river.

In the upper watershed some alterations in riparian vegetation are noted from localized recreation facilities (campgrounds) and past timber harvest. These conditions are considered minor at the watershed scale.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

Sediment

All of the dominant land types in the Icicle Creek watershed have high sediment delivery hazards. In 1994 forest fires burned approximately 12% of the Icicle Creek watershed. These burned areas have and will continue to increase sedimentation in Icicle Creek.

Confidence in conclusion

- HIGH

Habitat Diversity

In the upper Icicle Creek watershed, habitat diversity is at or near pristine conditions. In the lower watershed, development of the hatchery facilities and rural/agricultural developments may have increased the channel width-to-depth ratio and reduced habitat diversity.

Confidence in conclusion

- HIGH

Key Findings: Water Quality

The majority of the water flowing into Icicle Creek comes from high elevation wilderness streams and areas that have had minimal disturbances from management activities. Currently there are no concerns related to chemical contamination or excessive nutrients in Icicle Creek.

Elevated Temperatures

Elevated water temperatures in the lower Icicle watershed are the result of decreased flow and reduction in riparian vegetation. water temperatures monitored near the USFS Boundary (RM 4.8) exceed Forest Plan standards.

Temperatures are reduced by inflow from several high mountain lakes including the Snow Lakes (enters through Snow Creek at RM 5.4). The lakes are managed as storage reservoirs to augment lower Icicle Creek water flows in order to meet water rights and to assure a source of cold water for Leavenworth NFH.

Confidence in conclusion

- LOW-MODERATE There is not enough data to determine if temperatures are significantly different than the historic range in upper Icicle Creek.

Key Findings: Water Quantity

Low Flows

Low flows in the lower reaches (RM 0.0 – 5.7) are the result of natural conditions compounded by public water supply needs, irrigation diversions, and fish hatchery diversions. During drought years, the stream can be de watered from the Leavenworth NFH diversion at RM 4.5 downstream through the canal to RM 2.6 (downstream from the spill way) where the hatchery returns flow into Icicle Creek.

Confidence in conclusion

- HIGH

Key Findings: Obstructions to Fish Passage

Hatchery operations of the dams and weirs in the historic channel of Icicle Creek block fish passage. A steep boulder field at RM 5.8 is thought to prevent essentially all fish from moving upstream although adult bull trout have recently been identified upstream of this partial or potential obstruction. Passage may occur at specific flows for different species, but this is not well documented. Conditions of the screens on water diversions along Icicle Creek is not well documented, although screens need to be updated on some of the larger diversions.

Confidence in conclusion

MODERATE The status or need for screens for most of the smaller diversions is not available. Historic passage above RM 5.8 is speculative for most species.

Summary of Limiting Factors

- Competition (Leavenworth NFH)
- Habitat diversity (lower watershed)
- Elevated temperature (lower watershed)
- Flow (lower watershed)
- Obstructions

Hypothesis Statements

Elevated Temperature

Improving low summer flow conditions in the lower 6 miles of the assessment unit will decrease summer water temperatures and will improve habitat quality for the following focal species and life stages.

Table 50: Icicle Creek hypothesis statements: elevated temperature

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Summer Rearing Pre-spawning Adult	Moderate Low	Moderate Moderate
Coho	Summer Rearing	Moderate	Moderate
Late-run Chinook	Pre-spawning Adult	Moderate	Moderate
Steelhead	Summer Rearing	Low	Moderate
Bull Trout	Pre-spawning Adult	Moderate	Moderate

Low Flow

Increasing summer low flows will increase key habitat quantity and improved habitat quality for the following focal species and life stages.

Table 51: Icicle Creek hypothesis statements: low flow

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Pre-spawning Adult Summer rearing	Moderate Moderate	Moderate Moderate
Coho	Summer Rearing	High	Moderate
Late-run Chinook	Pre-spawning Adult Summer rearing	Moderate Moderate	Moderate Moderate
Steelhead	Summer Rearing	Moderate	Moderate

Bull Trout	Pre-spawning Adult	Moderate	Moderate

Riparian/Floodplain Condition

Improving and restoring riparian and floodplain habitats and functionality in the lower portions (below river mile 6) will contribute to decreased sediment delivery, decreased summer stream temperatures, an increased in-channel structural diversity and recruitment of large wood, an increase of micro-refugia during extreme flow and temperature conditions, and an increase in macro-invertebrate production. All of these contributions will increase productivity of all focal species and life stages occupying these areas by increasing key habitat quality and quantity.

Habitat Diversity

Increasing in-channel structural diversity and complexity, increasing large pool habitat will increase habitat quantity and quality in the lower 6 miles of the assessment unit over a wide range of flow conditions for the following focal species and life stages.

Table 52: Icicle Creek hypothesis statements: habitat diversity

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Egg Incubation Fry Colonization Juvenile Rearing Adult	Low Moderate Moderate Moderate	Moderate Moderate Moderate Moderate
Coho	All Life Stages	High	High
Late-run Chinook	Egg Incubation Fry Colonization Summer Rearing Adult	Low Moderate Moderate Moderate	Moderate Moderate Moderate Moderate
Steelhead	Fry Colonization Juvenile Rearing Adult	Moderate Moderate Low	Moderate Moderate Moderate
Bull Trout	Pre-spawning Adult	Moderate	Moderate

Fish Passage

Eliminating man-made barriers to fish passage in the mainstem (lower 6 miles) of this assessment unit will enhance life history diversity and will increase productivity for the following focal species and life stages.

Table 53: Icicle Creek hypothesis statements: fish passage

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Juvenile Rearing Pre-spawning Adult	Low Low	Moderate Moderate
Coho	All life stages	High	Moderate

Late-run Chinook	Juvenile Rearing	Low	Moderate
Steelhead	Juvenile Rearing Pre-spawning Adult	Low Low	Moderate Moderate
Bull Trout	Pre-spawning Adult	Low	Moderate

Fish Passage

The upper Icicle watershed had a higher degree of connectivity for fish passage in the past than it does now. Road and irrigation developments may have imposed upon the channel and made passage over a natural obstruction more difficult. Allowing greater fish passage to the upper Icicle could increase productivity and life history and genetic diversity for spring chinook, steelhead, bull trout and cutthroat trout. There is a Moderate-High degree of uncertainty associated with this hypothesis statement.

Competition and Predation

Control or elimination of brook trout will improve productivity and potentially life history diversity for bull trout and cutthroat trout by reducing inter-breeding, competition and predation in the upper watersheds of this assessment unit.

6.4.7 Nason Creek Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

In the lower 15 miles of Nason Creek, numerous activities have caused significant disturbances to the riparian areas and floodplains. The state high way, railroad, power lines, stream channel riprapping, recreational sites and residential developments all contribute to poor habitat conditions. All of the Nason tributaries are considered to have good conditions for off-channel habitat. Many of the tributaries have some wetland habitat in their floodplain, including Butcher, Mill, Roaring, and Coulter creeks.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

Channel Stability

In low gradient reaches upstream of Whitepine Creek (RM 15.4) problems are noted with width-to-depth ratios, sediment, substrate embeddedness, bank erosion, reduced large woody debris. Below Whitepine Creek, eroding banks are symptomatic of a channel artificially confined within its floodplain and artificially increased water velocity.

Confidence in conclusion

- HIGH

Habitat diversity

Large wood, pool depth and frequency, and in-channel structural diversity are considered to be in fair to poor condition in the lower Nason Creek reaches. Some side channels and oxbows have been cut off from the main channel by the transportation system. Juvenile salmonid passage into oxbows, wetlands, side channels and other key habitat has been significantly reduced by isolation of these habitats from mainstem Nason Creek.

Confidence in conclusion

- HIGH

Sediment (Nason Creek mainstem)

Various riparian and in-channel alterations throughout much of the watershed have resulted in increased sediment delivery into the lower Nason Creek reaches. Fine sediments have embedded cobble and gravel substrates, reducing interstitial spaces used as cover for over-winter rearing juveniles, smothering incubating eggs and reducing available habitat for macro-invertebrate production.

Confidence in conclusion

- HIGH

Key Findings: Water Quality

Elevated Temperature (lower Nason mainstem)

Substantial channel alterations and reduced riparian vegetation are thought to be responsible for increasing stream temperatures in late summer and early autumn months.

Confidence in conclusion

- MODERATE Temperature modeling has not been done for this stream. Conclusion is based upon relationship between elevated temperatures and lack of stream shade.

Contaminants

Water quality in Nason assessment unit is considered to be relatively good, although exceptions are noted in the lower watershed. Fecal coli form was present in most Nason Creek water samples, but not at levels that exceeded state water quality standards.

Confidence in conclusion

- LOW-MODERATE Adequate water quality monitoring has not been completed. Conclusion is based upon proximity of high way, railroad and residential developments.

Key Findings: Water Quantity

High Flow

General watershed conditions have been altered due to timber harvest, road densities and road location. These factors have likely resulted in increased peak flows during precipitation and significant snow melting events. As a result bedload stability is reduced which likely increases mortality on incubating eggs and juvenile over-winter rearing.

Confidence in conclusion

- MODERATE Conclusion is based upon relationship between general hydrologic response to watershed and in-channel conditions.

Key Findings: Obstructions to Fish Passage

Juvenile passage into oxbows, wetlands, side channels and other key habitat has been significantly reduced by isolation of these habitats from mainstem Nason Creek. Numerous culverts associated with road crossings also disrupt stream flow, possibly creating high velocity barriers during high flow events.

Confidence in conclusion

- HIGH

Summary of Limiting Factors

- Riparian/Floodplain Condition
- Channel Stability
- Habitat Diversity
- Sediment
- Elevated Temperature
- Flow
- Obstructions
- Competition (Brook Trout)

Hypothesis Statements

Elevated Temperature

Improving riparian/floodplains conditions in the assessment unit and upper tributaries will decrease summer water temperatures and will provide additional key habitat and improve habitat quality for the following focal species and life stages.

Table 54: Nason Creek hypothesis statements: elevated temperature

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Adult Summer Rearing	Moderate Moderate	High High
Coho	Adult Summer Rearing	Moderate Moderate	High High
Steelhead	Summer Rearing	Moderate	High
Bull Trout	Pre-spawning Adult	Moderate	High
Cutthroat Trout	Summer Rearing	Low (1)	Low

(1) Potentially increase life history diversity for cutthroat trout.

Riparian/Floodplain Condition

Improving and restoring riparian and floodplain habitats and functionality primarily in the lower 15 miles of the mainstem will contribute to decreased sediment delivery, decreased summer stream temperatures, an increased in-channel structural diversity and recruitment of large wood, an increase of micro-refugia during extreme flow and temperature conditions, and an increase in macro-invertebrate production. All of these contributions will increase productivity of all focal species and life stages occupying these areas by increasing key habitat quality and quantity.

Habitat Diversity

Increasing in-channel structural diversity and complexity, increasing large pool habitat and increasing the amount of side-channel habitats in the lower 15 miles of Nason Creek will increase habitat quantity and quality over a wide range of flow conditions for the following focal species and life stages.

Table 55: Nason Creek hypothesis statements: habitat diversity

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	All Life Stages	High	High
Coho	All Life Stages	High	High
Steelhead	All Life Stages	High	High
Bull Trout	Juvenile Rearing Pre-spawning Adult	Low High	Low High
Cutthroat Trout	All Life Stages	Unknown	Unknown

Channel Stability

Increasing riparian and floodplain habitat and functionality, reducing channel entrenchment and confinement and increasing in-channel structural complexity (primarily in the lower 15 miles) will improve channel (bedload) stability and will increase productivity for the following focal species and life stages.

Table 56: Nason Creek hypothesis statements: channel stability

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Egg Incubation Winter Rearing	High Moderate	High Moderate
Coho	Egg Incubation Winter Rearing	High Moderate	High Moderate
Steelhead	Egg Incubation Winter Rearing	High Moderate	High Moderate
Bull Trout	Winter Rearing	Moderate	Moderate

Fine Sediment

Decreasing fine sediment delivery and excessive accumulation in the assessment unit (primarily in the lower 15 miles) will enhance macro-invertebrate productivity and increase focal species productivity for the following species and life stages.

Table 57: Nason Creek hypothesis statements: fine sediment

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Egg Incubation	High	High
Coho	Egg Incubation	High	High
Steelhead	Egg Incubation	High	High
Bull Trout *(1)*	Egg Incubation	Moderate	High

(1) Bull Trout spawning occurs in tributary streams that are in relatively good condition.

Fish Passage

Eliminating man-made barriers to fish passage in the mainstem and tributary streams of this assessment unit will enhance life history diversity and will increase productivity for the following focal species and life stages

Table 58: Nason Creek hypothesis statements: fish passage

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Juvenile Rearing Adult	High Moderate	High Moderate
Coho	Juvenile Rearing Adult	High Moderate	High Moderate
Steelhead	Juvenile Rearing Adult	High High	High High
Bull Trout	Juvenile Rearing Adult	High High	High High
Cutthroat Trout	Juvenile Rearing Adult	High Unknown	Moderate Unknown

Competition and Predation

Control or elimination of brook trout will improve productivity and potentially life history diversity for bull trout and cutthroat trout by reducing inter-breeding, competition and predation in the upper watersheds of this assessment unit.

6.4.8 Little Wenatchee River Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

Riparian conditions in the Little Wenatchee assessment unit are in good condition with some alterations in localized areas (lower watershed). Affects to riparian resources are thought to be relatively minor at the watershed scale.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

In-stream habitat conditions and diversity are at or near pristine conditions throughout most of the Little Wenatchee assessment unit.

Habitat Diversity

Some harvest has occurred in riparian areas, contributing to lowered contribution of LWD within the channel. Some changes to width-to-depth ratios and increased sedimentation rates in low gradient sections of the lower river reaches are also noted.

Confidence in conclusion

- HIGH

Rainy Creek

According to the 1991 USFS stream survey report for Rainy Creek, visual estimates showed a high percent of embeddedness below the (fish passage) barrier falls (RM 5.5). Extensive timber harvest and road placement may result in accelerated sediment delivery to the stream.

Confidence in conclusion

- MODERATE Empirical measurements have not been made.

Key Findings: Water Quality

Water quality for the Little Wenatchee River is essentially in pristine condition.

Temperature

Although temperatures exceed state and USFS forest plan standards during the summer months, temperatures are likely at or near pristine condition.

Confidence in conclusion

- HIGH

Key Findings: Water Quantity

Flow

Water flow conditions are likely at or near pristine conditions within the White River watershed. Timber harvest in the Rainy Creek drainage may have increased peak flows due to road density, but to a minor degree.

Confidence in conclusion

- HIGH

Key Findings: Obstructions to Fish Passage

Fish passage throughout this watershed is similar to pristine conditions.

Confidence in conclusion

- HIGH

Summary of Limiting Factors

- Competition (brook trout)

Hypothesis Statements

Riparian/Floodplain Condition

Maintaining and improving riparian and floodplain habitats and functionality will maintain favorable summer stream temperatures, in-channel structural diversity and recruitment of large wood, adequate micro-refugia during extreme flow and temperature conditions and healthy macro-invertebrate production. All of these contributions will maintain productivity of all focal species and life stages occupying these areas by maintaining key habitat quality and quantity.

Competition and Predation

Control or elimination of brook trout will improve productivity and potentially life history diversity for bull trout and cutthroat trout by reducing inter-breeding, competition and predation in the upper watersheds of this assessment unit.

6.4.9 White River Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

Riparian and floodplain conditions are in good to excellent condition. The White River still has abundant, good quality, side channel and oxbow habitat in the lower reaches.

In the lower White River (from the mouth upstream to the Napeequa River confluence at RM 11.0), historic logging and land clearing has altered riparian habitat. Localized sections of the White River have been riprapped and/or active bank erosion is evident in association with roads, bridges, dispersed recreation, or other development.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

Throughout much the lower reaches of the White River (below Panther Creek) there is abundant, good quality, side channel habitat and also excellent oxbow habitat. The upper watershed remains hydrologically intact to the floodplain and is at or near pristine condition.

Habitat diversity

Channel conditions between Napeequa River and Panther Creek are altered as a result of past logging. Pool frequency in this area may be low for its channel type. Historic log drives and a large sediment pulse have contributed to this condition.

Confidence in conclusion

- MODERATE Empirical measurements have not been made.

Key Findings: Water Quality

Water quality

Water quality is considered to be at or near pristine conditions.

Confidence in conclusion

- HIGH

Key Findings: Water Quantity

Flow

Water quantity is considered to be at or near pristine conditions.

Confidence in conclusion

- HIGH

Key Findings: Obstructions to Fish Passage

Fish passage throughout this watershed is similar to pristine conditions.

Confidence in conclusion

- HIGH

Key Findings: Ecological Conditions

Summary of Limiting Factors

- Competition (brook trout)
- Riparian Floodplain Function
- Habitat Diversity

Hypothesis Statements

Riparian/Floodplain Condition

Maintaining and improving riparian and floodplain habitats and functionality will maintain favorable summer stream temperatures, in-channel structural diversity and recruitment of large wood, adequate micro-refugia during extreme flow and temperature conditions and healthy macro-invertebrate production. All of these contributions will maintain productivity of all focal species and life stages occupying these areas by maintaining key habitat quality and quantity.

Improving riparian, floodplain and in-channel conditions in the lower White River will increase key in-channel habitat quality and quantity for the following focal species and life stages.

Table 59: White River hypothesis statements: riparian/floodplain condition

Focal Species	Key Life Stages	Degree of Effect	Level of Certainty
Spring Chinook	Juvenile Rearing Pre-spawning Adult	Low Low	High High
Sockeye	Juvenile Rearing Pre-spawning Adult	Low Low	High High
Bull Trout	Juvenile Rearing Pre-spawning Adult	Low Low	High High
Cutthroat Trout	Juvenile Rearing Pre-spawning Adult	Low Low	High High

Competition and Predation

Control or elimination of brook trout will improve productivity and potentially life history diversity for bull trout and cutthroat trout by reducing inter-breeding, competition and predation in the upper watersheds of this assessment unit.

6.4.10 Chiwawa River Assessment Unit

Key Findings: Riparian Floodplain Condition and Function

Riparian and floodplain habitat conditions in the Chiwawa watershed are in good to excellent condition. Some riparian habitats have been altered in the lower reaches from road construction and rural development in the floodplain.

The Chiwawa River valley floor has an extensive high quality network of ponds, beaver canals, side channels, abandoned oxbows and other wetlands. Abundance, diversity, connectivity and quality of these wetlands are extremely high.

Confidence in conclusion

- HIGH

Key Findings: Stream Channel Conditions and Function

Streambank and in-channel conditions throughout the Chiwawa watershed are in good to excellent condition. Localized areas in the lower watershed have degraded stream banks. Overall, however, the degradation is considered relatively minor at the watershed scale.

Confidence in conclusion

- HIGH

Key Findings: Water Quality

water quality is considered to be at or near pristine condition.

Confidence in conclusion

- HIGH

Key Findings: Water Quantity

Flow

Soils are generally shallow in the Chiwawa watershed resulting in relatively low capacity for water storage and streams that rise rapidly in response to precipitation. Nevertheless, flow is well-sustained during the summer and fall months because of high altitude snow fields and glaciers.

An irrigation water diversion is located at RM 3.6. Although the diversion is for 33.3 cfs, the actual water diverted is approximately 12-16 cfs according to the Chiwawa watershed analysis (1996). This diversion is screened and can take up to 25% of the stream flow in late summer during low flow years. Potential affects to fish are thought to be low.

Confidence in conclusion

- MODERATE

Key Findings: Obstructions to Fish Passage

Fish movement throughout the Chiwawa watershed is essentially unhindered from the historic reference condition. Several culverts, though, have been identified within tributary streams that are known to limit bull trout movement. At RM 8.0 the Chelan Public Utility District operates a fish weir as part of their chinook salmon brood stock collection program. It is not yet understood if this weir significantly inhibits migration of bull trout into the Chiwawa River.

Confidence in conclusion

- HIGH

Key Findings: Ecological Conditions

Summary of Limiting Factors

- Competition (brook trout)

Hypothesis Statements

Riparian/Floodplain Condition

Maintaining and improving riparian and floodplain habitats and functionality will maintain favorable summer stream temperatures, in-channel structural diversity and recruitment of large wood, adequate micro-refugia during extreme flow and temperature conditions and healthy macro-invertebrate production. All of these contributions will maintain productivity of all focal species and life stages occupying these areas by maintaining key habitat quality and quantity.

Competition and Predation

Control or elimination of brook trout will improve productivity and potentially life history diversity for bull trout and cutthroat trout by reducing inter-breeding, competition and predation in the upper watersheds of this assessment unit.

6.4.11 Lake Wenatchee Assessment Unit

[No information to date]

6.5 Determination of Restoration Priorities

(*The following taken from the RTT Biological Strategy, 2003*.) The Wenatchee River is unique among subbasins in the upper Columbia region in that it supports the greatest diversity of populations and overall abundance of salmonids, yet is facing the greatest risk of habitat loss and degradation. There are core populations of sockeye salmon, steelhead, bull trout and both spring and late-run chinook salmon in the upper Wenatchee subbasin that are relatively strong, when compared to other populations in the Columbia basin. The current core population of coho salmon reintroduced to mid-Columbia tributaries is in the Wenatchee subbasin. The highest regional priority (Columbia Cascade Province) should be the protection of this salmonid community. The immediate strategy should be to protect the watersheds that contain these core populations so that they are robust to normal environmental disturbances, and then to expand their range to adjacent watersheds.

Priority watersheds within the Wenatchee subbasin are White River, Chiwawa River, and the upper and middle mainstem Wenatchee River (including Lake Wenatchee). These watersheds are well connected and support a diverse assemblage of native species. Efforts should be made to connect Nason Creek, Middle Mainstem Wenatchee River, and Icicle Creek to these strongholds, which would enable a fuller expression of life history strategies and increase population resilience.

Recent research indicates that the mainstem Wenatchee River provides important habitat for many life stages of spring and late-run chinook salmon, coho salmon, steelhead, and bull trout. The mainstem at this time is most vulnerable to riparian and instream habitat degradation. All remaining intact habitat on the mainstem should be maintained, and floodplain function should be restored, particularly from the Mission Creek confluence downstream to the Columbia River confluence. This could primarily be done with passive restoration. Since this reach has the highest discharge in the subbasin, the extent of riparian vegetation needed to restore flood plain function would be larger than the tributaries. Benefits of this action would be numerous to anadromous and inland salmonids, as well as a myriad of wildlife species.

Priorities in Species Distribution

Threatened, endangered and unlisted salmonids are found in most, but not all watersheds in the upper Columbia region. In order to help guide protection and restoration programs, the Regional Technical Team (RTT) identified significant sub watersheds (HUC-6 level) for spring chinook salmon, summer chinook salmon, sockeye salmon, summer steelhead, bull trout, and westslope cutthroat trout. The RTT considered a sub watershed to be significant if any one of the following criteria was met:

The sub watershed was identified as a stronghold for the species in the Interior Columbia Basin Assessment (ICBEMP 1997).

The sub watershed provides the primary spawning and/or rearing habitat within the watershed.

The sub watershed represents the only known occupied habitat within a watershed and is fairly isolated from populations in other watersheds, and thus is significant from a distribution standpoint.

The sub watershed contributes to ward the genetic integrity of a species. One of the problems facing many native fish populations is genetic introgression. Relatively pure populations, which may be very important to the evolutionary legacy of a species, may be limited. Recently genetic information has become available for some populations in the upper Columbia region. Populations judged to be “pure,” “essentially pure,” or “good” based upon genetic analysis were considered to be significant.

The sub watershed is known or strongly suspected to support a stable, strong population of a species.

Appendix C contains maps of RTT identified significant sub watersheds for sockeye salmon, spring chinook salmon, summer chinook salmon, steelhead, and bull trout. The designation of significant sub watershed does not necessarily depict the total distribution or life history stages of salmonids in the upper Columbia region. The status of some salmonid species is not fully known.

Priorities Across Varied Landscapes

The consensus of the RTT is that protection and restoration should focus first on maintaining the best remaining examples of biological integrity, connectivity, and diversity. This strategy will allow the populations to stabilize in abundance and productivity over the long term. It may be likely however, that current core populations have inadequate diversity and spatial distribution to ensure population resiliency.

To provide a framework to set priorities consistent with this strategy, the RTT classified each watershed (HUC-5 level) in the Wenatchee subbasin into four categories, based on the functionality of the aquatic ecosystems in those watersheds, and the capability of the ecosystem to protect against ecological catastrophe for endemic populations. The RTT adapted the classification system used by Quigley and Arbelbide (1997) for this report. In general, Category 1 watersheds should receive priority allocation of financial and/or management resources. Subsequent allocation of resources should be given to Categories 2 and 3, in that order, once refuge habitats (Category 1) for the target species are protected and secure. This does not mean however, that specific actions should not occur in Category 2 and 3 watersheds until all activities in Category 1 watersheds are completed. Any project within those watersheds that increase the range, life history diversity, or age cohorts of one or more species would contribute to the overall strategy of making them more robust to disturbances within and outside the region. As salmon recovery progresses, founder populations from core areas would colonize many watersheds that are suitable, yet unoccupied. Restoration of Category 4 watersheds should be considered in the regional recovery planning process, but immediate actions there would not be a priority.

Category 1

These watersheds represent systems that most closely resemble natural, fully functional aquatic ecosystems (Table 60). In general, they comprise large, often continuous blocks of high-quality habitat and sub watersheds supporting multiple populations. Connectivity among sub watersheds and through the mainstem river corridor is good, and more than two species of federally listed fish are known to occur. Exotic species may be present but are not dominant. Protecting the functioning ecosystems in these watersheds is a priority.

Category 2

These watersheds support important aquatic resources, often with sub watersheds classified as strongholds for one or more populations throughout. The most important difference between Category 1 and Category 2 is an increased level of fragmentation that has resulted from habitat disturbance or loss. These watersheds have a substantial number of sub watersheds where native populations have been lost or are at risk for a variety of reasons. At least one federally listed fish species can be found within the watershed. Connectivity among sub watersheds may still exist or could be restored within the watershed so that it is possible to maintain or rehabilitate life history patterns and dispersal. Restoring ecosystem functions and connectivity within these watersheds are priorities.

Category 3

These watersheds may still contain sub watersheds that support salmonids. In general, however, these watersheds have experienced substantial degradation and are strongly fragmented by extensive habitat loss, most notably through loss of connectivity with the mainstem corridor. At this time, there are limited opportunities for restoring full expression of life histories for multiple populations found within the watershed. The priority for funding in these watersheds should be to rectify the primary factor that is causing the habitat degradation.

Category 4

These watersheds contain both functional and non-functional habitats that historically supported populations of one or more federally listed species. Exotic species may now be dominant in one or more sub watersheds; native species are typically not present in sustainable numbers.

Table 60. Comparison of key indicators for watershed categories

Categories used to identify priority actions for protection and restoration of salmonid habitat in the upper Columbia region					
Category	**Significant Sub watersheds**	**Principle Actions**	**Habitat Fragmentation**	**Exotic Species**	**Listed Species**
1	Yes	Protection	Low	Low	Two or more
2	Yes	Protection / Restoration	Medium	Medium	One or more
3	Possible	Restoration	High	High	Possible
4	No	Restoration	High	High	Possible

Priorities in Habitat Activities

Habitat Protection

The highest priority for protecting biological productivity should be to allow unrestricted stream channel migration, complexity, and flood plain function. The principal means to meet this objective is to protect riparian habitat in Category 1 and 2 sub watersheds. Predetermined riparian protection measures (i.e., buffer strip widths) for each site may not be biologically effective. Riparian function depends on site-specific considerations including channel type, floodplain character, presence of wetlands or off-channel features, and the potential for channel migration. Obviously, some areas have more acute needs, because they may be within significant population areas, or may be at risk to habitat degradation, and should be given greater emphasis. These efforts will likely occur throughout the subbasins where properly functioning habitat remains.

Protection of existing stream flows in virtually all subbasins in the Wenatchee subbasin is important to maintaining biological productivity. Currently, the primary means to protect existing flows are regulatory in nature. Additionally, some streams may need increased flows to address chronic sources of mortality to salmonids; inadequate flows may be natural or human-caused. Diversion of water for out-of-stream uses (principally for irrigation and municipalities) is the most tangible impact to instream flow needs for fish. In addition, degradation of floodplain (and some upland) habitats exacerbates the peak and nadir of seasonal flows in all upper

Columbia subbasins; this strongly reduces the productivity and expression of diverse life histories in the region. The full effects of upland habitat degradation on peak flows in the Wenatchee subbasin are not understood and should be assessed. The means to increase flows are discussed in the section on habitat restoration.

Habitat Restoration

The highest priority for increasing biological productivity is to restore the complexity of the stream channel and floodplain. The RTT recommends a range of strategies for habitat restoration in the upper Columbia region, based on a fundamental emphasis of promoting habitat diversity, instream flows, and water quality throughout the watershed. Most of these efforts will likely be on the lower stream reaches and aggradation zones (typically areas of low stream gradient where deposition of substrate materials occurs). Restoration in these areas would benefit a broad range of species and populations.

The RTT Biological Strategy (2003) strongly recommends that structural manipulation of the stream channel (such as boulder or log placements) not be used unless (1) they are designed at the reach level or context and (2) those factors that are causing the habitat degradation cannot be corrected within a reasonable time. Remedial measures to rectify the effects of improper land use practices can have more benefits to biological productivity, may be economically more efficient, and be more permanent than measures that require active management of the stream channel. The simple alteration of physical features in the stream channel does not necessarily restore biological productivity when improper riparian or upland management practices continue to exert their effects on the aquatic ecosystem. Attempts to restore habitat are likely to fail if structures are placed in the stream channel without addressing those activities that are causing habitat degradation. For example, some short-term habitat benefits might be achieved by adding large woody debris to streams, but the benefits can only be temporary from an ecological perspective unless riparian management practices ensure the long term recruitment of LWD from the riparian zone.

In some isolated situations, restoration projects may be accomplished with both short-term and long term objectives. For example, LWD may be secured to stabilize erosive banks, allowing interim streambank protection and salmonid habitat, while passive restoration and re-vegetation will ensure proper functioning riparian conditions for the long term. We feel these projects are biologically effective when the initiation of the short-term strategy has been integrated with the long term strategy. Each active restoration project should be reviewed on a case-by-case basis.

Table 61. Categories of watersheds the Wenatchee subbasin

Categories of watersheds (HUC*-5 level) and number of significant sub watersheds (HUC-6 level) within those watersheds			
Subbasin	**Watershed**	**Category**	**Significant watersheds**
Wenatchee	Mainstem Upper Wenatchee	1	2
	Mainstem Middle Wenatchee	1	2
	Mainstem Lower Wenatchee	2	1
	White River	1	5
	Little Wenatchee River	1	5

Categories of watersheds (HUC*-5 level) and number of significant sub watersheds (HUC-6 level) within those watersheds			
Subbasin	**Watershed**	**Category**	**Significant watersheds**
	Lake Wenatchee	1	NA
	Nason Creek	2	3
	Chiwawa River	1	6
	Icicle Creek	2	4
	Chumstick Creek	3	0
	Peshastin Creek	2	3
	Mission Creek	3	3

(1) HUC – hydrologic unit code

(2) Definitions of watershed categories and Significant Sub watersheds are provided in text.

6.6 Reference Conditions

A reference condition is a benchmark from which habitat changes and/or population performance can be compared over time. The Technical Subcommittee used the Qualitative Habitat Assessment (QHA) process to define the Historic, Current and Existing Trend reference conditions. Reference conditions are described below, each are qualitative in nature but intended to provide context for identifying potential policy considerations over a relatively large time (year 2050) and geographic (subbasin) scale.

The Presumed Historic reference condition establishes the hypothetical "natural" environment. This description is based upon professional judgment, although it is important to note that there are many environments within the Wenatchee subbasin and Columbia Cascade Province that retain pristine habitat features that allow resource managers to confidently describe many historic environmental attributes. The presumed historic reference condition is described in the Qualitative Habitat Analysis in electronic appendix (see NPCC ftp site).

The Current reference condition describes existing conditions. Because habitats and populations respond to many variables, responses are described as an "average" over the past 10-years. Many of these habitat attributes were evaluated using existing information available to the Technical Subcommittee, although some attributes remain un-surveyed and are not documented. The Current reference condition is described in the Qualitative Habitat Analysis in electronic appendix (see NPCC ftp site).

There are two future reference conditions; the Optimal (or Desired Future Condition) and the Existing Trend. Each of these future conditions projects to the year 2050. The Optimal reference condition (with regards to fish and wildlife habitat and population attributes) anticipates that substantial resources are available for fish and wildlife habitat and propagation improvements over a sustained time period. The Optimal reference condition is synonymous with biological and environmental conditions stated in the Habitat and Biological Objectives, as identified in Section 7, Management Plan.

The Existing Trend reference condition anticipates a relatively constant pattern in urban/rural development and fish/wildlife funding levels (as compared to the last 10-years) to maintain and/or enhance fish and wildlife resources. The Technical Subcommittee examined general trend in land use. From these discussions, the following general statements can be derived:

Environmental conditions for focal species on lands under public management are generally improving, particularly for floodplain/riparian areas and in-channel (stream) management. Environmental conditions in the upper watersheds of Mission, Peshastin and Chumstick creeks are likely to improve significantly over existing conditions as large-scale natural disturbance regimes are being managed to mimic a more natural range of environmental variability. Improvements in road management will also contribute to improved environmental function and health.

Rural, agricultural and urban developments within the subbasin are expected to continue growing through time. Development will probably be most acute throughout the lower portions of the Wenatchee River, Mission Creek, Chumstick Creek. To a lesser degree development is also expected to occur in lower Icicle Creek, Nason Creek the Chiwawa River and areas surrounding Lake Wenatchee. These areas have key environmental attributes that long term viability of anadromous salmonid productivity will be dependent upon . Because these areas are some of the most sensitive within the subbasin (in terms of critical salmonid habitats) a relatively high potential exists that habitat conditions for these species may be degraded over time. As riparian and floodplain areas are developed, there is a tendency for land owners to protect investments. Typically this results in riparian simplification, bank hardening or armoring (dikes) and stream channel confinement. As habitat modifications occur, geo-fluvial processes and function will be disrupted. Habitat attributes most likely affected will include, but are not limited to lost riparian/floodplain vegetation and connectivity to the mainstem streams, lost side-and off-channel habitats, stream down-cutting (entrenchment) and channel destabilization, lost habitat diversity and lost carrying capacity for most focal species life stages.

Focal fish species responses have been estimated for each of the reference conditions. These estimates are qualitative and meant more to indicate trend rather than an absolute value. The reader should note the difficulty involved in separating out-of-basin effects from those within basin. This evaluation assumes effects within the Wenatchee subbasin.

The following discussion summarizes the key assumptions and estimated affects to focal species for each of the reference conditions.

6.6.1 Spring Chinook

Assumptions: Spring chinook were widely distributed throughout much of the subbasin. Distribution has been reduced somewhat, primarily in Peshastin Creek, and possibly in Chumstick and Mission creeks but to a lesser degree. Past developments have reduced habitat quality and quantity. Future developments will continue this trend, and key habitats may not be adequately protected under existing land use regulations. Integrated hatchery production should aid population abundance if implemented correctly. There are significant opportunities to maintain, improve and create additional habitat in the long term although much of this work would be relatively costly.

Table 62. Summary of estimated spring chinook population responses to reference conditions.

	Spatial Distribution	Population Abundance	Biological Productivity	Life History Diversity
Historic	High	Moderate-High	Moderate	High
Current	Moderate-High	Low-Moderate	Low-Moderate	Moderate
Existing Trend	Moderate	Moderate	Low-Moderate	Moderate
Optimal	High	Moderate-High	Moderate-High	Moderate-High

6.6.2 Late-run Chinook

Distribution of late-run chinook is contained within the mainstem of the Wenatchee River and lower Icicle Creek and remains similar to historic conditions. Changes in habitat conditions throughout the system have reduced habitat quality and quantity thereby reducing life history diversity, population abundance and productivity. Future trends are not expected to significantly improve existing biological parameters and potential degradation of conditions could occur above Tumwater Canyon with additional development and alteration of riparian areas. Future habitat enhancements could increase these parameters to a relatively high level.

Table 63. Summary of estimated late-run chinook population responses to reference conditions.

Late-run Chinook	Spatial Distribution	Population Abundance	Biological Productivity	Life History Diversity
Historic	Moderate	Very High	Very High	High
Current	Moderate	Moderate-High	High	Moderate-High
Existing Trend	Moderate	Moderate-High	High	Moderate-High
Optimal	Moderate	High	Very High	High

6.6.3 Sockeye

Biological parameters for sockeye have decreased since historic reference conditions primarily related to out-of-basin effects. Habitat degradation above Lake Wenatchee may have decreased abundance of egg and fry life stages. Degradation below Lake Wenatchee has reduced juvenile spatial distribution and life history diversity (Nason Creek). Maintaining key in-basin habitat conditions, implementing envisioned future habitat improvements and reduced mortality out-of-basin will likely increase all biological parameters.

Table 64. Summary of estimated sockeye population responses to reference conditions.

Sockeye Salmon	Spatial Distribution	Population Abundance	Biological Productivity	Life History Diversity
Historic	Moderate	High	Moderate-High	Moderate-High
Current	Moderate	Moderate	Moderate	Moderate
Existing Trend	Moderate	Moderate	Moderate	Moderate
Optimal	Moderate-High	Very High	Moderate-High	Moderate-High

6.6.4 Coho

Existing feasibility efforts to re-introduce coho appear promising but results are difficult to measure at this early point. Continuation of artificial production efforts will likely continue to increase all biological parameters, especially if brood stock selection techniques can develop a more genetically suitable stock for this subbasin. Improvements in habitat conditions in the mainstem Wenatchee River, in lower Nason, Mission and Chumstick creeks, and to a lesser degree Icicle Creek is needed to provide for increases in biological parameters and achievement of a long term self-sustainable population.

Table 65. Summary of estimated coho population responses to reference conditions.

Coho Salmon	Spatial Distribution	Population Abundance	Biological Productivity	Life History Diversity
Historic	Moderate-High	Unknown	Unknown	Moderate-High
Current	Low-Moderate	Low	Low-Moderate	Low
Existing Trend	Moderate	Moderate	Moderate	Moderate
Optimal	Moderate-High	Moderate-High	Moderate-High	Moderate-High

6.6.5 Steelhead

Assumptions: Steelhead were and continue to be widely distributed throughout much of the subbasin. Past developments have reduced habitat quality and quantity, thereby decreasing abundance and productivity. Future developments will continue this trend, and key habitats in the lower portions of most Assessment Units may not be adequately protected under existing land use regulations. Key habitats in the upper watersheds are likely to remain protected habitat conditions will continue to improve. There are significant opportunities to improve and create additional habitat in the long term. Much of this work would be relatively costly. Providing additional fish passage will increase each of the biological parameters.

Table 66. Summary of estimated steelhead trout population responses to reference conditions.

Steelhead Trout	Spatial Distribution	Population Abundance	Biological Productivity	Life History Diversity
Historic	High	High	Moderate-High	High
Current	Moderate-High	Low	Low	Moderate
Existing Trend	Moderate	Moderate-Low	Moderate-Low	Moderate
Optimal	High	Moderate-High	Moderate-High	High

6.6.6 Bull Trout

Biological parameters for bull trout have all been degraded from the Presumed Historic reference condition. Changes in habitat conditions, in-basin harvest and obstructions to fish passage have significantly reduced these parameters. Recent changes in many management practices have reversed this trend. Future management trends in the upper watersheds will likely allow an increase to all parameters, especially if passage is restored to higher elevation streams and competition with brook trout can be reduced or eliminated.

Table 67. Summary of estimated bull trout population responses to reference conditions.

Bull Trout	Spatial Distribution	Population Abundance	Biological Productivity	Life History Diversity
Historic	High	Moderate-High	Moderate	High
Current	Moderate-High	Low-Moderate	Low-Moderate	Moderate
Existing Trend	Moderate-High	Moderate	Moderate	Moderate-High
Optimal	High	Moderate-High	Moderate	High

6.6.7 Westslope Cutthroat Trout

Westslope cutthroat trout were introduced into areas that were not inhabited in the Presumed Historic reference condition, thereby increasing spatial and life history diversity. As a result abundance is assumed to also have increased. Cutthroat trout inhabit high elevation streams that are essentially pristine in condition. It is likely that these conditions will remain stable or improve (locally) somewhat over time. Productivity and abundance are likely to increase with improvements in water temperature, improvements in fish passage and implementation of a brook trout control or elimination program.

Table 68. Summary of estimated westslope cutthroat trout population responses to reference conditions.

Cutthroat Trout	Spatial Distribution	Population Abundance	Biological Productivity	Life History Diversity
Historic	Moderate	Low	Low-Moderate	Moderate
Current	Moderate-High	Low-Moderate	Low-Moderate	Moderate-High
Existing Trend	Moderate-High	Low-Moderate	Low-Moderate	Moderate-High
Optimal	Moderate-High	Moderate	Moderate	Moderate-High

6.6.8 Pacific Lamprey

Very little is known about Pacific Lamprey population abundance and distribution in the Wenatchee subbasin. Pacific Lamprey do require good water quality and relatively clean substrates to exist. There is essentially no information about habitat preference or suitability within the subbasin streams. The following summary is projected primarily from an academic understanding of this species.

Table 69. Summary of estimated Pacific lamprey population responses to reference conditions.

Cutthroat Trout	Spatial Distribution	Population Abundance	Biological Productivity	Life History Diversity
Historic	High	Higher than present	Higher than present	Higher than present
Current	Unknown	Unknown	Unknown	Unknown
Existing Trend	Unknown	Unknown	Unknown	Unknown
Optimal	High	High	High	High

7 Management Plan

7.1 Vision for the Subbasin

The vision of the Wenatchee subbasin plan is to voluntarily bring people together in a collaborative setting to improve communication, reduce conflicts, address problems, reach consensus and implement actions to improve coordinated natural resource management on private and public lands in the Wenatchee subbasin. The strategy is to complete a science-based watershed management plan using watershed specific information ultimately leading towards compliance with the federal Endangered Species Act (ESA) and Clean Water Act (CWA). End products will reflect a balance between existing natural resources and human uses, and will capitalize on opportunities to improve these values.

Specific goals to advance this vision under the Watershed Planning Act (WPA) are as follows:

- Optimize quantity and quality of water to achieve a balance between natural resources and human use, both current and projected
- Provide for coexistence of people, fish and wildlife while sustaining lifestyles through planned community growth, and maintaining and/or improving habitats
- Prevent avoidable human-caused mortality of state and federal threatened, endangered and candidate species
- Develop and implement an adaptive action plan to address priority issues, emphasizing local customs, and culture and economic stability in balance with natural resources. All actions will comply with existing laws and regulations, however, changes to existing laws and regulations will be recommended as needed to attain the common vision and avoid one-size-fits-all solutions.
- Recognize the significance of the roles of limiting factors outside of the watershed and natural events within the watershed. The long term goal is to have the Wenatchee River's existing and future habitats contribute to the recovery of listed species and to eventually provide harvestable and sustainable populations of fish and other aquatic resources.
- Since 1993, landowner members of the CRMP Group/EWPU have insisted that good science be applied to the collection and interpretation of information for all resource elements of concern. Landowners hope that through the continued use of good science, the mission and goals of the group will be met and with landowner cooperation during implementation, regulating agencies may not find it necessary to apply one-size-fits-all regulations to achieve their management objectives for the Wenatchee subbasin (CCCD 2004).
- Wildlife and fisheries vision for the Wenatchee subbasin is to have natural habitats with sufficient quantity, quality, and linkages to perpetuate existing native wildlife and fish populations into the foreseeable future. Furthermore, the vision is to restore extirpated wildlife and fisheries through protection and restoration of the subbasin where sufficient habitat exists.

7.2 Purpose and Scope

The Management Plan integrates the vision for the Wenatchee subbasin with the Assessment (Section 4) and Inventory (Section 5). The vision and goals were crafted by the Wenatchee Planning Unit (WPU) and are incorporated into the Wenatchee subbasin plan. The vision and goals also drive for the selection of objectives and strategies for restoration of fish and wildlife habitat and populations, which form the bulk of the management plan.

The scope of the management plan is somewhat narrower than the scope of the assessment or the inventory. The assessment and inventory are designed to guide restoration and management actions by many parties under their own authorities in the course of ongoing efforts to protect and enhance the fish and wildlife populations and the aquatic and terrestrial ecosystems that exist within the Wenatchee subbasin. The management plan is based on the assessment and inventory, but is specifically designed to act as a draft amendment to the Columbia Basin Fish and Wildlife Program, and to be reviewed and approved by the Northwest Power and Conservation Council (NPCC).

The management plan describes the most effective ways that NPCC and Bonneville Power Administration (BPA) can use funding resources to meet obligations in the Wenatchee subbasin for protection and mitigation of resources that have been affected by the construction and operation of the Federal Columbia River Power System (FCRPS). As such, the management plan is non-regulatory in nature and contingent on BPA ratepayer funds to construct or improve existing infrastructure, acquire land or protective easements as a means of habitat protection, fund personnel to improve management of natural resources, monitor and research the relationships between management actions and the health of the resource, and fund other actions that protect or restore the health of natural resources that have been negatively impacted by the FCRPS.

7.2.1 Overarching Principles

The Wenatchee subbasin has a long history of citizen participation in resource management efforts. The WPU recognizes the close connection between community well-being and watershed conditions, and as a result a set of basic principles regarding the past, present and future of Subbasin became clear during this planning process. The WPU therefore acknowledges the following overarching principles:

- Continued community participation and involvement with the Wenatchee WPU is necessary to ensure its future success and achievement of the group's vision and goals
- Future projects proposed in the subbasin need to be communicated to and coordinated with the Chelan County Conservation District (CCCD) and Wenatchee WPU in order to reduce duplication of effort and assure compatibility with this strategic plan
- Monitoring and continual feedback are key to the design of future projects and tracking progress towardss the achievement of desired results
- Surface and ground water in the subbasin have a high degree of connectivity; therefore surface and ground water in the watershed should be treated as one source for all water quality, water quantity, habitat and instream flow actions

7.3 Subbasin Planning Guidelines

The natural environment including its fish and wildlife resources is society's common cultural heritage. The WPU's mission and goals is to prepare and implement a balanced plan of action that play a key role in the long term sustainability of the natural resources within the Wenatchee subbasin.

The quality of water, near natural timing, and quantity of water flow (normative hydrograph) are principle indicators of a healthy river ecosystem. These indicators must be improved and monitored to measure the progress of the subbasin plan.

The Wenatchee subbasin management plan enhances Native Americans' continued exercise of treaty reserved and aboriginal rights for religious, subsistence, commercial, and recreational use of cultural (natural) resources.

The Wenatchee subbasin management plan is based on voluntary incentives.

The processes of plan preparation, implementation, and amendment, must be open to the public and equitable to all stakeholders.

The costs of plan actions must be estimated in relation to benefits. Alternatives that achieve the highest benefit/cost ratio are preferred. Costs of habitat/species restoration should be mitigated and distributed equitably.

The science, strategies, and art of restoring ecosystems is evolving, hence programs and actions must be monitored and evaluated for effect, and may be altered as necessary.

Balanced sustainable resources management recognizes these basic precepts: a)that the physical and biological environments are functionally interdependent relative to productivity, b)that at any level of function, productivity is finite; c)without actions to restore degraded functions and to protect, avoid, and mitigate impacts to the physical and biological environment, the increasing demands of human population growth would reduce productivity to zero, with unacceptable costs to the cultures and economies of the subbasin.

7.4 Subbasin Management Plan Goals

7.4.1 Wildlife/Terrestrial Biological Goals, Objectives, and Strategies

Riparian Wetlands

Goal

- Provide sufficient quantity and quality riparian wetlands to support the diversity of wildlife as represented by sustainable focal species populations

Habitat Objective 1

- Determine the necessary amount, quality, and connectivity of riparian wetlands by the year 2008

Strategy: Select and implement methodology, alternative to IBIS or GAP, to accurately characterize riparian wetlands habitats in the Wenatchee subbasin

Habitat Objective 2

- Based on findings of Habitat Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010

Strategy: Utilize federal, state, tribal, and local government programs, to conserve riparian wetlands habitat

Strategy: Achieve permanent protection of riparian wetlands through acquisition, conservation easement, cooperative agreements, etc

Strategy: Emphasize conservation connectivity of high-quality riparian wetlands habitat

Strategy: Promote local planning and zoning to maintain or enhance riparian wetlands habitat

Habitat Objective 3

- Enhance beaver (Castor canadensis) habitat where appropriate to increase the quantity and quality of riparian wetlands for focal species by 2009

Strategy: Determine the number and location of active and inactive beaver lodges and dams in the subbasin

Strategy: Using GIS and aerial photos identify and quantify occupied, unoccupied, and potential beaver habitat

Strategy: Identify areas where beaver habitat can be enhanced, beginning with areas lower in the watershed where beaver dams can create more extensive wetlands

Strategy: Enhance beaver habitat within 100 m of riparian areas by thinning specific areas of dense conifers and by planting hardwood succors for forage (e.g. cottonwood and aspen)

Strategy: Reintroduce beaver into suitable unoccupied habitat where natural recolonization is less likely

Strategy: Work closely with landowners, orchardists, public land managers, and local and state transportation departments to reduce damages caused by beaver

Strategy: Through state harvest restrictions, protect beaver populations at a level sufficient to allow natural and reintroduced beaver populations to perpetuate

Habitat Objective 4

- Enhance beaver populations to benefit habitat for threatened/endangered fish species

Strategy: Identify positive and negative aspects of beaver on fish species

Strategy: Determine suitable sites where beaver could help increase and restore habitat for juvenile and adult populations of fish

Strategy: Reintroduce beaver into suitable unoccupied habitat where natural recolonization may not occur

Habitat Objective 5

- Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silviculture and agricultural practices, fire management, weed control, livestock grazing practices, and road construction and maintenance on and adjacent to existing riparian wetlands

Strategy: Implement habitat stewardship projects with private landowners

Strategy: Develop fire management protocols (protection and prescribed burning) to produce desired riparian wetlands habitat conditions

Strategy: Wenatchee National Forest plan, Chelan County Watershed Mgt Plan, North Cascades National Park General Management Plan, WDFW Wildlife Area Management Plan, Colville Tribes Integrated Resource Management Plan

Strategy: Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan

Strategy: Develop and implement a coordinated, cross-jurisdictional road management plan

Biological Objective 1

- Determine population status of red-eyed vireo (*Vireo olivaceous*) and yellow-breasted chat by 2008

Strategy: Select survey protocol and measure abundance of focal species

Strategy: Select survey protocol and measure diversity and richness of species assemblages within riparian wetland habitats

Biological Objective 2

- Within the framework of the focal species population status determinations, inventory other riparian wetlands obligate populations to test assumption of the umbrella species concept for conservation of other riparian wetlands obligates

Strategy: Implement federal, state, tribal management and recovery plans

Shrubsteppe

Goal

- Provide sufficient quantity and quality shrubsteppe habitat to support the diversity of wildlife as represented by sustainable focal species populations

Habitat Objective 1

- Determine the necessary amount, quality, and juxtaposition of shrubsteppe by the year 2008

Strategy: Select and implement methodology, alternative to IBIS or GAP, to accurately characterize shrubsteppe habitat in the Wenatchee subbasin

Habitat Objective 2

- Based on findings of Objective 1, identify and provide biological and social conservation measures to sustain focal species populations and habitats by 2010

Strategy: Utilize federal, state, tribal, and local government programs, such as USDA Farm Bill programs, to conserve shrubsteppe habitat

Strategy: Achieve permanent protection of shrubsteppe through acquisition, conservation easement, cooperative agreements, etc

Strategy: Emphasize conservation of large blocks and connectivity of high quality shrubsteppe habitat

Strategy: Promote local planning and zoning to maintain or enhance large blocks of habitat

Habitat Objective 3

- Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving agricultural practices, fire management, weed control, livestock grazing practices, and road management on existing shrubsteppe

Strategy: Implement habitat stewardship projects with private landowners

Strategy: Develop fire management protocols (protection and prescribed burning) to produce desired shrubsteppe habitat conditions

Strategy: Consider and integrate the following plans for the Subbasin: Wenatchee National Forest Plan, Chelan County Watershed Mgt Plan, North Cascades National Park General Management Plan, Washington Department of Fish and Wildlife (WDFW) Wildlife Area Management Plan, Colville Tribes Integrated Resource Management Plan

Strategy: Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan

Strategy: Develop and implement a coordinated, cross-jurisdictional road management plan

Biological Objective 1

- Determine population status of Brewer’s sparrow by 2008

Strategy: Select survey protocol and measure abundance of focal species

Strategy: Select survey protocol and measure diversity and richness of species assemblages within shrubsteppe

Biological Objective 2

- Within the framework of the Brewer’s sparrow population status determination, inventory other shrubsteppe obligate populations to test assumption of the umbrella species concept for conservation of other shrubsteppe obligates

Strategy: Implement federal, state, tribal management and recovery plans

Biological Objective 3

- Maintain and enhance mule deer populations consistent with state/tribal herd management objectives

Strategy: Implement state and tribal mule deer management plans

Strategy: Ensure mule deer habitat needs are met on federal, state, and tribal managed lands during land use planning

Strategy: Conserve and enhance winter range habitat for mule deer

Strategy: Replant shrub forage species that were eliminated/reduced due to wildfire

Strategy: Maintain mule deer populations within private landowner tolerances

Strategy: Reduce mortality of mule deer from vehicle collisions

Ponderosa Pine

Goal

- Provide sufficient quantity and quality ponderosa pine habitats to support the diversity of wildlife as represented by sustainable focal species populations

Habitat Objective 1

- Determine the necessary amount, quality, and juxtaposition of ponderosa pine habitats by the year 2008

Strategy: Select and implement methodology, alternative to IBIS or GAP, to accurately characterize ponderosa pine habitat in the Wenatchee subbasin

Habitat Objective 2

- Based on findings of Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010

Strategy: Utilize federal, state, tribal, and local government programs, to conserve ponderosa pine habitat

Strategy: Achieve permanent protection of ponderosa pine through acquisition, conservation easement, cooperative agreements, etc

Strategy: Emphasize conservation of large blocks and connectivity of high quality ponderosa pine habitat

Strategy: Promote local planning and zoning to maintain or enhance large blocks of habitat

Habitat Objective 3

- Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silvicultural practices, fire management, weed control, livestock grazing practices, and road management in existing and restored ponderosa pine habitat

Strategy: Implement habitat stewardship projects with private landowners

Strategy: Develop fire management protocols (protection and prescribed burning) to produce desired ponderosa pine habitat conditions

Strategy: Wenatchee National Forest plan, Chelan County Watershed Mgt Plan, North Cascades National Park General Management Plan, WDFW Wildlife Area Management Plan, Colville Tribes Integrated Resource Management Plan

Strategy: Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan

Strategy: Develop and implement a coordinated, cross-jurisdictional road management plan

Biological Objective 1

- Determine population status of white-headed woodpecker, flammulated owl, and pygmy nuthatch by 2008

Strategy: Select survey protocol and measure abundance of focal species

Strategy: Select survey protocol and measure diversity and richness of species assemblages within ponderosa pine

Biological Objective 2

- Within the framework of the focal species population status determinations, inventory other ponderosa pine obligate populations to test assumption of the umbrella species concept for conservation of other ponderosa pine obligates

Strategy: Implement federal, state, tribal management, and recovery plans

7.5 Wildlife Research, Monitoring and Evaluation Plan

The Research, Monitoring, and Evaluation (RME) plan for the subbasin is intended as a tool that will allow managers to evaluate the efficacy of employed strategies in achieving corresponding focal habitat objectives for the subbasin. If implemented, elements of the plan will also facilitate coordination and tracking of management activities within the subbasin, periodic review of progress, and a basis for recommended adjustments to management direction over time (adaptive management).

The RME plan, as presented, consists of a variety of quantitative elements, ranging from scientific wildlife and vegetation surveys, spacial analyses of project location and acreage, to simple enumeration of land-use projects/regulations commented upon by cooperating agencies.

Implementation of the subbasin plans is ultimately the responsibility of all managers and stakeholders who participated in its development. It is recommended that this group form an Implementation Oversight Committee, to track and guide research, monitoring and reporting activities included in the plan. Organization of the RME plan is as follows:

7.5.1 Research

- Research needs, with justification, are also listed. Detailed research project design is not presented, however, being beyond the scope of the current planning effort

- Existing data gaps, as identified through the subbasin planning process, are listed in this section, because many will require effort above routine monitoring and evaluation to address

7.5.2 Monitoring and Evaluation

- Focal habitat monitoring methodology, and management plan strategies addressed
- Focal species monitoring methodology, and management plan strategies addressed

Existing Date Gaps and Research Needs

In the course of subbasin plan development, a number of data gaps were identified. Some of these gaps will be filled as data is collected via the monitoring and evaluation process as the plan is implemented. Others will require formal research efforts to address. Data gaps and research needs identified during development of the subbasin plan are listed in Table 70.

As part of the adaptive management philosophy of subbasin planning, managers believe that additional research needs not yet identified will become apparent over time. These needs will be addressed in future subbasin plan iterations.

Table 70. Data gaps and research needs in the Wenatchee subbasin

RESEARCH NEEDS AND DATA GAPS	STRATEGY TO ADDRESS	AGENCY/ PERSONNEL
GENERAL		
Testing of assumption that focal habitats are functional if a focal species assemblage's recommended management conditions are achieved		Coordinated government & NGO effort
Testing of assumption that selected species assemblages adequately represent focal habitats		Coordinated government & NGO effort
Current, broad-scale habitat data	Spatial data collection and GIS analysis	Coordinated government & NGO effort
RIPARIAN WETLANDS		
Research Needs, recommended priority order		
Refinement of recommended management conditions for Riparian Wetlands	Research need; use for update to future subbasin plan iterations	Coordinated government & NGO effort.
Data are needed on all aspects of red-eyed vireo, yellow-breasted chat and beaver ecology in the subbasin.		Coordinated government & NGO effort
Data Gaps		

RESEARCH NEEDS AND DATA GAPS	STRATEGY TO ADDRESS	AGENCY/ PERSONNEL
Accurate habitat type maps are needed to improve assessment quality and support management strategies and actions, including, updated and fine resolution historic/current riparian wetland data and GIS products e.g., structural conditions and KEC ground-truthed maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Riparian habitat quality data. Assessment data do not address habitat quality.	Monitoring activities	Subbasin managers
Refined habitat type maps	Spatial data collection and GIS analysis	Subbasin managers
Model for predicting suitable heaver habitat	Habitat data collection at active beaver colonies	WDFW
Knowledge of where beaver dams/wetlands could enhance endangered/threatened wildlife and fish species	GIS analysis	WDFW
GIS soils products including wetland delineations	Spatial data collection and GIS analysis	Subbasin managers
Local population/distribution data for red-eyed vireo, yellow-breasted chat	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
PONDEROSA PINE		
Research Needs, recommended priority order		
Assess the historic and current winter range for mule deer in the Subbasin		Coordinated government & NGO effort
Data are needed on all aspects of white-headed woodpecker nesting ecology and habitat use within the Wenatchee subbasin		Coordinated government & NGO effort
Data are needed on all aspects of pygmy nuthatch nesting ecology and habitat use within the Wenatchee subbasin		Coordinated government & NGO effort
Data are needed on all aspects of flammulated owl nesting ecology and habitat use, specifically related to the size, configuration, and abundance of grassy openings for foraging and clumped thickets of sapling/pole trees for roosting		Coordinated government & NGO effort
Research to determine if restored sites attract white-headed woodpeckers and provide viable habitat, to include recommendations on effective treatment conditions		Coordinated government & NGO effort
Research to determine if restored sites attract pygmy nuthatches and provide viable habitat, to include recommendations on effective treatment conditions		Coordinated government & NGO effort
Research to determine whether an intensively harvested landscape that meets snag and large tree objectives support viable white-headed woodpecker populations		Coordinated government & NGO effort

RESEARCH NEEDS AND DATA GAPS	STRATEGY TO ADDRESS	AGENCY/ PERSONNEL
Research to determine whether a managed site attracts flammulated owls and provides viable habitat. Identification of the most effective treatment processes and conditions most effective.		Coordinated government & NGO effort
Data Gaps		
Refinement of recommended management conditions for Ponderosa pine: collect current ponderosa pine structural condition/habitat variable data	Management Objective for Ponderosa pine	Subbasin managers
Accurate habitat type maps are needed to improve assessment quality and support management strategies and actions, including, updated and fine resolution historic/current ponderosa pine data and GIS products e.g., structural conditions and KEC ground-truthed maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Habitat quality data. Assessment data do not address habitat quality.	Coordinated, standardized monitoring efforts); Spatial data collection and GIS analysis	Subbasin managers
Finer resolution GIS habitat type maps that include structural component and KEC data.	Coordinated, standardized monitoring efforts); Spatial data collection and GIS analysis	Subbasin managers
GIS soils products	Spatial data collection and GIS analysis	Subbasin managers
Identify current distribution and population levels of white-headed woodpeckers, pygmy nuthatches and flammulated owls	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Identify current and potential areas of high quality flammulated owl habitat (short-term strategy i.e., <2 years).	Habitat Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Monitor white-headed woodpecker, pygmy nuthatch and flammulated owl distributions within the Wenatchee subbasin, to determine current distributions, population levels and population trends	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
SHRUBSTEPPE		
Research Needs, recommended priority order		
Data are needed on all aspects of Brewer's sparrow nesting ecology, especially area requirements to maintain populations		WDFW, Subbasin managers
Data are needed on all aspects of Brewer's sparrow nesting ecology, particularly relationship to livestock grazing and pesticide use		WDFW, Subbasin managers
An assessment of the viability of small populations of Brewer's sparrow in fragments of habitat versus those in large contiguous blocks		WDFW, Subbasin managers
Data Gaps		

RESEARCH NEEDS AND DATA GAPS	STRATEGY TO ADDRESS	AGENCY/ PERSONNEL
Accurate habitat type maps are needed to improve assessment quality and support management strategies and actions, including, updated and fine resolution historic/current shrubsteppe data and GIS products e.g., structural conditions and KEC ground-truthed maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Habitat quality data. Assessment data bases do not address habitat quality	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Refined habitat type maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
GIS soils products, including wetland delineations	Spatial data collection and GIS analysis	Subbasin managers
Local population/distribution distribution for Brewer's sparrow	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Monitor Brewer's sparrow distribution within the Wenatchee subbasin, to determine current distribution, population level and population trends	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Evaluate the role of fire, mowing, and other management treatments to maintain/improve shrubsteppe habitat quality	Coordinated, standardized monitoring efforts	Subbasin managers

Monitoring and Evaluation: Focal Habitat and Species Monitoring Methodology

Recommended monitoring and evaluation strategies contained below for each focal habitat type, including sampling and data analysis and storage, are derived from national standards established by Partners in Flight for avian species (Ralph et al, 1993, 1995) and habitat monitoring (Nott et al, 2003). Deer and elk sampling methodology follow standard protocols established by the WDFW (pers. comm., P. Fowler, WDFW). In addition, protocols for specific vegetation monitoring/sampling methodologies are drawn from USDA Habitat Evaluation Procedure (HEP) standards (USFWS 1980a and 1980b). A common thread in the monitoring strategies which follow is the establishment of permanent census stations to monitor bird population and habitat changes.

Wildlife managers will include statically rigorous sampling methods to establish links between habitat enhancement prescriptions, changes in habitat conditions, and target wildlife population responses.

Specific methodology for selection of Monitoring and Evaluation (M&E) sites within all focal habitat types follows a probabilistic (statistical) sampling procedure, allowing for statistical inferences to be made within the area of interest. The following protocols describe how M&E

sites will be selected (from WDFW response to ISRP http://www.cbf wa.org/files/province/cascade/projects/199609400resp.pdf):

- Vegetation/HEP monitoring and evaluation sites are selected by combining stratified random sampling elements with systematic sampling. Project sites are stratified by cover types (strata) to provide homogeneity within strata, which tends to reduce the standard error, allows for use of different sampling techniques between strata, improves precision, and allows for optimal allocation of sampling effort resulting in possible cost savings (Block et al. 2001). Macro cover types such as shrubsteppe and forest are further sub-cover typed based on dominant vegetation features i.e., percent shrub cover, percent tree cover, and/or deciduous versus evergreen shrubs and conifer versus deciduous forest. Cover type designations and maps are validated prior to conducting surveys in order to reduce sampling inaccuracies.

- Pilot studies are conducted to estimate the sample size needed for a 95% confidence level with a 10% tolerable error level (Avery 1975) and to determine the most appropriate sampling unit for the habitat variable of interest (BLM 1998). In addition, a power analysis is conducted on pilot study data (and periodically throughout data collection) to ensure that sample sizes are sufficient to identify a minimal detectable change of 20% in the variable of interest with a Type I error rate # 0.10 and P = 0.9 (BLM 1998, Hintze 1999, Block et al. 2001). M&E includes habitat trend condition monitoring on the landscape scale (Tier 1-HEP) and plant community monitoring (Tier 2) i.e., measuring changes in vegetative communities on specific sites.

- For HEP surveys, specific transect locations within strata are determined by placing a Universal Transverse Mercator (UTM) grid over the study area (strata) and randomly selecting X and Y coordinates to designate transect start points. Random transect azimuths are chosen from a computer generated random number program, or from a standard random number table. Data points and micro plots are systematically placed along the line intercept transect at assigned intervals as described in Part 2 – monitoring section of the proposal. Sample sizes for statistical inferences are determined by replication and systematic placement of lines of intercept within the strata with sufficient distance between the lines to assume independence and to provide uniform coverage over the study site.

- Permanent vegetation monitoring transect locations are determined by placing a UTM grid over the strata and randomly selecting X and Y coordinates to designate plot locations as described for HEP surveys. One hundred meter baseline transect azimuths are randomly selected from a random numbers table. Ten perpendicular 30 meter transects are established at 10 meter intervals along the baseline transect to form a 100m x 30m rectangle (sample unit). Micro plot and shrub intercept data are collected at systematic intervals on the perpendicular transects.

- By systematically collecting and analyzing plant species frequency, abundance, density, height, and percent cover data, vegetative trends through time can be described. Likewise, the effectiveness of exotic weed control methods can be evaluated and weed control plans can be adjusted accordingly.

- Presence of all exotic weeds i.e., knapweeds, yellow starthistle, etc. will be mapped in GIS using Global Positioning System (GPS) equipment. This information will be used to develop an annual exotic vegetation control plan.
- Causes of seeding or planting failure will be identified and planting methods/site preparation will be modified as necessary. Data will be collected and analyzed, and, where necessary, changes in the management plan (adaptive management) will be identified and implemented.
- General and site specific M&E protocols, outlining monitoring goals and objectives and specific sampling designs are included in the following monitoring section.
- In addition to defining habitat and species population trends, monitoring will also be used to determine if management actions have been carried out as planned (implementation monitoring). In addition to monitoring plan implementation, monitoring results will be evaluated to determine if management actions are achieving desired goals and objectives (effectiveness monitoring) and to provide evidence supporting the continuation of proposed management actions. Areas planted to native shrubs/trees and/or seeded to herbaceous cover will be monitored each year to determine shrub/seeding survival, and causes of shrub mortality and seeding failure i.e. depredation, climatic impacts, poor site conditions, poor seed/shrub sources.
- Monitoring of habitat attributes and focal species in this manner will provide a standardized means of tracking progress towards conservation, not only within the Wenatchee subbasin. Monitoring will provide essential feedback for demonstrating adequacy of conservation efforts on the ground, and guide the adaptive management component that is inherent in the subbasin planning process.

7.6 Wildlife Monitoring and Evaluation

7.6.1 Riparian Wetlands

Focal Species: Red-eyed vireo, yellow-breasted chat (*Icteria virens*), and American beaver (*Castor canadensis*)

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed Riparian Wetland sites to monitor focal species population and habitat changes and evaluate success of efforts.

Overall Habitat and Species Monitoring Strategy: Establish permanent censusing stations to monitor bird population and habitat changes.

Focal Habitat Monitoring:

Factors affecting habitat: 1)direct loss of riparian deciduous and shrub understory, 2)fragmentation of wetland habitat, 3) flooding and de watering of areas by beaver, 4)agricultural and sub-urban development and disturbance, 5)reduction in water quality, 6)organochlorines such as dieldrin or DDE may cause thinning in egg shells which results in reproductive failure (Graber et al. 1978; Ohlendorf et. al. 1980; Konermann et. al. 1978) (Sec. 5.2.3.3.6).

Riparian Wetlands Working Hypothesis Statement: The proximate or major factors affecting this focal habitat type are direct loss of habitat due primarily to urban/agricultural development; reduction of habitat diversity and function resulting from exotic vegetation, livestock overgrazing, fragmentation and recreational activities; and changes in habitat due to beaver. The principal habitat diversity stressor is the spread and proliferation of invasive exotics. This coupled with poor habitat quality of existing vegetation have resulted in extirpation and or significant reductions in riparian habitat obligate wildlife species.

Recommended Range of Management Conditions:

Well-distributed range of 20 to 100% tree canopy closure (cottonwood and other hardwood species), with a young to mature cottonwood component including trees at least 160 feet tall

Multi-structure/age tree canopy (includes trees less than 6 in. in diameter and mature/decadent trees)

Forty to 80% native shrub cover (greater than 50% comprised of hydrophytic shrubs), with scattered herbaceous openings

Multi-structured shrub canopy greater than 3 feet in height, at least 10% of which are comprised of young cottonwoods

Focal Habitat Monitoring Strategies: Establish an inventory and long term monitoring program for protected and restored riparian wetlands to determine success of efforts.

1. Identify riparian wetland sites within the subbasin that support populations of focal species for this habitat.
2. Quantify occupied, unoccupied, and potential beaver habitat using GIS and aerial photos (McCall et al. 1996). Monitor changes in habitat on an annual basis.
3. Monitor areas that have been enhanced for beaver with plantings of cottonwood and aspen (Slough and Sadleir 1977). Every 2 years, measure the survival and growth of plantings.
4. Evaluate habitat site potential on existing public lands and adjacent private lands for protection. (short-term strategy i.e., < 2 years).
5. Enhance habitat on public lands and adjacent private lands, and
6. Identify high quality/functional privately owned riparian wetlands sites that are not adjacent to public lands (long term strategy 2 to 15 years).
7. Establish permanent censusing stations to monitor bird population and habitat changes

Sampling Design: HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type. (Riparian zone width within portions of the subbasin will require modification of this 100 foot buffer requirement.)

In addition, at any permanently established avian species monitoring site established within the Riparian Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Sampling Methods (USFWS 1980a and 1980b):

1. Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

2. Shrub canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible "hits" per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible "hits" per 100 ft segment).

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

3. Tree canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

In addition, at any permanently established avian species monitoring site established within the Riverine Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003) (http://www.birdpop.org/DownloadDocuments/manual/HSAManual03.PDF).

Analysis: Transects are divided into 100 ft. segments, and total transect length is determined using a "running mean" to estimate variance (95% probability of being within 10% of the true mean).

Sample size equation: $n = \frac{t^2 \text{ x } s^2}{E^2}$

Where: t = value at 95 percent confidence interval with suitable degrees of freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring:

Beaver, Yellow-breasted chat and Red-eyed vireo

Rationale: Maintaining and enhancing beaver, yellow-breasted chat and red-eyed vireo populations within the subbasin will assure the maintenance and rehabilitation of riparian wetlands.

Limiting Factors: 1) Loss of deciduous tree cover and sub-canopy/shrub habitat in riparian zones. 2.) Conversion of riparian habitat due to channelization, agriculture, and development, 3) flooding of habitat resulting from hydropower facilities, 4) habitat fragmentation, 5) degradation of existing habitats from overgrazing and introduced weedy vegetation, and 6) tree/shrub removal in riparian areas. Proximity to agriculture, suburban development creates a hostile landscape where a high density of nest parasites, such as, brown cowbird and predation by domestic cats may occur. Disturbance from agriculture, silviculture, road management and recreational activities can also cause nest abandonment.

Assumptions: 1) Addressing factors that affect riparian wetlands, will also address yellow-breasted chat, red-eyed vireo, beaver and other wetland obligate species limiting factors. 2) If riparian wetland habitat is of sufficient quality, extent, and distribution to support viable yellow-breasted chat, red-eyed vireo and beaver populations, the needs of most other riparian wetland obligate species will also be addressed and habitat functionality could be inferred. 3) Beaver will persist in these habitats if suitable habitat is maintained.

Sampling Strategy: Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 25% increase in abundance of yellow warbler with a power of 0.8 or greater. This protocol is based on the point count survey (Ralph et al. 1993, Ralph et al. 1995), with each survey station referred to as a “point count station.” In addition to these bird survey data, information about the distance at which individual birds are detected will also be collected, allowing absolute density estimated to be made using distance-sampling methodology (e.g., the program DISTANCE).

Methods: The number and location of active beaver lodges and dams will be determined using a fixed-wing aircraft and inspection of each lodge and dam from the ground to verify activity (McCall et al. 1996).

We will survey birds on randomly selected (stratified) points along the riparian corridor. Each site will have 4 100-m fixed-radius point counts (Ralph et al. 1993) established along a transect and spaced 200m apart (Fig 4). Each point will be marked with a permanent fiberglass stake (1m electric fence post) and colored flagging will be placed on shrubs at 50 and 100m from the point in each of the 4 cardinal directions to aid in determining distance. Counts at each point will be 5 minutes in duration during which all birds seen or heard will be noted, along with their sex (if known), distance from the point (within 50m, >50 but <100m, or beyond 100m), and behavior (singing, calling, silent, or flying over the site). Surveys will be conducted once each in May and June and within prescribed weather parameters (e.g., no rain and low wind).

Analysis: Analysis is described by Nur et al. (1999). Absolute density estimation (see Buckland et al. 1993) can be estimated using the program DISTANCE, a free program

available on the World-Wide Web (http://www.ruwpa.st-and.ac.uk/distance); an example is given in Nur et al. (1997). In brief: for species richness and species diversity, these can be analyzed as total species richness or as species richness for a subset of species; the same is true for species diversity. Species diversity can be measured using the Shannon index (Nur et al. 1999), also called the Shannon-Weiner or Shannon-Weaver index. Statistical analysis can be carried out using linear models (regression, ANOVA, etc.), after appropriate transformations (examples in Nur et al. 1999).

7.6.2 Ponderosa Pine

Focal Species: Flammulated owl (*Otus flammeolus*), white-headed woodpecker (*Picoides albolarvatus*), pygmy nuthatch (*Sitta pygmaea*)

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed Ponderosa pine sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat:

1. Direct loss old growth forest and associated large diameter trees and snags;
2. Fragmentation of remaining Ponderosa pine habitat;
3. Agricultural and sub-urban development and disturbance;
4. Hostile landscapes which may have high densities of nest parasites, exotic nest competitors, and domestic predators;
5. Fire suppression/wildfire;
6. Overgrazing;
7. Noxious weeds;
8. Silvicultural practices;
9. Insecticide use.

Ponderosa Pine Working Hypothesis Statement: The near term or major factors affecting this focal habitat type are direct loss of habitat due primarily to timber harvesting, fire reduction/wildfires, mixed forest encroachment, development, recreational activities, reduction of habitat diversity and function resulting from invasion by exotic species and vegetation and overgrazing. The principal habitat diversity stressors are the spread and proliferation of mixed forest conifer species within ponderosa pine communities due primarily to fire reduction and intense, stand-replacing wildfires, and invasive exotic weeds. Habitat loss and fragmentation (including fragmentation resulting from extensive areas of undesirable vegetation) coupled with poor habitat quality of existing vegetation (i.e., lack of old growth forest and associated large diameter trees and snags) have resulted in significant reductions in ponderosa pine habitat obligate wildlife species.

Recommended Range of Management Conditions: Recognizing that extant ponderosa pine habitat within the subbasin currently covers a wide range of seral conditions, wildlife habitat managers have identified three general ecological / management conditions that, if met, will provide suitable habitat for multiple wildlife species at the subbasin scale within the ponderosa pine habitat type. These ecological conditions correspond to life requisites represented by a species' assemblage that includes white-headed woodpecker, flammulated owl, and pygmy nuthatch

1. Mature ponderosa pine forest: The white-headed woodpecker represents species that require/prefer large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10 - 50 percent and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags greater than 31 inches DBH).
2. Multiple canopy ponderosa pine mosaic: Flammulated owls represent wildlife species that occupy ponderosa pine sites that are comprised of multiple canopy, mature ponderosa pine stands or mixed ponderosa pine/Douglas-fir forest interspersed with grassy openings and dense thickets. Flammulated owls nest in habitat types with low to intermediate canopy closure (Zeiner et al. 1990), two layered canopies, tree density of 508 trees/acre (9 foot spacing), basal area of 250 feet2/acre (McCallum 1994b), and snags greater than 20 inches DBH 3-39 feet tall (Zeiner et al. 1990). Food requirements are met by the presence of at least one snag greater than 12 inches DBH/10 acres and 8 trees/acre greater than 21 inches DBH.
3. Heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age: pygmy nuthatches represent those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 inches DBH) trees characteristic of mature undisturbed forests. Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

Focal Habitat Monitoring Strategies: Establish an inventory and long term monitoring program for protected and managed Ponderosa pine habitats to determine success of efforts. Subbasin managers recognize that restoration of late-successional forest is a long term process, but these short-term (i.e., up to 15 years) strategies reflect the commitment and initiation of the process of management.

1. Identify Ponderosa pine habitat sites within the subbasin that support populations of focal species for this habitat.
2. Evaluate habitat site potential on existing public lands and adjacent private lands for protection of focal species habitat (short-term strategy i.e., < 2 years).
3. Enhance habitat on public lands and adjacent private lands (intermediate strategy; 2 to 10 years)
4. Identify high quality/functional privately owned Ponderosa pine sites that are not adjacent to public lands (long term strategy 2 to 15 years).
5. Establish permanent roadside and off-road censusing stations to monitor bird population and habitat changes.

Sampling Design: Permanent survey transects will be located within Ponderosa pine habitats using HEP protocols. HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type.

In addition, at any permanently established avian species monitoring site established within the Riverine Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Sampling Methods (USFWS 1980a and 1980b):

1. Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.
2. Shrub canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible “hits” per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible “hits” per 100 ft segment).

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

3. Tree canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

Measurement of Attributes (Habitat Conditions):

>10 snags/40 ha (>30cm DBH and 1.8m tall)

Method: A direct count in the 1/10 acre circle plot at the end of each 100

ft segment of the transect. DBH (measured with a loggers tape) and condition is noted for each snag. Snag condition scale follows Parks et al. (1997).

>20 trees /ha (>21” DBH)

Method: A direct count in the 1/10 acre circle plot. DBH measured with a logger’s tape. Ponderosa Pine – old growth: >10 trees/ac (>21” DBH w/ >2 trees >31” DBH)

Method: A direct count in the 1/10 acre circle plot. DBH measured with a logger’s tape. 10-50% canopy closure

Method: A line intercept ‘hit’ or ‘miss’ measurement. Ten direct measurements along each 100 foot section of the transect (one every 10 feet) taken with a moosehorn densitometer. > 1.4 snags/ac (>8” DBH w/ >50% >25”)

Method: A direct count in the 1/10 acre circle plot at the end of each 100 ft segment of the transect. DBH (measured with a loggers tape) and condition is noted for each snag. Snag condition scale follows Parks et al. (1997).

In addition, at any permanently established avian species monitoring site established within the Riverine Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Analysis: Transects are divided into 100 ft. segments, and total transect length is determined using a “running mean” to estimate variance (95% probability of being within 10% of the true mean).

Sample size equation: $n = \frac{t^2 \times s^2}{E^2}$

Where: t = value at 95 percent confidence interval with suitable degrees of freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring

Flammulated Owl

Rationale: The Flammulated owl is listed as candidates for inclusion on the WDFW endangered species list and is considered a species-at-risk by the Washington GAP Analysis and Audubon-Washington. Flammulated owls are highly structurally dependent on the Ponderosa Pine habitat. Therefore, it is important to maintain and enhance the structure and function of ponderosa pine habitats for flammulated owls.

Limiting Factors: 1) Silvicultural practices that reduce habitat quality; 2) pesticide use; 3) predation/competitors; 4) exotics.

Assumptions: 1) Addressing factors that affect ponderosa pine, will also address flammulated owl and other ponderosa pine obligate species limiting factors. 2) If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable flammulated owl and white-headed woodpecker populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy: The following methods are designed to, 1.) facilitate delineation of current distribution and population levels of flammulated owls, and; 2) identify current and potential areas of high quality flammulated owl habitat (short-term strategy i.e., <2 years).

Methods: Nighttime surveys will be conducted throughout potentially suitable Flammulated Owl breeding habitat, which will be determined according to habitat use reported in the literature, other reports, GIS habitat mapping, and other reported sightings the species.

Routes will be randomly selected from within the potential habitat area using a stratified sampling scheme. Each route should have between 10-12 stations, distributed along the route at equal intervals of .5 km, a standard methodology based on the distance owls can be heard on a calm night (at least 1.0 km) and the average size of territories (<500 m across) (Reynolds and Linkhart 1984, Howle and Ritchie 1987, Van Woudenberg and Christie 1997). The location of the starting point of the route, and of each station along the route, should be recorded as precisely as possible using a GPS (Global Positioning System). Each route should be surveyed three times per year during May-July – the time of year when vocal activity of the majority of species is greatest. Conduct surveys between 2200 and 0100 hours (Howle and Ritcey 1987, Groves et al.

1997). An attempt should be made to conduct the survey at the same time of night each year. At the beginning of the breeding season the greatest calling intensity for the Flammulated Owl is during much of the evening, and then after nestling hatching singing is "later at night" (Reynolds and Linkhart 1987).

Surveys should only be conducted under favorable conditions: wind speeds <20 km per hour, a wind speed of Beaufort 3 or less and no precipitation (including rain and/or snow). Temperatures should be close to the average for the season and efforts should be made to avoid extremely cold temperatures because of evidence that owls may be less vocal in very cold weather (Takats 1998a).

Surveys will consist of visiting a point for two minutes to listen for Flammulated Owls calling, and if no owls are heard then a male territorial call will be imitated or played from tape for one minute. After listening for an additional two minutes, the observer will then walk to the next point while still listening for calling owls. (Two minutes appears to be adequate for most spontaneously calling owls to be detected, at least during the period of peak calling activity. In Alberta, relatively few additional owls were detected during a third minute of listening (Takats, pers. comm.). In Ontario, more than 70% of 5 species of owls that were detected over a 5 minute period (included playback) were detected in the first two minutes (Takats 1997, 1998b)

Playback recordings should be as clear and loud as possible without distortion. Digital technology is recommended (CD-ROM, solid state, or digital tape) as the sound quality can be better controlled and is less likely to deteriorate over time. The audio equipment should be of sufficient quality that it will not distort the sound at loud volumes. We suggest the volume be such that the recording can be heard at 400m, but not at 800m (to minimize bias at the next survey station due to owls hearing the recording from the previous station). If possible, the volume should be measured at a standard distance (e.g., 1m from the speakers) using a decibel meter.

The recording should include both the silent listening periods as well as the playback sequence time period. A soft ‘beep’ or other sound can be used to indicate the start of the first silent listening period, and another beep to indicate the end of the final listening period. This will ensure that the time is fully standardized at each station, and reduce the need for participants to keep checking their watches.

Surveyors should be asked to estimate the approximate direction and distance to the first position where they detect each owl and plot location on a map. This data can help to determine whether the same owls are being detected at different stations along the route, to adjust for some of the variation in detection rates, and to aid in daytime nest searches.

Male presence is not adequate to determine habitat suitability as many males may remain unmated (Reynolds and Linkart 1987a, McCallum 1994a). The nests should be monitored so that success can be determined. Parallel transects 50 m apart through areas where owls were detected were surveyed in June and early July to try and find nest site locations. Since most of the calls heard in the field are from territorial reproductive males, nests can be located by systematic nest searches during the day (Bull et al. 1990). Once territory boundaries are delineated, all suitable nesting cavities (tree cavities with entrance diameters >4 cm) within territories will be checked for nesting owls (Linkart and Reynolds 1997).

Nest sites will be searched for using a pinhole camera system attached to a telescoping pole that reaches approximately 11 m high (Proudfoot 1996). This is an effective nest finding technique, but is limited to cavities within reach. Tree scratching (with a stick) can also used, which imitates a predator climbing the nest tree and often stimulates incubating or brooding females to look out of the nest cavity entrance (Bull et al. 1990). Observation of a female Flammulated Owl at a cavity entrance will document a nest site.

Analysis: Data from the surveys described here are similar to those of the Breeding Bird Survey, though some modifications may be required in the future. A wide variety of methods have been developed for analysis of BBS data (James et al. 1996, Link and Sauer 1994, 1998), but there is still some disagreement as to which methods are best (James et al. 1996, Link and Sauer 1994a, Link and Sauer 1994b, Thomas 1996). There are two main methods currently being used by the coordinators of the BBS. One involves route regression using estimating equations (Link and Sauer 1994), which assumes that trends may differ among routes, and calculates a weighted mean of the trends within routes. The selection of weighting factors is strongly dependent upon the sampling scheme used to select routes. An alternate approach involves a generalized linear model assuming over-dispersed Poisson residuals and a log-link function (Link and Sauer 1998). This approach assumes that trends are similar within a broader region, and allows more robust modeling of nonlinear population changes (e.g., year to year fluctuations). A simplified version of this latter approach has been used for analysis of population trends in Ontario (Lepage et al 1999, Francis and Whittam 2000), but it is not yet known whether this is the most appropriate analysis method.

The power of the survey technique will be investigated after its first three years in its present design to determine the actual variance. This will allow us to determine the number of routes required to detect our objective of a 35% change by 2020.

Finally, we recommend that relevant data be made publicly available, preferably over the Internet. This will encourage further research into analysis methods, thus ensuring that maximum use is made of the data for conservation purposes. However, care should be taken to protect sensitive information, such as precise nesting locations of rare species.

White-headed woodpecker

Rationale: Suitable white-headed woodpecker habitat includes large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10 - 50 percent and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags greater than 31 inches DBH). Maintaining white-headed woodpecker populations will require that this mature/old growth component of ponderosa pine habitat is maintained or enhanced within the Ecoregion.

Limiting Factors: 1) Silvicultural practices that reduce habitat quality; 2) pesticide use; 3) predation/competitors; 4) exotics.

Assumptions: If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable white-headed woodpecker populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy: Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 25% increase in abundance of white-headed woodpecker with a power of 0.8 or greater.

Methods: The method used, point counts, is derived from Dixon (1998)

POINT COUNTS

Each observer will conduct one transect per day individually. Survey low-elevation transects first to assure accessibility. The protocol for point counts will follow standardized methods for variable circular plots (Reynolds et al. 1980, Ralph et al.1995, Hutto and Hoffland 1996), but modified to better census White-headed Woodpeckers.

WHEN TO SURVEY: Point counts should be conducted between April 1 and May 15 when the detectability of White-headed Woodpeckers is highest and most stable. After this period the woodpeckers typically excavate from within the nest cavity and become less visible and less vocal. Counts should begin at official sunrise and end no later than 1030 and 1100. Each transect will be visited once.

POINT COUNTS: Counts will begin as soon as the observer arrives at the station and will be comprised of a 5-minute listening period without the use of tape playbacks followed by a 6-minute sequence of tape playbacks of White-headed Woodpecker calls and drums for a total count of 11 minutes. Data from the two types of counts will be recorded separately-with a code-on a the bird data sheet.

TAPE PLAYBACK PROCEDURE: Tape playback procedures will essentially follow the Payette National Forest Protocol for Broadcast Vocalizations (Payette National Forest 1993). The tape playback sequence should begin immediately after the 5-min unsolicited point count-be ready to start the tape at exactly 5 min. A total of four 30-second tape-playbacks of White-headed Woodpecker drums and calls will be projected at 1-min intervals (e.g. using a Johnny Ste wart™ game caller); that is, begin the first sequence of vocalizations to the north. During the one minute pause after the first sequence, rotate 90° for the second sequence, pause, then rotate another 90° for the third sequence of vocalizations after the second one minute break. When the third sequence is complete, rotate 90° for the fourth and final sequence for a total of 6 minutes of tape-playbacks.

WHEN NOT TO SURVEY: Surveys will not be conducted during heavy rain, fog, or when wind interferes with an observer's ability to detect calls (greater than 20 mph). If the weather appears prohibitive, wait 1 to 1.5 hours, or until you cannot reasonably complete the transect by 1100 hours. If the weather puts you in danger, STOP-your safety comes first.

WHAT TO RECORD: Record all species detected, visual or auditory. At the bottom of the data sheet, record any birds you might have detected either before or after a point count, or between stations.

Pygmy nuthatch

Rationale: Suitable pygmy nuthatch habitat contains heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age. Pygmy nuthatch represents those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 inches DBH) trees characteristic of mature undisturbed forests.

Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

Limiting Factors: 1) Silvicultural practices that reduce habitat quality; 2) fragmentation; 3) predation/competitors; 4) exotics.

Assumptions: If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable pygmy nuthatch populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy: This is a survey development need.

7.6.3 Shrubsteppe

Focal Species: Sharp-tailed Grouse, Brewer's sparrow (*Spizella breweri*), mule deer (*Odocoileus hemionus hemionus*)

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed shrubsteppe sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat:

1. Direct loss shrubsteppe due to conversion to agriculture, residential, urban and recreation developments
2. Fragmentation of remaining shrubsteppe habitat, with resultant increase in nest parasites
3. Fire Management, either suppression or overuse, and wildfires
4. Invasion of exotic vegetation
5. Habitat degradation due to overgrazing, and invasion of exotic plant species
6. Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities.

Shrubsteppe Working Hypothesis Statement: The near term or major factors affecting this focal habitat type are direct loss of habitat due primarily to conversion to agriculture, reduction of habitat diversity and function resulting from invasion of exotic vegetation and wildfires, and livestock grazing. The principal habitat diversity stressor is the spread and proliferation of annual grasses and noxious weeds such as cheatgrass and knapweeds that either supplant and/or radically alter entire native bunchgrass communities significantly reducing wildlife habitat quality. Habitat loss and fragmentation (including fragmentation resulting from extensive areas of undesirable vegetation) coupled with poor habitat quality of extant vegetation have resulted in extirpation and/or significant reductions in shrubsteppe obligate wildlife species.

Recommended Range of Management Conditions:

1. Condition 1: Sagebrush dominated shrubsteppe: The Brewer's sparrow was selected to represent wildlife species that require sagebrush dominated sites, but prefer a patchy distribution of sagebrush clumps 10-30 percent cover, lower sagebrush height (between 20 and 28 inches),

native grass cover 10 to 20 percent (Dobler 1994), non-native herbaceous cover less than 10 percent, and bare ground greater than 20 percent (Altman and Holmes 2000).

Sage sparrows are still common throughout sagebrush habitats and have a high probability of being sustained wherever large areas of sagebrush and other preferred native shrubs exist for breeding. Similar to other shrubsteppe obligate species, sage sparrows are associated with habitats dominated by big sagebrush cover and perennial bunchgrasses (Paige and Ritter 1999; Vander Haegen et al. 2000). Habitat attribute conditions recommended for sage sparrows include; dominant sagebrush canopy with 10 to 25 percent sagebrush cover, mean sagebrush height greater than 20 inches, high foliage density, mean native grass cover greater than 10 percent, mean exotic annual grass cover less than 10 percent, mean open ground cover greater than 10 percent, and, where appropriate, suitable habitat conditions in patches greater than 400 acres (Altman and Holmes 2000).

2. Recommended Condition 2 - Diverse shrubsteppe habitat: Mule deer were selected to represent species that require/prefer diverse, dense (30 to 60 percent shrub cover less than 5 feet tall) shrubsteppe habitats comprised of bitterbrush, big sagebrush, rabbitbrush, and other shrub species (Leckenby 1969; Kufeld et al. 1973; Sheehy 1975; Jackson 1990; Ashley et al. 1999) with a palatable herbaceous understory exceeding 30 percent cover (Ashley et al. 1999).

Focal Habitat Monitoring Strategies: Establish an inventory and long term monitoring program for protected and managed shrubsteppe habitats to determine success of management strategies. Subbasin managers recognize that restoration of shrubsteppe is still very much a fledgling field, and complete restoration of degraded or converted shrubsteppe may not be feasible. These monitoring strategies reflect the commitment to and initiation of the process of long term management.

1. Identify shrubsteppe habitat sites within the subbasin that support populations of Brewer's sparrow
2. Evaluate habitat site potential on existing public lands and adjacent private lands for protection of focal species habitat (short-term strategy i.e., < 2 years).
3. Enhance habitat on public lands and adjacent private lands (intermediate strategy; 2 to 10 years)
4. Identify high quality/functional privately owned shrubsteppe sites that are not adjacent to public lands (long term strategy 2 to 15 years).
5. Establish permanent censusing stations to monitor bird population and habitat changes.

Sampling Design: Permanent survey transects will be located within shrubsteppe habitats using HEP protocols. HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type.

In addition, at any permanently established avian species monitoring site established within the Shrubsteppe habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Sampling Methods (USFWS 1980a and 1980b):

1. Bare ground or cryptogram crust measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

The percentage of the microplot consisting of either bare ground or cryptogram crust is estimated via ocular estimate.

2. Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

Herbaceous cover % is measured via an ocular estimate of the percentage of the microplot shaded by any grass or forb species.

3. Shrub canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible "hits" per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible "hits" per 100 ft segment).

Shrub canopy cover is measured on a line intercept 'hit' or 'miss'. Measurements are taken every 2 or 5 feet, depending upon shrub density.

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

4. Tree canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

Analysis: Transects are divided into 100 ft. segments, and total transect length is determined using a "running mean" to estimate variance (95% probability of being within 10% of the true mean).

Sample size equation: $n = \frac{t^2 \times s^2}{E^2}$

Where: t = value at 95 percent confidence interval with suitable degrees of freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring

Brewer's Sparrow

Rationale: The main premise for focal species selection is that the requirements of a demanding species assemblage such as Brewer's sparrow encapsulate those of many co-occurring less demanding species. By directing management efforts to ward the requirements of the most exigent species, the requirements of many cohabitants that use the same habitat type are met. Therefore, managing habitat conditions for a species assemblage comprised of these three species should provide life requisite needs for most other shrubsteppe obligate species.

Limiting Factors: 1) Conversion of native shrubsteppe habitat for agricultural purposes, 2) habitat fragmentation; 3) degradation of existing habitats from overgrazing and introduced weedy vegetation, 4) brush removal, 5.) wildfire

Assumptions: 1) Addressing factors that affect shrubsteppe habitat will address Brewer's sparrow; 2) If shrubsteppe habitat is of sufficient quality, extent, and distribution to support Brewer's sparrow populations, the needs of most other shrubsteppe obligate species will also be addressed and shrubsteppe functionality could be inferred.

Sampling Strategy: Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 35% increase in abundance of key species with a power of 0.8 or greater.

Methods: We will survey birds on 64 sites in different vegetation types and levels of fragmentation. Each site will have 4 100-m fixed-radius point counts (Ralph et al. 1993) established along a transect and spaced 200m apart (Fig 4). The outer points of the point-count circles will describe a rectangular plot of 16ha that will be the focus of all survey work in Objectives 2-4. Each point will be marked with a permanent fiberglass stake (1m electric fence post) and colored flagging will be placed on shrubs at 50 and 100m from the point in each of the 4 cardinal directions to aid in determining distance. Counts at each point will be 5 minutes in duration during which all birds seen or heard will be noted, along with their sex (if known), distance from the point (within 50m, >50 but <100m, or beyond 100m), and behavior (singing, calling, silent, or flying over the site). Surveys will be conducted once each in May and June and within prescribed weather parameters (e.g., no rain and low wind).

Mule Deer

Rationale: Mule deer inhabit all habitats within the subbasin. Shrubsteppe habitat quality determines the size and persistence of mule deer populations within the subbasin, as they are both critical winter habitat and the limiting factor for this species in the subbasin. Mule deer have been selected as a focal species due to the significant economic, recreational, and cultural values this species provides.

Limiting Factors: 1) flooding of habitat resulting from hydropower facilities, 2) loss of habitat due to urban and suburban development, 3) road and high way construction, 4) degradation of existing habitats from overgrazing and introduced weedy vegetation, 5) alteration of historic fire regimes, 6) past silvicultural practices, 7) deer control efforts necessitated by agricultural damage, 8) natural predation and over-harvest by hunters, 9) disease and parasites

Assumptions: Addressing factors that affect shrubsteppe habitats, will also address mule deer and other shrubsteppe obligate species limiting factors.

Management Objective: The population management objective for mule deer will be to increase or maintain populations within the limitations of available mule deer habitat and landowner tolerance (agricultural damage). Population monitoring variables and objectives are established in the Washington Department of Fish and Wildlife Game Management Plan (WDFW 2003). In areas with periodically high mule deer populations and significant agricultural damage complaints, WDFW will regulate populations as appropriate through hunter harvest.

Monitoring Methods: Mule deer populations will be monitored using a combination of post hunting surveys, winter surveys and harvest data. Current surveys allow the monitoring of age/sex ratios to determine if management objectives established in the Game Management Plan (WDFW 2003) are being met for post-season buck survival (> 15 bucks/100 does) and fawn production and recruitment. Harvest data is used as an indicator of population trend.

Evaluation Strategies:

1. Use winter aerial and ground surveys to classify mule deer to determine post-hunt buck/fawn to doe ratios and population size trends
2. Monitor harvest level of bucks and antlerless deer using mandatory hunter report system
3. Model the Chelan PMU mule deer population
4. [No information listed here]

7.7 Fisheries Biological Objectives

Recovery and maintenance of key populations must achieve two broad objectives:

- Restore populations to a point where they no longer require the protection of the ESA
- Maintain populations at a level that allows meaningful opportunity for tribal and non-tribal hunting and fishing rights

Achievement of these objectives requires a healthy ecosystem and application of sound management principles. Four parameters form the key to evaluating and measuring the status of a population's health. They are: 1)abundance (population size), 2)population growth rate, 3)population spatial structure and 4)life history diversity. These parameters are reasonable predictors for extinction risks. They reflect general processes that are important to all populations of all species, and they are measurable.

Below is a synopsis of the biological objectives underlying each of these four parameters. This information is derived from the NOAA Fisheries Technical Memorandum NMFS-NWFSC-42 (2000). Although many of the principles established in this work are technically sound, use of NOAA Fisheries concepts in this subbasin plan does not imply adoption of the referenced document. The subbasin plan recognizes the biological objectives for cutthroat and bull trout contained in the USFWS Draft Bull Trout Recovery Plan, (2004) and incorporates by reference this document and biological objectives.

Abundance

Populations are large enough to have a high probability of surviving environmental variation of the patterns and magnitudes observed in the past as well as those expected in the future.

Populations have sufficient abundance for compensatory processes to provide resilience to environmental and human caused disturbances.

Populations should be sufficiently large to maintain genetic diversity over a long term.

Populations should be sufficiently abundant to provide important ecological functions throughout its life cycle.

Population Growth Rate

Population natural productivity is sufficient to maintain its abundance above the viable level.

The population that includes naturally spawning hatchery fish exhibits sufficient productivity from naturally produced spawners to maintain population abundance above viability thresholds in the absence of supplemented hatchery production.

Populations exhibit sufficient productivity during fresh water life history stages to maintain abundance above thresholds, even during poor ocean (or other relevant environmental) conditions.

Populations do not exhibit sustained declines in abundance that span multiple generations and affect multiple broodyear cycles.

Populations do not exhibit trends or shifts in traits that portend declines in a population's growth rate.

Salmonid habitat should not be destroyed faster that is naturally created.

Natural rates of straying among subpopulations should not be substantially increased or decreased by human actions.

Some salmonid habitat should be maintained that appear suitable or marginally suitable, even though it currently contains no fish.

Key subpopulations (highly productive) should be maintained to support other subpopulations with lower productivity.

Life History Diversity

Human caused changes such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not alter variation in traits such as migration timing, age structure, size, fecundity, morphology, behavior, and molecular genetic characteristics.

Natural processes of dispersal should be maintained. Human caused factors should not substantially alter the rate of gene flow among populations.

Natural processes that cause ecological variation should be maintained.

Contribution to Recovery of Salmonids and Pacific lamprey

[No information to date]

7.8 Fisheries Habitat Objectives and Desired Future Conditions

7.8.1 Introduction

Habitat objectives are organized in a manner consistent with the information presented in the assessment of the Wenatchee subbasin plan. The intent is to provide specific and measurable objectives for habitat attributes important to maintain long term viability to native aquatic and riparian dependent species within the subbasin. Resource managers attaining these objectives will provide a baseline for long term environmental desired future conditions. (The following habitat objectives come primarily from "A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation watershed Scale" (US Fish and Wildlife Service 1999)).

It is understood that not all environments and habitat are inherently capable of achieving or maintaining these general standards. Human developments will also preclude attainment of these standards in some cases. However, to the extent feasible, the objective of the Wenatchee subbasin plan is to maintain and improve healthy ecosystems within the Wenatchee subbasin, via measurable habitat objectives that can be monitored.

7.8.2 Watershed Conditions

Disturbance Regime

Environmental disturbances (wildfire, etc.) are short lived with little or no long term change to the hydrograph. High quality habitats and watershed complexity continue to provide refuge and rearing space for the expected assemblage of organisms, for all life stages and/or multiple life history forms. Natural processes are stable and resilient to significant changes over time.

Road Density/Location

At the watershed scale (6^{th} field hydrologic unit code – HUC) road densities do not exceed one linear mile per square mile. Roads are maintained to provide adequate drainage and to minimize sediment transport. Valley bottom roads are relocated where feasible to minimize the affects to riparian and floodplain habitat, and functional attributes.

Refugia

Landscape scale habitats capable of supporting strong and significant populations are maintained and are well distributed and connected for the expected assemblage of organisms and for all life stages.

Water Quality

Temperature

Water temperatures will be at or near normative conditions throughout the year. Where possible the 7-day average maximum temperature in a stream reach will not exceed 2-5°C during incubation periods; 4-12°C during juvenile rearing periods and 4-9°C during spawning periods. Also, water temperatures do not exceed 15°C in areas usedby adults during migration thereby providing no thermal barriers to movement.

Sediment

Fine sediment (< 0.85mm) measured in spawning and incubation habitat is less than 12% of the total substrate composition. (If surface fines (< 0.6mm) are included, then total substrate composition should not exceed 20%.

Cobble and gravel substrate embedded by fine sediment/materials in juvenile rearing areas does not exceed 20%.

Contaminants and Nutrients

Low levels of chemical contaminants, waste materials (nutrients) from agricultural, industrial and other sources are measured in surface and ground water systems. There are no stream reaches designated as impaired (303d) under the CWA.

Water Quantity

The watershed hydrograph is at or near normative condition (peak flow, base flow and flow timing characteristics) compared to other watersheds of similar size, geology, and geography.

Riparian/Floodplain Condition

Riparian Condition

Riparian areas provide adequate shade, large woody debris (LWD) recruitment, and habitat protection and connectivity in sub watersheds. Riparian areas provide buffers and includes refugia for sensitive aquatic species (>80% intact). Riparian areas maintain at least 50% similarity of riparian vegetation to the potential natural community/composition.

Floodplain Connectivity

Off-channel and side channel areas are frequently (annually) hydrologically linked to main river. High flows that exceed the natural stream bank capacity are allowed to occur to reduce water velocity and energy within the stream channel and to maintain wetland functions, riparian vegetation, and succession.

In-Channel Conditions

A relatively high degree of in-channel structural diversity exists throughout stream reaches where expected. LWD occupies the channel at greater than 20 pieces per mile. LWD pieces must be >12 in. diameter at the small end and at least 35 ft. in length. Also, there is an adequate source of woody debris available within the riparian corridors for both long and short-term LWD recruitment into the stream channel.

Pool Quantity and Quality

In streams that are greater than 9.8 ft. in wetted width at base flow, large pools (those that occupy most of the channel width and are greater than one meter deep) are commonly found in reaches with adult holding, juvenile summer or overwintering rearing.

Pool frequency is known to be variable, typically depending upon the stream width. Pool frequency in a stream reach closely approximates:

Table 71. Pool frequency in the Wenatchee subbasin

Wetted width (ft)	#pools/mile
0-5	39
5-10	60
10-15	48
15-20	39
20-30	23
30-35	18
35-40	10
40-65	9
65-100	4

Pools have good cover and cool water, and only minor reduction of pool volume by fine sediment

Off-Channel Habitat

Watersheds have many ponds, oxbows, back waters, and other off-channel areas with adequate hiding cover. Side channels provide areas with low hydrologic energy that act as refuge for juvenile fish, especially during high flow events.

Channel Condition/Dynamics

Channel width to depth ratios, as measured for the stream reach, is at or near the expected normative value as described by Rosgen (1996).

Stream bank condition as measured for the stream reach is approximately 90% stable for approximately 80% of the linear stream channel.

Fish Passage

Man-made barriers present in watershed allow upstream and downstream fish passage at all flows. There are no barriers to fish passage within the subbasin.

Ecological

To the extent possible, non-native and non-desirable species are not present or do not have a significant affect through competition or predation on other native or desired species within the watershed.

7.8.3 Recommendations for Management

Strategies, Objectives, and Near-term Opportunities

The following pages summarize recommendations for management strategies, management objectives and near-term opportunities at both the subbasin scale and for each of the individual assessment units. For each assessment unit important information from the assessment and key findings are summarized. For each of the habitat attributes, recommended management strategies are provided that identify general direction for future management emphasis. For each management strategy, one or more management objectives are listed that imply certain types of actions that might be employed to successfully achieve the management strategy. Concluding the recommendations for each assessment unit, near-term opportunities are suggested.

Near term opportunities are a list of evaluations and potential restoration/enhancement projects that have been identified as having relatively high benefit to subbasin planning goals and objectives. This list is not intended to be comprehensive, nor is it intended to provide the basis for prioritization. Rather, these are projects that could be accomplished within a 10-year time frame and would significantly contribute towards achievement of long term objectives and desired future conditions related to salmon recovery. Due to the nature of the landscape and/or the project type, near-term opportunities are likely to be more easily implemented than many other actions. Many other activities should be considered, although development of these projects is expected to be more complex and requiring more time than available within the scope of this planning process.

7.8.4 Lower Wenatchee River Assessment Unit

Assessment Unit Summary

Table 72. Lower Wenatchee River assessment unit summary

Summary of Lower Wenatchee River Assessment Unit	
Focal species Spring chinook, Late-run chinook, Coho, Steelhead, Bull trout	Assessment Unit Priority Category 1 Key Sub watersheds Lower Wenatchee
Limiting Factors Key Habitat Quantity Habitat Diversity Channel Stability Sediment Low Flow Elevated Temperature	Hypothesized Effect on Focal Species Water Quality (Moderate-Low) Water Quantity (Moderate) Riparian (Moderate-High) In-Channel (Moderate-High) Fish Passage (Low) Ecological (Low)

Management Strategy Recommendations

Water Quality

Temperature

Management Strategy

- Reduce late summer mainstem temperatures

Management Objectives

- Improve low flow conditions
- Increase riparian shade and floodplain function
- Enhance or improve tributary stream temperatures by improving riparian and channel conditions

Sediment

Management Strategy

- Reduce elevated fine sediment percentages in the mainstem and tributary stream substrates

Management Objectives

- Improve streambank conditions
- Increase riparian ground cover
- Continue monitoring sediment on an annual basis

Contaminants

Management Strategy

- Enhance water quality for both mainstem and tributary streams

Management Objectives

- Develop programs and strategies for the application of toxic pesticides and herbicides that also restrict these materials from contacting surface water
- Support efforts that restrict waste materials from entering subbasin waters

Water Quantity

Management Strategy

- Enhance mainstem flows

Management Objectives

- Improve overall watershed vegetative and hydrologic conditions
- Support the development and use of programs that increase water use efficiency
- Restore tributary flows to the natural hydrograph by improving the road network and relocating valley bottom roads where feasible

Riparian and Floodplain

Management Strategy

- Improve riparian and floodplain conditions and functional characteristics in both mainstem and tributary streams

Management Objectives

- Re-establish riparian vegetation corridors where they have been lost using active restoration practices
- Avoid activities within riparian corridors that disrupt riparian function
- Retain high quality riparian patches as refuge habitats
- Where feasible, relocate valley bottom roads to allow for channel migration, riparian vegetation recolonization, and improved floodplain function
- Avoid the loss of wetland and off-channel habitat
- Reconnect and increase side-channel habitat to the main stream channel
- Where appropriate, establish areas where natural channel migration can occur
- Retain fluvial processes and floodplain function

- Evaluate the condition of the hyporheic zone with respect to existing and future floodplain developments (Data Gap)

In-Channel

Management Strategy

- Restore and enhance in-channel habitat diversity and structural complexity for native species in both mainstem and tributary streams
- Management Objectives
- Where appropriate, provide instream structures (large wood, rock, or other natural materials) that will enhance salmonid habitat diversity, habitat quality and quantity, and channel integrity
- Improve natural stream bank stability by increasing riparian vegetation
- Where approprioate restore natural channel form, including reconnection to floodplain

Passage

Management Strategy

- Continue to monitor and evaluate fish passage at Dryden Dam

Management Objectives

- Restore unhindered juvenile and adult passage if determined to be appropriate
- Evaluate and restore fish passage in tributary streams

Ecological

[No information to date]

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Increase the amount of riparian area by 50 acres. Most of this would be associated with side channel enhancement and/or developments.

Monitoring Indicator:

- Increase in riparian ground cover, vegetation structure and composition
- Evaluate the existing condition of the hyporheic zones and determine how flow conditions may influence biological and physical attributes of the hyporheic zone.

Monitoring Indicator:

- Report on biological and physical attributes and condition and long term monitoring strategy

Stream Channel Condition and Function

- Increase the amount of useable side channel habitat by 20% over current condition to provide additional juvenile summer and winter rearing habitat.

Monitoring Indicator:

- Increase acres side channel habitat; useable habitat for focal species at various flow and environmental conditions
- Evaluate and implement the appropriate placement of 10 in-channel structures. These structures would be designed to control flows and maintain developed side channels and/or to develop pool habitat. These structures will serve as a pilot project for potential future similar developments.

Monitoring Indicator:

- Number of structures implemented; amount useable habitat for focal species made available at various flow conditions, effect on side channel maintenance
- Initiate surveys and begin long term monitoring of sediment yield and substrate embeddedness in spawning gravels.

Monitoring Indicator:

- Annual sediment monitoring scheme developed and implemented by year 2006

Water Quality

- Determine point and non-point source pollution and establish a plan to prevent pollutants from entering the water system.

Monitoring Indicator:

- Annual water quality monitoring scheme developed and implemented by year 2006

Water Quantity

- Continue evaluating flow conditions and identify potential actions, benefits and risks to increase low flows (i.e. surface or ground water storage). Implement appropriate actions as identified.

Monitoring Indicator:

- Implementation to begin on priority findings and objectives in 2007 (Report completed by 2006)
- Continue to evaluate various scenarios and improvements to increase efficiencies in water delivery and use. Identify areas and specific improvements where irrigation diversions do not directly impair salmonid habitat. Determine the feasibility for pumping Columbia River water for exchange of diverting portions of the Wenatchee River system.

Monitoring Indicator:

- Implementation to begin on priority findings and objectives in 2007 (Report completed by 2006)

Obstruction to Fish Passage

- Replace all culverts that are currently blocking fish (rainbow/steelhead trout) passage in Derby Canyon

Monitoring Indicator:

- All priority obstructions to passage identified and replaced

Ecological Conditions

- Near-term opportunity not identified to date. Reference: Monitoring Strategy for the Wenatchee Subbasin

7.8.5 Middle Wenatchee River Assessment Unit

Assessment Unit Summary

Table 73. Middle Wenatchee River assessment unit summary

Summary of Middle Wenatchee River Assessment Unit	
Focal species Spring chinook, Late-run chinook, Coho, Steelhead, Bull trout	Assessment Unit Priority Category 1
	Key Sub watersheds Tumwater Canyon Chiwakum Creek
Limiting Factors Riparian/Floodplain Function Habitat Diversity Obstructions	Hypothesized Effects to Focal Species Water Quality (Data Gap) Water Quantity (None) Riparian/Floodplain (Moderate) In-Channel (Moderate) Fish Passage (Moderate) Ecological (Data Gap)

Management Strategy Recommendations

Water Quality

Temperature

Management Strategy

- Reduce late summer mainstem temperatures

Management Objectives

- Enhance by increasing riparian shade and floodplain function in the upper reaches of this assessment unit
- Enhance or restore tributary stream temperatures by improving riparian and channel conditions

Sediment

Management Strategy

- Reduce elevated fine sediment percentages in the mainstem and tributary stream substrates

Management Objective

- Improve riparian condition and increase natural streambank stability

Contaminants

Management Strategy

- Maintain existing good water quality

Management Objective

- Support efforts that restrict waste materials from entering subbasin waters

Water Quantity

Management Strategy

- Maintain flows and hydrograph to current condition

Management Objective

- Enhance or restore flows in some tributary streams by improving overall watershed condition and reducing stream channel confinement where possible

Riparian Floodplain

Management Strategy

- Maintain and improve mainstem riparian and floodplain conditions, particularly above Tumwater Canyon

Management Objectives

- Avoid activities within riparian corridors that disrupt riparian function
- Maintain existing floodplains connectivity with the river system
- Avoid the loss of wetland and off-channel habitat
- Maintain and enhance fluvial processes and floodplain function
- Improve riparian and floodplain conditions in some tributaries

In-Channel

Management Strategy (mainstem)

- Maintain and improve mainstem in-channel structural diversity and habitat quality

Management Objectives (mainstem)

- Enhance riparian areas to ensure long term recruitment of large wood into the stream channel
- Evaluate the feasibility of improving existing large wood contribution to habitat diversity
- Reduce channel confinement where feasible

Management Strategy (tributaries)

- Improve tributary habitat quality and quantity in some locations

Management Objectives (tributaries)

- Improve degraded channel form and function, including reconnection to floodplain
- Enhance riparian areas to ensure long term recruitment of large wood into the stream channel
- Where appropriate, provide instream structures that will enhance habitat diversity and channel integrity

Passage

Management Strategy

- Continue to monitor and evaluate fish passage at Tumwater Dam. Restore unhindered juvenile and adult passage if determined to be appropriate

Management Objectives

- Evaluate and restore fish passage in tributary streams

Ecological

[No information to date]

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Implement and maintain approximately 30-50 acres of riparian plantings primarily on the mainstem Wenatchee but also in appropriate locations in tributary streams.

Monitoring Indicator:

- Increase in riparian ground cover, vegetation structure and composition

Obstruction to Fish Passage

- Replace all culverts that are currently blocking fish passage in Skinney and Beaver creeks.

Monitoring Indicator:

- All priority obstructions to passage identified and replaced

Ecological Conditions

- Develop a short-term (2-3 years) pilot program to determine the feasibility and benefit for pike minnow control program downstream of Tumwater Dam.

Monitoring Indicator:

- Program developed and fully implemented by 2008, Report completed and long term management strategy developed

7.8.6 Mission Creek Assessment Unit

Assessment Unit Summary

Table 74. Mission Creek assessment unit summary

Summary of Mission Creek Assessment Unit	
Focal species Steelhead Coho	Assessment Unit Priority Category 3 Key Sub watersheds Sand Creek Devils Gulch Lower Mission
Limiting Factors Key Habitat Quantity Riparian/Floodplain Function Habitat Diversity Channel Stability Elevated Temperature Flow Obstructions	Hypothesized Effects to Focal Species Water Quality (High) Water Quantity (High) Riparian/Floodplain (High) In-Channel (High) Fish Passage (Moderate-High) Ecological (Data Gap)

Management Strategy Recommendations

Water Quality

Temperature

Management Strategy

- Improve water temperatures in Mission Creek and tributaries

Management Objectives

- Develop strategies to improve low flow conditions
- Increase riparian shade and floodplain function

Sediment

Management Strategy

- Reduce elevated fine sediment percentages in the mainstem and tributary stream substrates

Management Objectives

- Maintain and improve road conditions to minimize or eliminate sediment delivery into the stream channel
- Improve riparian vegetation and stream bank conditions to reduce or eliminate elevated sediment delivery to streams

Contaminants

Management Strategy

- Enhance water quality primarily for the mainstem of Mission and Brender creeks and preserve water quality in tributary streams

Management Objectives

- Develop programs and strategies for the application of toxic pesticides and herbicides that also restrict these materials from contacting surface water
- Support efforts that restrict waste materials from entering subbasin waters

Water Quantity

Management Strategy

- Enhance mainstem flows by improving overall watershed vegetative and hydrologic conditions and water use efficiency

Management Objectives

- Support the development and use of programs that increase water use efficiency
- Evaluate the potential and feasibility for water storage within the assessment unit

Management Strategy (tributaries)

- Restore tributary flows towards the natural hydrograph

Management Objective (tributaries)

- Reduce the road network where roads are no longer needed and relocate valley bottom roads where feasible
- Minimize stream channel confinement where possible

Riparian/Floodplain

Management Strategy

- Improve riparian and floodplain characteristics throughout the assessment unit where feasible

Management Objectives

- Improve lost sections of riparian vegetation corridors using active restoration practices
- Avoid activities within riparian corridors that disrupt riparian function or preventing recovery
- Maintain high quality riparian patches as refuge habitats
- Where feasible, relocate valley bottom roads to allow for restoring riparian vegetation, enhancing floodplain function, and providing for channel migration

- Where applicable, remove bank armoring/dikes
- Increase habitat diversity by reconnecting or increasing off-channel habitat back waters with cover and low energy refugia
- Maintain and increase floodplain connectivity to re-establish and dissipate high flow energy within the stream channel, maintain and enhance wetland complexes, and enhance ground water recharge
- Where applicable, remove bank armoring/dikes
- Increase natural nutrient recruitment from riparian vegetation
- Where possible increase the number of large trees (site potential tree height) and complex riparian communities that will eventually increase the natural recruitment of LWD
- When growing tall trees is not desirable, increase shrub and deciduous (willow) tree cover
- Where appropriate, establish areas where natural channel migration can occur
- Maintain fluvial processes and floodplain function

In-Channel

Management Strategy

- Improve in-channel attributes for the mainstem and tributary streams throughout the assessment unit

Management Objectives

- Maintain and enhance riparian vegetation along unstable stream banks
- Increase natural stream bank stability using active and passive restoration techniques
- Where appropriate, provide in-stream structures (large wood, rock or other natural materials) that will increase pool habitat and enhance salmonid habitat diversity, habitat quality and quantity, and channel integrity
- Where appropriate, restore natural channel form, including reconnection to floodplain

Passage

Management Strategy

- Restore adult and juvenile fish passage throughout the assessment unit

Ecological

Management Strategy

- Control or eliminate brook trout from the assessment unit

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Create approximately two acres of off-channel habitat that would provide additional perennial wetland habitat and ground water storage.

Monitoring Indicator:

- Acres of perennial wetland habitat

Water Quality

- Determine point and non-point source pollution and establish a plan to prevent pollutants from entering the water system.

Monitoring Indicator:

- Report for annual water quality monitoring scheme developed and begin implementation by 2007

Water Quantity

- Continue evaluating flow conditions and identify potential actions, benefits and risks to increase low flows (i.e. surface or ground water storage, conveyance and/or on-farm efficiencies, etc.). Implement appropriate actions as identified.

Monitoring Indicator:

- Report completed in 2007. Begin implementing priority items

Obstruction to Fish Passage

- Identify priority fish passage obstructions and replace as identified

Monitoring Indicator:

- Report identifying all priority passage issues completed by 2007. Implement all priority actions

Ecological Conditions

- Encourage beaver populations and developments where appropriate

Monitoring Indicator:

- Number of colonies of beaver families. Identify suitable areas by 2007

7.8.7 Peshastin Creek Assessment Unit

Assessment Unit Summary

Table 75. Peshastin Creek assessment unit summary

Summary of Peshastin Creek Assessment Unit	
Focal species Spring chinook Coho Steelhead Bull trout Cutthroat trout	Assessment Unit Priority Category 2 Key Sub watersheds Upper Peshastin Lower Peshastin Ingalls Creek
Limiting Factors Key Habitat Quantity Riparian/Floodplain Function Habitat Diversity Channel Stability Elevated Temperature Flow Obstructions	Hypothesized Effects to Focal Species Water Quality (Low) Water Quantity (Moderate) Riparian/Floodplain (High) In-Channel (High) Fish Passage (Moderate-High) Ecological (Data Gap)

Management Strategy Recommendations

Water Quality

Temperature

Management Strategies

- Improve elevated water temperatures in Peshastin Creek by improving low flow conditions and increasing riparian shade and floodplain function
- Improve elevated water temperatures in tributaries by reducing channel confinement and improving degraded riparian conditions

Sediment

Management Strategy (tributaries)

- Reduce elevated fine sediment percentages in the mainstem and tributary stream substrates

Management Objectives (tributaries)

- Maintain and improve road conditions to minimize or eliminate sediment delivery into the stream channel
- Improve riparian vegetation and stream bank conditions to reduce or eliminate elevated sediment delivery to streams

Contaminants

Management Strategy

- Enhance water quality in the mainstem Peshastin Creek

Management Objectives

- Develop programs and strategies for the application of toxic pesticides and herbicides that also restrict these materials from contacting surface water
- Support efforts that restrict waste materials from entering subbasin waters

Management Strategy (tributaries)

- Preserve water quality in tributary streams

Water Quantity

Management Strategy

- Enhance mainstem flows by improving overall watershed vegetative and hydrologic conditions, and water use efficiency

Management Objectives

- Support the development and use of programs that increase water use efficiency
- Evaluate the potential and feasibility for water storage within the assessment unit

Management Strategy (tributaries)

- Improve tributary flows to the natural hydrograph by improving the road network, improving stream channel confinement, and relocating valley bottom roads where feasible

Management Objectives (tributaries)

- Improve the road network by minimizing the restrictive interactions with streams
- Minimize stream channel confinement
- Relocate valley bottom roads where feasible

Riparian Floodplain

Management Strategy

- Improve riparian and floodplain characteristics throughout the assessment unit where feasible

Management Objectives

- Improve riparian vegetation corridors where they have been lost using active restoration practices
- Avoid activities within riparian corridors that disrupt riparian function

- Preserve high quality riparian patches as refuge habitats
- Where feasible, relocate valley bottom roads to allow for restoring riparian vegetation, enhancing floodplain function, and providing for channel migration
- Increase habitat diversity by reconnecting or increasing off-channel habitat, back waters with cover, and low energy refugia
- Maintain and increase floodplain connectivity to re-establish and dissipate high flow energy within the stream channel, maintain and enhance wetland complexes, and enhance ground water recharge
- Where applicable, remove bank armoring/dikes
- Increase nutrient recruitment of detritus from riparian vegetation
- Increase the number of large trees (site potential tree height) and complex riparian communities that will eventually increase the natural recruitment of large woody debris
- Where appropriate, establish areas where natural channel migration can occur
- Maintain fluvial processes and floodplain function
- Avoid the loss of wetlands and off-channel habitats
- Explore sediment data gap

In-Channel

Management Strategy

- Improve in-channel attributes for the mainstem and enhance or maintain tributary streams throughout the assessment unit

Management Objectives

- Maintain and enhance riparian vegetation along unstable stream banks
- Increase stream bank stability using active and passive restoration techniques
- Where appropriate, provide in-stream structures (large wood, rock or other natural materials) that will increase pool habitat and enhance salmonid habitat diversity, habitat quality and quantity, and channel integrity
- Where appropriate, restore natural channel form, including reconnection to floodplain

Passage

Management Strategy

- Restore adult and juvenile fish passage throughout the assessment unit

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Implement and maintain approximately 5-10 acres of riparian plantings throughout the Assessment Unit. Focus of these efforts is to increase shrub and tree vegetation and increase streambank stability and stream shade.

Monitoring Indicator:

- Increase in riparian ground cover, vegetation structure and composition

Stream Channel Condition and Function

- Evaluate and implement 15 in-channel structures that would provide additional pool habitat, provide for reduction of channel width to depth ratio, sort substrates and provide for additional spawning gravels and increase structural diversity in the stream channel.

Monitoring Indicator:

- Number of in-channel structures implemented. Increase in amount of useable habitat available for focal species; width to depth ration; substrate composition
- Create approximately two acres of off-channel habitat that would provide additional perennial wetland habitat and ground water storage.

Monitoring Indicator:

- Number acres of perennial wetlands and off channel habitat created

Water Quantity

- Continue evaluating flow conditions and identify potential actions, benefits and risks to increase low flows (i.e. surface or ground water storage, conveyance and/or on-farm efficiencies, etc.). Implement appropriate actions as identified.

Monitoring Indicator:

- Report completed by 2007. Priority actions begin implementation

Obstruction to Fish Passage

- Identify and replace all culverts that are currently blocking fish passage and would provide significant benefit for additional habitat availability.

Monitoring Indicator:

- Report identifying all priority passage issues completed by 2007. Implement all priority actions
- Continue to evaluate and develop a fish passage structure in the lower Peshastin River to restore year-around passage into the upper watersheds.

Monitoring Indicator:

- Passage restored throughout the year

Ecological Conditions

- Encourage beaver populations and developments where appropriate

Monitoring Indicator:

- Number of colonies of beaver families. Identify suitable locations for beavers by 2007

7.8.8 Chumstick Creek Assessment Unit

Assessment Unit Summary

Table 76. Chumstick Creek assessment unit summary

<table>
<tr><th colspan="2">Summary of Chumstick Creek Assessment Unit</th></tr>
<tr><td rowspan="2">Focal species
Steelhead, Coho</td><td>Assessment Unit Priority
Category 3</td></tr>
<tr><td>Key Sub watersheds
None</td></tr>
<tr><td>Limiting Factors
Key Habitat Quantity
Riparian/Floodplain Function
Habitat Diversity
Channel Stability
Sediment
Flow
Obstructions</td><td>Hypothesized Effects to Focal Species
Water Quality (None)
Water Quantity (Moderate –High)
Riparian/Floodplain (High)
In-Channel (Moderate-High)
Fish Passage (High)
Ecological (Data Gap)</td></tr>
</table>

Management Strategy Recommendations

Water Quality

Temperature

Management Strategy

- Enhance elevated stream temperatures in the mainstem and tributaries throughout the assessment unit

Management Objective

- Improve low flow by improving channel confinement and degraded riparian conditions

Sediment

Management Strategy (tributaries)

Reduce elevated fine sediment percentages in the mainstem and tributary stream substrates

Management Objectives (tributaries)

- Maintain and improve road conditions to minimize or eliminate sediment delivery into the stream channel
- Improve riparian vegetation and stream bank conditions to reduce or eliminate elevated sediment delivery to streams

Contaminants

Management Strategy

- Enhance water quality primarily for the mainstem of Chumstick Creek

Management Objectives

- Develop programs and strategies for the application of toxic pesticides and herbicides that also restrict these materials from contacting surface water
- Support local and regional efforts that restrict waste materials from entering subbasin waters

Management Strategy (tributaries)

- Enhance water quality in tributary streams

Management Objective (tributaries)

- Support efforts that restrict waste materials from entering subbasin waters

Water Quantity

Management Strategy

- Enhance mainstem flows by improving overall watershed vegetative and hydrologic conditions and water use efficiency

Management Objectives

- Support the development and use of programs that increase water use efficiency
- Evaluate the potential and feasibility for water storage within the assessment unit

Management Strategy (tributaries)

- Restore tributary flows towards the natural hydrograph

Management Objectives (tributaries)

- Reduce the road network where roads are determined to no longer be needed
- Minimize stream channel confinement where possible
- Relocate valley bottom roads where feasible

Riparian/Floodplain

Management Strategy

- Improve riparian and floodplain characteristics throughout the assessment unit where feasible

Management Objectives

- Improve riparian vegetation corridors where they have been lost using active restoration practices
- Avoid activities within riparian corridors that disrupt riparian function
- Preserve high quality riparian patches as refuge habitats
- Where feasible, relocate valley bottom roads to allow for restoring riparian vegetation, enhancing floodplain function, and providing for channel migration
- Increase habitat diversity by reconnecting or increasing off-channel habitat, back waters with cover, and low energy refugia
- Maintain and increase floodplain connectivity to re-establish and dissipate high flow energy within the stream channel, maintain and enhance wetland complexes, enhance ground water recharge, and remove bank armoring where applicable
- Increase nutrient recruitment of detritus from riparian vegetation
- Where possible, increase the number of large trees (site potential tree height) and complex riparian communities that will eventually increase the natural recruitment of LWD
- When growing large trees is not desirable increase shrub and deciduous tree cover
- Where appropriate, establish areas where natural channel migration can occur
- Maintain fluvial processes and floodplain function

In-Channel

Management Strategy

- Improve in-channel attributes for the mainstem and tributary streams throughout the assessment unit

Management Objectives

- Maintain and enhance riparian vegetation along unstable stream banks
- Replace the invasive reed canary grass (Phalaris arundinacea) with a native ground cover to maintain stream bank stability
- Increase stream bank stability using active and passive restoration techniques
- Provide in-stream structures (large wood, rock or other natural materials) that will increase pool habitat and enhance salmonid habitat diversity, habitat quality and quantity and channel integrity
- Where appropriate, restore natural channel form, including reconnection to floodplain

Passage

Management Strategy

- Restore adult and juvenile fish passage throughout the assessment unit

Ecological

Management Strategy

- Control or eliminate brook trout from the assessment unit

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Implement and maintain approximately 50 acres of riparian plantings throughout the Assessment Unit. Focus of these efforts is to increase shrub and tree vegetation and reduce Canary Reed Grass where ever feasible.

Monitoring Indicator:

- Increase in riparian ground cover, vegetation structure and composition.
- Identify and relocate approximately 5-miles of roads embedded in riparian reas.

Monitoring Indicator:

- Number of miles road relocated from riparian areas
- Create approximately two acres of off-channel habitat that would provide additional perennial wetland habitat and ground water storage.

Monitoring Indicator:

- Number acres of perennial wetlands and off channel habitat created

Stream Channel Condition and Function

- Evaluate and implement 10 in-channel structures that would provide additional pool habitat and increase structural diversity in the stream channel.

Monitoring Indicator:

- Number of in-channel structures implemented. Increase in amount of useable habitat available for focal species; width to depth ration; substrate composition

Water Quality

- Determine point and non-point source pollution and establish a plan to prevent these pollutants from entering the water system.

Monitoring Indicator:

- Monitoring Indicator: Report for annual water quality monitoring scheme developed and begin implementation by 2007

Water Quantity

- Continue evaluating flow conditions and identify potential actions, benefits and risks to increase low flows (i.e. surface or ground water storage, conveyance and/or on-farm efficiencies, etc.). Implement appropriate actions as identified.

Monitoring Indicator:

- Report completed by 2008. Implementation to begin on priority findings and objectives in 2009

Obstruction to Fish Passage

- Restore year-around passage above the North Road culvert
- Identify and replace 10-15 culverts that are currently blocking fish passage and would provide the greatest benefit for additional habitat availability

Monitoring Indicator:

- Report identifying all priority passage issues completed by 2007. Implement all priority actions

Ecological Conditions

- Encourage beaver populations and developments where appropriate.

Monitoring Indicator:

- Number of colonies of beaver families. Identify suitable areas by 2007

7.8.9 Icicle Creek Assessment Unit

Assessment Unit Summary

Table 77. Icicle Creek assessment unit summary

Summary of Icicle Creek Assessment Unit	
Focal species Spring chinook, Late-run chinook, Coho, Steelhead, Bull trout (lower watershed) Bull trout, Cutthroat trout (upper watershed)	Assessment Unit Priority Category 2 Key Sub watersheds: Upper Icicle Creek Jack Creek French Creek Head waters Icicle Creek
Limiting Factors Competition (Leavenworth NFH) Habitat Diversity (lower watershed) Elevated Temperature (lower watershed) Flow (lower watershed) Obstructions	Hypothesized Effects to Focal Species Water Quality (Low-Moderate) Water Quantity (Moderate) Riparian/Floodplain (Moderate) In-Channel (Moderate) Fish Passage (Low) Ecological (1)

(1)Hypothesized Effects to Focal Fish Species pertains primarily to the lower mainstem of Icicle Creek

Management Strategy Recommendations

Water Quality

Temperature

Management Strategy

- Enhance elevated stream temperatures in the lower mainstem creek by improving low flow and degraded riparian conditions

Management Strategy

- Maintain existing condition and trend in tributary streams

Sediment

Management Strategy (tributaries)

- Reduce fine sediment level in the lower mainstem

Management Objective (tributaries)

- Improve streambank stability and riparian ground cover

Management Strategy

- Maintain existing condition and trend in tributary streams

Contaminants

Management Strategy

- Maintain or enhance water quality in the lower mainstem

Management Objectives

- Develop programs and strategies for the application of toxic pesticides and herbicides that also restrict these materials from contacting surface water
- Support efforts that restrict waste materials from entering subbasin waters

Water Quantity

Management Strategy

- Improve stream flow in lower mainstem

Management Objectives

- Support the development and use of programs that increase water use efficiency
- Continue to evaluate and improve irrigation, municipal, and rural efficiencies that conserve waters of Icicle Creek
- Evaluate the potential and feasibility for additional water storage within the assessment unit

Management Strategy (tributaries)

- Maintain tributary existing condition and trend

Riparian Floodplain

Management Strategy

- Improve riparian and floodplain characteristics in the lower portion of the assessment unit (mainstem river below Snow Creek)

Management Objectives

- Improve riparian vegetation corridors where they have been lost using active restoration practices
- Avoid activities within riparian corridors that disrupt riparian function
- Increase habitat diversity by reconnecting or increasing off-channel habitat, back waters with cover and low energy refugia
- Increase the number of large trees (site potential tree height) and complex riparian communities that will eventually increase the natural recruitment of LWD

- Where appropriate, establish areas where natural channel migration can occur
- Maintain fluvial processes and floodplain function
- Where feasible, relocate valley bottom roads to allow for restoring riparian vegetation, enhancing floodplain function, and providing for channel migration

Management Strategy (tributaries)

- Maintain and enhance existing condition and trend in the upper mainstem river and tributary streams

Management Objectives (tributaries)

- Where feasible, relocate valley bottom roads and recreational facilities (campgrounds) to allow for restoring riparian vegetation, enhancing floodplain function, and providing for channel migration
- Continue to allow for passive restoration of riparian vegetation and natural recruitment of large wood in fire damaged areas

In-Channel

Management Strategy

- Enhance in-channel attributes in the lower portion of the assessment unit (mainstem river below Snow Creek)

Management Objectives

- Provide in-stream structures (large wood, rock or other natural materials) that will increase pool habitat and enhance salmonid habitat diversity, habitat quality and quantity, and channel integrity
- Where appropriate, restore natural channel form, including reconnection to floodplain
- Increase natural stream bank stability using active and passive restoration techniques

Management Strategy (tributaries)

- Maintain and enhance in-channel characteristics in the upper mainstem river (above Snow Creek) and tributaries

Management Objective (tributaries)

- Maintain natural riparian, floodplain and fluvial processes

Passage

Management Strategies

- Restore adult and juvenile fish passage within the lower Icicle Creek (below Snow Creek)
- Maintain existing condition and trend in the upper Icicle Creek and tributaries

Ecological

Management Strategy

- Control and eradicate brook trout from the upper watershed

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Complete on-going investigations considering suitable in-channel and riparian habitat improvement projects and implement the priority and appropriate recommendations.

Monitoring Indicator:

To be determined upon findings of assessment.

Stream Channel Condition and Function

- Complete on-going investigations considering suitable in-channel and riparian habitat improvement projects and implement the priority and appropriate recommendations.

Monitoring Indicator:

- To be determined upon findings of assessment

Water Quality

- Near-term opportunity not identified to date. Reference: Monitoring Strategy for the Wenatchee Subbasin.

Water Quantity

- Complete on-going USFWS in-stream flow study from Snow Creek to the Leavenworth NFH Project area. Implement the priority and appropriate recommendations. Complete evaluation of re-connecting all or portions of historic river channel to existing channel.

Monitoring Indicator:

- Report completed in 2007. Begin implementing priority actions Measure changes in stream flow

Obstruction to Fish Passage

- Evaluate the feasibility and benefit/risks of enhancing fish passage through the “boulder field” at river mile 5.6. Implement passage if determined appropriate.
- Allow passage of bull trout and steelhead past the Leavenworth National Fish Hatchery.
- Identify and replace all culverts that are currently blocking fish passage and would provide significant benefit for additional habitat availability.

Monitoring Indicator:

- Report identifying all priority passage issues completed by 2007. Implement all priority actions.

7.8.10 Nason Creek Assessment Unit

Assessment Unit Summary

Table 78. Nason Creek assessment unit summary

Summary of Nason Creek Assessment Unit	
Focal species Spring chinook, Coho, Steelhead, Bull trout, Cutthroat trout	Assessment Unit Priority Category 1
	Key Sub watersheds Head waters Nason, Upper Nason Lower Nason
Limiting Factors Key Habitat Quantity Riparian / Floodplain Condition Channel Stability Habitat Diversity Sediment Elevated Temperature Obstructions Competition (Brook trout)	Hypothesized Effects to Focal Species Water Quality (Moderate) Water Quantity (None) Riparian/Floodplain (High) In-Channel (High) Fish Passage (Moderate-High) Ecological (Low-Moderate)

Management Strategy Recommendations

Water Quality

Temperature

Management Strategies

- Improve elevated stream temperatures in the lower mainstem creek (below Mill Creek) by improving low flow conditions, channel confinement, and degraded riparian conditions
- Maintain and enhance elevated temperatures in the upper mainstem and tributary streams by improving riparian conditions where needed

Sediment

Management Strategy

- Reduce fine sediment level in the lower mainstem

Management Objective

- Improve stream-bank stability, floodplain connectivity and riparian conditions and ground cover

Management Strategy

- Maintain and reduce sediment delivery in tributary streams

Management Objective

- Improve riparian road conditions to reduce sediment delivery

Contaminants

Management Strategy

- Enhance water quality in the lower mainstem (below Mill Creek)

Management Objective

- Continue to augment and coordinate programs that restrict waste materials from the transportation systems, rural sources, failing septic systems and livestock from entering surface and ground water

Management Strategy (tributaries)

- Maintain water quality in tributary streams

Water Quantity

Management Strategy

- Enhance mainstem flows by improving overall watershed vegetative and hydrologic conditions and water use efficiency

Management Strategy

- Maintain or improve tributary flows towards the natural hydrograph
- Improve the road network, where roads are determined to no longer be needed
- Improve stream channel confinement where possible
- Relocating valley bottom roads where feasible

Management Objective

- Evaluate the potential to decrease summer surface withdrawals by converting water withdrawals to ground water wells
- Evaluate the potential and feasibility for water storage within the assessment unit

Riparian Floodplain

Management Strategy

- Improve riparian and floodplain characteristics in the lower mainstem (below Mill Creek) where feasible

Management Strategy (tributaries)

- Maintain and enhance tributary riparian and floodplain characteristics

Management Objectives

- Improve riparian vegetation corridors where they have been lost using active restoration practices
- Avoid activities within riparian corridors that disrupt riparian function
- Preserve high quality riparian patches as refuge habitats
- Where feasible, relocate valley bottom roads to allow for restoring riparian vegetation, enhancing floodplain function, and providing for channel migration
- Increase habitat diversity by reconnecting or increasing off-channel habitat, back waters with cover and low energy refugia
- Maintain and increase floodplain connectivity to re-establish and dissipate high flow energy within the stream channel, maintain and enhance wetland complexes, enhance ground water recharge, and where applicable, remove bank armoring/dikes
- Increase the number of large trees (site potential tree height) and complex riparian communities that will eventually increase the natural recruitment of large woody debris
- Establish areas where natural channel migration can occur (where appropriate)
- Maintain fluvial processes and floodplain function

In-Channel

Management Strategy

- Improve in-channel attributes for the mainstem (focus on lower 15 miles of Nason Creek) and some tributary streams throughout the assessment unit

Management Objectives

- Maintain and enhance riparian vegetation along unstable stream banks
- Increase natural stream bank stability using active and passive restoration techniques
- Where appropriate, provide in-stream structures (large wood, rock or other natural materials) that will increase pool habitat and enhance salmonid habitat diversity, habitat quality and quantity, and channel integrity
- Where appropriate, restore natural channel form, including reduction of channel confinement, reconnection to tributary confluences, side channels, and floodplain

Passage

Management Strategy

- Restore adult and juvenile fish passage throughout the assessment unit

Ecological

Management Strategy

- Control or eradicate brook trout throughout the assessment unit

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Implement and maintain approximately 5-10 acres of riparian plantings throughout the Assessment Unit. Focus of these efforts is to increase streambank stability and stream shade and to enhance re-connected side channel habitat.

Monitoring Indicator:

- Increase in stream shade, riparian ground cover, vegetation structure and composition. Lineal measurements of stable stream channel.
- Create approximately two acres of off-channel habitat that would provide additional perennial wetland habitat and ground water storage

Monitoring Indicator:

- Acres of off-channel and wetland habitat
- Maintain the existing high quality riparian and perennial wetland, side channel and off-channel habitats within the assessment unit.

Monitoring Indicator:

- Increase acres side channel habitat; useable habitat for focal species at various flow and environmental conditions

Stream Channel Condition and Function

- In the lower 14-miles of Nason Creek, identify approximately 10 sites to reconnect side-channel habitat to the mainstem river and implement the appropriate actions.
- In the lower 14-miles of Nason Creek, evaluate and implement 10-15 in-channel structures that would provide additional pool habitat and increase structural diversity in the stream channel.

Monitoring Indicator:

- Number of miles of additional side channel habitat and number of sites of new in-channel structures that are useable habitat for focal species at various flow and environmental conditions

Water Quantity

- Continue evaluating flow conditions and identify potential actions, benefits and risks of actions that would increase base flows (i.e. surface or groundwater storage). Implement appropriate actions as identified.

Monitoring Indicator:

- Report completed by 2008. Implementation to begin on priority findings and objectives in 2010

Ecological Conditions

- Encourage beaver populations and developments where appropriate.

Monitoring Indicator:

- Number of colonies of beaver families. Identify suitable areas by 2007

7.8.11 Little Wenatchee River Assessment Unit

Assessment Unit Summary

Table 79. Little Wenatchee assessment unit summary

Summary of Little Wenatchee Assessment Unit	
Focal species Spring chinook, Coho, Sockeye, Steelhead, Bull trout, Cutthroat trout	Assessment Unit Priority Category 1 Key Sub watersheds Head waters Little Wenatchee Upper Little Wenatchee Lower Little Wenatchee Rainy Creek Lake Creek
Limiting Factors Competition (Brook trout)	Hypothesized Effects to Focal Species Water Quality (None) Water Quantity (None) Riparian/Floodplain (None) In-Channel (None) Fish Passage (None) Ecological (Data Gap)

Management Strategy Recommendations

Water Quality

Temperature

Management Strategy

- Maintain existing condition and trend in mainstem and tributary streams

Management Objective

Continue to monitor for condition and trend in the lower mainstem due to exceedences of water quality standards (focus on lower mainstem)

Sediment

Management Strategy

Maintain existing condition and trend in mainstem and tributary streams

Management Objective

- Continue to monitor condition and trend for sediment and cobble embeddedness. (focus on Rainy Creek due to potential past hydrologic disturbance from logging activities)

Contaminants

Management Strategy

- Maintain existing condition in mainstem and tributaries

Management Objective

- Monitor for trend

Water Quantity

Management Strategy

- Maintain existing condition for mainstem and tributaries

Management Objectives

- Monitor for trend (focus on Rainy Creek)
- Evaluate the potential and feasibility for additional water storage within the assessment unit

Riparian/Floodplain

Management Strategy

- Maintain and enhance lower mainstem riparian vegetation along the Little Wenatchee River

Management Strategy (tributaries)

- Maintain existing condition and trend in tributary streams

Management Objective

- Where feasible, relocate valley bottom roads and recreational facilities (campgrounds) to allow for restoring riparian vegetation, enhancing floodplain function and connection to stream channel, and providing for channel migration

In-Channel

Management Strategy

- Enhance lower Little Wenatchee River habitat diversity

Management Strategy (tributaries)

- Maintain existing condition and trend in tributary streams

Management Objective

- Where appropriate, provide instream structures (large wood or other natural materials) that will increase pool habitat and enhance salmonid habitat diversity, habitat quality and quantity, and channel integrity

Passage

Management Strategy

- Maintain existing condition throughout watershed

Ecological

Management Strategy

- Control or eradicate brook trout

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Maintain the existing high quality riparian and perennial wetland, side channel and off-channel habitats within the assessment unit.

Monitoring Indicator:

- No net loss of these habitat variables measured by aerial photography and GIS technology.

7.8.12 White River Assessment Unit

Assessment Unit Summary

Table 80. White River assessment unit summary

Summary of White River Assessment Unit	
Focal species Spring chinook, Sockeye, Steelhead, Bull trout, Cutthroat trout	Assessment Unit Priority Category 1
	Key Sub watersheds: Head waters White Rive Upper White River Lower White River Napeequa Creek Panther Creek
Limiting Factors Key Habitat Quantity (lower stream reaches only) Competition (Brook trout)	Hypothesized Effects to Focal Species Water Quality (None) Water Quantity (None) Riparian/Floodplain (Low) In-Channel (Low) Fish Passage (None) Ecological (Data Gap)

Management Strategy Recommendations

Water Quality

Temperature

Management Strategy

- Maintain existing condition for mainstem and tributaries

Sediment

Management Strategy

- Maintain existing condition for mainstem and tributaries

Contaminants

Management Strategy

- Maintain existing condition for mainstem and tributaries

Water Quantity

Management Strategy

- Maintain existing condition for mainstem and tributaries

Riparian/Floodplain

Management Strategy

- Improve lower mainstem (11 miles) interaction with floodplain

Management Objectives

- Where possible, remove berms and reconnect floodplain with mainstem channel
- Allow large trees to begin growing next to mainstem where possible
- Where feasible, relocate valley bottom roads and recreational facilities (campgrounds) to allow for restoring riparian vegetation, enhancing floodplain function and connection to stream channel, and providing for channel migration
- Avoid activities within riparian corridors that disrupt riparian function
- Where applicable, maintain and increase floodplain connectivity to re-establish and dissipate high flow energy within the stream channel, maintain and enhance wetland complexes, enhance ground water recharge, and remove bank armoring/dikes
- Enhance fluvial processes and floodplain function
- Maintain existing conditions in tributary streams

In-Channel

Management Strategy

- Enhance in-channel attributes for the mainstem (focus on lower 11 miles of the White River)

Management Objective

- Increase habitat diversity by reconnecting or increasing off-channel habitat, back waters with cover and low energy refugia

Passage

Management Strategy

- Maintain existing condition throughout the assessment unit

Ecological

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Improve 5-10 acres of riparian condition and channel connectivity with the floodplain.
- Monitoring Indicator: Increase in stream shade, riparian ground cover, vegetation structure and composition.

- Maintain the existing high quality riparian and perennial wetland, side channel and off-channel habitats within the Assessment Unit.

  Monitoring Indicator:

- No net loss of these habitat variables measured by aerial photography and GIS technology

Stream Channel Condition and Function

- Improve 2-3 river miles of in-channel habitat diversity.

  Monitoring Indicator:

- Evaluate pool quality, pools per mile and amount of large wood complexes in stream channel

7.8.13 Chiwawa River Assessment Unit

Assessment Unit Summary

Table 81. Chiwawa River assessment unit summary

Summary of Chiwawa River Assessment Unit	
Focal species Spring chinook, Steelhead, Bull trout, Cutthroat trout.	Assessment Unit Priority Category 1
	Key Sub- watersheds: Head waters Chiwawa Upper Chiwawa Middle Chiwawa Lower Chiwawa Rock Creek Chikamin Creek
Limiting Factors Competition (Brook trout)	Hypothesized Effects to Focal Species Water Quality (None) Water Quantity (None) Riparian/Floodplain (None) In-Channel (None) Fish Passage (None) Ecological (Data Gap)

Management Strategy Recommendations

Water Quality

Temperature

Management Strategy

- Maintain existing condition for mainstem

Management Strategy (tributaries)

- Reduce elevated temperatures in Big Meadow Creek

Management Objective

- Maintain trend for increased riparian vegetating and improving stream channel conditions

Sediment

Management Strategy

- Bring sediment delivery into the range of natural conditions in Big Meadow Creek

Management Objective

- Maintaining existing reforestation trend

Contaminants

Management Strategy

- Maintain existing condition for mainstem and tributaries

Water Quantity

Management Strategy

- Maintain existing condition for mainstem and tributaries

Riparian Floodplain

Management Strategy

- Maintain and enhance lower mainstem

Management Objectives

- Where feasible, relocate valley bottom roads and recreational facilities (campgrounds) to allow for restoring riparian vegetation, enhancing floodplain function and connection to stream channel, and providing for channel migration
- Avoid activities within riparian corridors that disrupt riparian function
- Preserve high quality riparian patches as refuge habitats
- Reduce impacts to floodplain and riparian characteristics from future developments, agricultural practices and livestock management
- Where appropriate, establish areas where natural channel migration can occur
- Maintain fluvial processes and floodplain function
- Maintain existing condition in tributaries

In-Channel

Management Strategy

- Enhance lower Little Wenatchee River

Management Objective

- Enhance and maintain in-stream characteristics that will provide high quality pool habitat and structural diversity

Management Strategy

- Maintain existing condition and trend in tributary streams

Passage

Management Strategy

- Maintain existing conditions in the mainstem

Management Objective

- Continue to monitor potential affects to passage at the Chiwawa (spring chinook) brood stock collection weir

Management Strategy

- Enhance fish passage in some tributary streams

Management Objective

- Evaluate and replace culverts as needed

Ecological

[No information to date]

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Maintain the existing high quality riparian and perennial wetland, side channel and off-channel habitats within the assessment unit.

Monitoring Indicator:

- No net loss of these habitat variables measured by aerial photography and GIS technology

7.8.14 Lake Wenatchee Assessment Unit

Assessment Unit Summary

Table 82. Lake Wenatchee assessment unit summary

Summary of Lake Wenatchee Assessment Unit	
Focal species: Sockeye, Bull trout	Assessment Unit Priority Category 1 Key Sub watersheds: NA
Limiting Factors: Nutrients/Food Competition	Hypothesized Effects to Focal Species Water Quality (Data Gap) Water Quantity (None) Riparian/Floodplain (Moderate) In-Channel (Moderate) Fish Passage (Low-Moderate) Ecological (Data Gap)

Management Strategy Recommendations

[No information to date]

Near Term Opportunities and Measurable Objectives

Riparian/Floodplain Condition and Function

- Maintain the existing high quality riparian and perennial wetland habitats surrounding Lake Wenatchee.

Monitoring Indicator:

- No net loss of these habitat variables measured by aerial photography and GIS technology.

Water Quality

- Develop and implement long term water quality evaluation strategy to monitor condition and trend of Lake Wenatchee.

Monitoring Indicator:

Report for annual water quality monitoring scheme developed and begin implementation by 2007.

Ecological Conditions

- Develop and implement a long term biological community evaluation and strategy to monitor condition and trend with a particular focus on bull trout and sockeye salmon abundance and ecological relationships.

- Evaluate the effects of existing and future developments surrounding the lake on the associated floodplains and biological conditions.
- Evaluate the benefits and risks of enhancing nutrients in Lake Wenatchee to salmonid, specifically sockeye production.

Monitoring Indicator:

- Reports identifying long term management and/or monitoring completed by 2008. Begin implementing priority actions by 2010

7.8.15 Subbasin Wide Opportunities

The following actions are in common to most or all assessment units. These actions should be evaluated for their level of need and suitability for each individual assessment unit and be implemented as appropriate.

Riparian Floodplain Conditions

- Near-term opportunity identified within the assessment unit.

Stream Channel Condition and Function

- Complete a comprehensive evaluation of sediment delivery into streams from the road system. Prioritize management actions and implement actions to reduce or eliminate sediment delivery for all high priority roads.
- Monitoring Indicator: Complete a long term management plan which is coordinated between all parties with authority and responsibility for road systems by 2007.
- Evaluate existing and potential salmonid carrying capacity in all of the Assessment Units to increase our knowledge and understanding on what population target numbers for salmon recovery may be supportable by the available habitats.
- Monitoring Indicator: Complete report by 2008 for all assessment units.

Water Quality

- Evaluate bio-accumulation of toxic materials within the flesh of indicator species to determine the extent that these materials are entering into the ecological and human food chain.

Monitoring Indicator: Develop long term strategy and complete the Report by 2008. Begin implementing priority actions.

- Continue to use FLIR (forward looking infrared) technology to identify areas where important differences in water temperature may signal important micro-refugia for winter and summer rearing. FLIR information is presently available for summer months. FLIR information should be made available during winter months.

Monitoring Indicator: Complete additional FLIR flights by 2006 and complete analytical report by 2008. Begin implementing priority actions.

Water Quantity

- As demand for water use continues to grow within the subbasin, so does the need to evaluate critical flows to support geo-fluvial processes and the stream/floodplain ecosystems. Evaluation of annual flow and potential withdrawals using, but not limited to the IFIM methodology should be completed. This work will contribute to a completed long term strategy for water management within the subbasin.

Monitoring Indicator: Complete IFIM (instream flow incremental methodology) and related work by 2007 and adopt instream flows by 2009. Begin implementing priority actions.

Obstruction to Fish Passage

- Identify and replace all priority culverts that are currently blocking fish passage into good quality habitat.

Monitoring Indicator: Report identifying all priority passage issues and opportunities completed by 2007. Implement all priority actions.

Ecological Conditions

- The extent of harassment and poaching on salmonids is unknown, especially when pre-spawning adults are holding and are very vulnerable. Develop and implement a long term and sustained public education campaign and increase enforcement activities to reduce harassment and poaching of salmonids.

Monitoring Indicator: Long term program defined and adopted by 2008. Begin implementing priority actions.

- Macro-invertebrate sampling within the Wenatchee subbasin has been infrequent and conducted without a larger-scale strategy. Complete a long term macro-invertebrate monitoring strategy and implement all high priority components of this strategy.

Monitoring Indicator: Long term program defined and adopted by 2006. Sample locations, protocol responsibilities identified. Begin implementing priority actions.

- It is generally assumed that significant biological (primary) productivity has been lost in the mainstem and tributary streams of the Wenatchee River due to a decrease of salmonid carcasses left after spawning. Resource managers should evaluate the best means to replenish these lost nutrients into the stream system and implement pilot projects to determine the potential benefits to salmonids and the stream ecology.

Monitoring Indicator: Develop pilot program by 2006 including monitoring strategy, protocols and responsibilities. Implement pilot program through 2009 and identify appropriate actions thereafter.

- Control and/or eradicate brook trout populations where appropriate within various assessment units to reduce competition and predation on native fish species.

Monitoring Indicator: Develop pilot program by 2006 including monitoring strategy, protocols and responsibilities. Implement pilot program through 2009 and identify appropriate actions thereafter.

7.8.16 Summary of Near-term Opportunities by Focal Species

The following opportunities exist for each of the fish focal species. This summary list is not intended to be all inclusive nor a prioritization of all needed actions. Implementation of these, and many other actions or evaluations would greatly benefit recovery of these focal populations.

Spring Chinook

Understanding the contribution of fall emigrating juveniles to returning adult escapement is an important piece of information that is currently lacking. Understanding the spawning success of hatchery fish and their naturally reproducing progeny is another important concern when making decisions on how to increase populations within the subbasin. This information would aid recovery efforts of this population.

Late-run Chinook

Increased habitat diversity (e.g., off-channel habitat, increased structural diversity, etc.) primarily in the lower Wenatchee River, coupled with increased nutrients and macro-invertebrate production should improve productivity for late-run chhinook.

Sockeye

Increasing understanding of those factors that affect juvenile survival (primarily in Lake Wenatchee) would aid in the ability to improve production of this species. Investigations regarding increased nutrient loads in Lake Wenatchee should be undertaken to determine the benefits and potential risks of this management action.

Coho

Continued development of a locally adapted broodstock is essential to ensure future populations of naturally spawning coho salmon in the Wenatchee subbasin. Increased habitat diversity (e.g. off channel habitat, increased structural diversity, etc,) primarily in Nason Creek, Peshastin Creek, Mission Creek, and the lower Wenatchee River would increase the success of naturally spawning coho and increase productivity. Evaluation of migrational delays in Tumwater Canyon could improve extreme flow passage conditions for adults migrating to the upper Wenatchee subbasin.

Steelhead

Increased habitat diversity (e.g., off channel habitat, increased structural diversity, etc.) primarily in the lower Wenatchee River, coupled with increased nutrients and macro-invertebrate production, and increased access to spawning and rearing habitats in tributary streams should improve productivity for steelhead. Information on spawning distribution and juveniles rearing needs are lacking in the Wenatchee River and collection of this information would increase managers' efforts at recovery.

Bull Trout and Westslope Cutthroat Trout

Population estimates and distribution remain widely unknown throughout the subbasin. Evaluations to better understand population characteristics of these species should continue, including but not limited to genetic analysis. Access to historic habitat is important to preserving life history diversity and increasing overall productivity.

Pacific Lamprey

Very little information about this species is available for the Wenatchee Subbasin. Evaluations should begin that identifies species presence, habitat preferences and habitat availability. Evaluations addressing artificial propagation of this species should be included within a larger and similar effort throughout the Columbia Cascade Province. Habitat improvement work should be implemented as determined appropriate.

8 Monitoring

8.1 Introduction

Managers often implement actions within tributary streams to improve the status of fish populations and their habitats. Until recently, there was little incentive to monitor such actions to see if they met their desired effects. Now, however, many programs require that funded actions include monitoring efforts. Within the Wenatchee subbasin several different organizations, including federal, state, tribal, local, and private entities currently implement tributary actions and conduct monitoring studies. Because of different goals and objectives, different entities are using different monitoring approaches and protocols. In some cases, however, different entities are measuring the same (or similar) things in the same streams with little coordination or awareness of each others efforts. The Upper Columbia Regional Technical Team (RTT) is aware of this problem and desires a monitoring strategy or plan that reduces redundancy, increases efficiency, and meets the goals and objectives of the various entities.

At least three different groups within the region have drafted integrated monitoring strategies that address many of the concerns of the RTT. For example, the Independent Scientific Advisory Board (ISAB) of the Northwest Power Planning Council outlined a monitoring and evaluation plan for assessing recovery of tributary habitat (ISAB 2003). They describe a three-tiered monitoring program that includes trend or routine monitoring (Tier 1), statistical (status) monitoring (Tier 2), and experimental research (effectiveness) monitoring (Tier 3). Trend monitoring obtains repeated measurements, usually representing a single spatial unit over a period of time, with a view to quantifying changes over time. Changes must be distinguished from background noise. This type of monitoring does not establish cause-and-effect relationships and does not provide inductive inferences to larger areas or time periods. Statistical monitoring, on the other hand, provides statistical inferences that extend to larger areas and longer time periods than the sample. This type of monitoring requires probabilistic selection of study sites and repeated visits over time. Experimental research monitoring is often required to establish cause-and-effect relationships between management actions and population/habitat response. This requires the use of experimental designs incorporating “treatments” and “controls” randomly assigned to study sites.

According to the ISAB (2003), the value of monitoring is greatly enhanced if the different types of monitoring are integrated. For example, trend and statistical monitoring will help define the issues that should be addressed with more intensive, experimental research monitoring. The latter will identify which habitat attributes are most informative and will provide conclusive information about the efficacy of various restoration approaches. Implementing experimental research in the absence of trend and statistical monitoring would increase uncertainty about the generalization of results beyond the sampling locations. The ISAB (2003) identified the following essential elements of a valid monitoring program.

- Develop a trend monitoring program based on remotely-sensed data obtained from sources such as aerial photography or satellite imagery or both.
- Develop and implement a long term statistical monitoring program to evaluate the status of fish populations and habitat. This requires probabilistic (statistical) site selection

procedures and establishment of common (standard) protocols and data collection methods.

- Implement experimental research monitoring at selected locations to establish the underlying causes for the changes in habitat and population indicators.

Another strategy developed by the Bonneville Power Administration, the U.S. Army Corps of Engineers, the Bureau of Reclamation (collectively referred to as the Action Agencies), and NOAA Fisheries responds to the Federal Columbia River Power System (FCRPS) Biological Opinion issued by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. Although the Action Agencies/NOAA Fisheries Draft Research, Monitoring, and Evaluation (RME) Program was developed before the release of the ISAB (2003) report, it is in many respects consistent with ISAB recommendations. For example, the draft RME Program calls for the classification of all watersheds that have listed fish populations and receive restoration actions. Classification is hierarchical and captures physical/environmental differences spanning from the largest scale (regional setting) down to the channel segment. This component of the draft RME Program comports with Tier 1 Trend Monitoring. Status Monitoring (similar to Tier 2 Statistical Monitoring) and Action Effectiveness Research (similar to Tier 3 Experimental Research) are also included in the RME Program. The ISAB is currently reviewing the RME Program.

About the time the Action Agencies/NOAA Fisheries released their draft program, the Washington Salmon Recovery Funding Board (WSRFB) released a draft monitoring and evaluation strategy for habitat restoration and acquisition projects. The document identified implementation, effectiveness, and validation monitoring as key components of their program. The monitoring program is scaled to capture factors operating at different hierarchical levels. At the lowest level (Level 0), the program determines if the action was implemented (implementation monitoring). Level 1 monitoring determines if projects meet the specified engineering and design criteria. Level 2 and 3 monitoring assess the effectiveness of projects on habitat and fish abundance, respectively. Levels 1-3 constitute effectiveness monitoring. Finally, level 4 (validation) monitoring addresses how management and habitat restoration actions, and their cumulative effects, affect fish production within a watershed. This type of monitoring is the most complex and technically rigorous.

Although the three programs (ISAB, Action Agencies/NOAA Fisheries, and WSRFB) describe monitoring in slightly different terms, they all address the same goal. That is, all three intend to assess the effectiveness of restoration projects and management actions on tributary habitat and fish populations. Consequently, the overall approaches among the three programs are similar, with the Action Agencies/NOAA Fisheries RME Program being the most intensive and extensive, in part because of the requirements of the FCRPS Biological Opinion. Indeed, the Action Agencies/NOAA Fisheries Program calls for monitoring all tributary actions with intensive, standardized protocols and data collection methods. For each tributary action, a list of specific indicators, ranging from water quality to watershed condition, are to be measured.

As noted earlier, various entities, including the Washington Salmon Recovery Fund Board, will be funding and implementing various restoration projects and actions within the Wenatchee Basin. These projects will be monitored to assess their effectiveness. Other groups, such as the U.S. Forest Service, U.S. Fish and Wildlife Service, Washington Department of Ecology, Washington Department of Fish and Wildlife, Chelan County, and Chelan County Public Utility District, will continue their ongoing monitoring of fish and habitat in the basin. In addition, NOAA Fisheries, with funding from the Bonneville Power Administration, will implement the status/trend monitoring component of the Action Agencies/NOAA Fisheries RME Plan in the basin. Because of all the activities occurring within the basin, it is important that the monitoring plan capture the needs of all entities, avoids duplication of sampling efforts, increases monitoring efficiency, and reduces overall monitoring costs.

The monitoring plan described in this document is not another regional monitoring strategy. Rather, this plan draws from the existing strategies (ISAB, Action Agencies/NOAA Fisheries, and WSRFB) and outlines an approach specific to the Wenatchee Basin. The plan described here addresses the following basic questions:

1. What are the current habitat conditions and abundance, distribution, life-stage survival, and age-composition of ESA-listed fish in the Wenatchee Basin (status monitoring)?
2. How do these factors change over time (trend monitoring)?
3. What effects do tributary habitat actions have on fish populations and habitat conditions (effectiveness monitoring)?

The plan is designed to address these questions and at the same time eliminate duplication of work, reduce costs, and increase monitoring efficiency. The implementation of valid statistical designs, probabilistic sampling designs, standardized data collection protocols, consistent data reporting methods, and selection of sensitive indicators will increase monitoring efficiency. An efficient monitoring plan reduces “error” to the maximum extent possible. (One can think of error as unexplained variability (see Section 3.3), which can reduce monitoring efficiency through the use of invalid statistical designs, biased sampling designs, poorly selected indicators, biased measurement protocols, and non-standardized reporting methods.) For this plan to be successful, all organizations involved must be willing to cooperate and freely share information. Cooperation includes sharing monitoring responsibilities, adjusting or changing sampling methods to comport with standardized protocols, and adhering to statistical design criteria. In those cases where the standardized method for measuring an indicator is different from what was used in the past, it may be necessary to measure the indicator with both methods for a few years so that a relationship can be developed between the two methods. Scores generated with a former method could then be adjusted to correct for any bias.

For convenience, I divided this report into eight major parts. The first part (Section 2) identifies valid statistical designs for status/trend and effectiveness monitoring. Section 3 discusses issues associated with sampling design, emphasizing how one selects a sample and how to minimize measurement error. Section 4 examines how sampling should occur at different spatial scales. Section 5 describes the importance of classification and identifies a suite of classification variables. Section 6 identifies and describes biological and physical/environmental indicators, while Section 7 identifies methods for measuring each indicator variable. These six sections provide the foundation for implementing an efficient monitoring plan in the Wenatchee Basin. The last two sections deal with how the program will be implemented. Section 8 provides a checklist of questions that need to be addressed in order to implement a valid plan. Section 9 begins to lay out a monitoring plan for the Wenatchee Basin by answering the questions identified in Section 8.

As much as possible, I attempted to keep discussions fairly general. Because this report discusses some issues that are quite involved, I used footnotes to define technical terms, offer further explanation, offer alternative explanations, or to describe a given topic or thought in more detail. I hope the reader will not be too distracted by the extensive use of footnotes. In some instances, it was necessary to provide considerable detail within the text (e.g., discussion on choosing sample sizes).

8.2 Statistical Design

This document defines "statistical design" as the logical structure of a monitoring study. It does not necessarily mean that all studies require rigorous statistical analysis. Rather, it implies that all studies, regardless of the objectives, must be designed with a logical structure that reduces bias and the likelihood that rival hypotheses are correct. (Rival hypotheses are alternative explanations for the outcome of an experimental study. In effect, rival hypotheses state that observed changes are due to something other than the management action under investigation.) My purpose in this section is two-fold. First, I identify the minimum requirements of valid statistical designs and second I identify the appropriate designs for status/trend and effectiveness monitoring. The following discussions draw heavily on the work of Hairston (1989), Hicks et al. (1999), Krebs (1999), Manly (1992, 2001), and Hillman and Giorgi (2002).

Throughout this document I talk about the "validity" of monitoring designs. The validity of a monitoring design is influenced by the degree to which the investigator can exercise experimental control; that is, the extent to which rival variables or hypotheses can be controlled or dismissed. Experimental control is associated with randomization, manipulation of independent variables, sensitivity of dependent (indicator) variables to management activities (treatments), and sensitivity of instruments or observations to measure changes in indicator variables. There are two criteria for evaluating the validity of any effectiveness research design: (1) does the study infer a cause-and-effect relationship (*internal validity*) and (2) to what extent can the results of the study be generalized to other populations or settings (*external validity*)? Ideally, when assessing cause-and-effect, the investigator should select a design strong in both internal and external validity. With some thought, one can see that it becomes difficult to design a study with both high internal and external validity. (Studies with high internal validity (laboratory studies) tend to have low external validity. In the same way, studies with high external validity (field studies) tend to have lower internal validity.) Because the intent of effectiveness research is to demonstrate a treatment effect, the study should err on the side of internal validity. Without internal validity the data are difficult to interpret because of the confounding effects of uncontrolled variables. Below I identify some common threats to validity.

- Sampling units that change naturally over time, but independently of the treatment, can reduce validity. For example, fine sediments within spawning gravels may decrease naturally over time independent of the treatment. Alternatively, changes in land-use activities upstream from the study area and unknown to the investigator may cause levels of fine sediments to change independent of the treatment.

- The use of unreliable or inconsistent sampling methods or measuring instruments can reduce validity. That is, an apparent change in an indicator variable may actually be nothing more than using an instrument that was not properly calibrated. Changes in indicator variables may also occur if the measuring instrument changes or disturbs the sampling site (e.g., core sampling).

- Measuring instruments that change the sampling unit before the treatment is applied can reduce validity. That is, if the collection of baseline data alters the site in such a way that the measured treatment effect is not what it would be in the population, the results of the study cannot be generalized to the population.
- Differential selection of sampling units can reduce validity, especially if treatment and control sites are substantially different before the study begins. This initial difference may at least partially explain differences after treatment.
- Biased selection of treatment sites can reduce validity. The error here is that the investigator selects sites to be treated in such a way that the treatment effects are likely to be higher or lower than for other units in the population. This issue is complicated by the fact that treatment areas are often selected precisely because they are thought to be problematic.
- Loss of sampling units during the study can reduce validity. This is most likely to occur when the investigator drops sites that shared characteristics such that their absence has a significant effect on the results.
- Multiple treatment effects can reduce validity. This occurs when sampling units get more than one treatment, or the effects of an earlier treatment are present when a later treatment is applied. Multiple treatment effects make it very difficult to identify the treatment primarily responsible for causing a response in the indicator variables.
- The threats above could interact or work in concert to reduce validity.

In most cases, there are simple design elements or requirements that reduce threats to internal and external validity. What follows is a brief description of those elements.

8.2.1 Minimum Requirements

What are the required elements of a "valid" monitoring study? In general, the more complex the study, the more complex the requirements, but the minimum requirements include *randomization*, *replication*, *independence*, and *controls*.

Randomization—Randomization should be used whenever there is an arbitrary choice to be made of which units will be measured in the sampling frame, or of the units to which treatments will be assigned. The intent is that randomization will remove or reduce systematic errors (bias) of which the investigator has no knowledge. If randomization is not used, then there is the possibility of some unseen bias in selection or allocation. In some situations, complete randomization (both random selection of sampling units and random assignment of treatments) is not possible. Indeed, there will be instances where the investigator cannot randomly assign management activities to survey areas (e.g., removal of mine contaminants from a stream). In this case replication in time and space is needed to generalize inferences of cause-effect relationships. (This does not mean that one cannot infer a cause-effect relationship in the study area. The point here is that without random assignment of management activities, it is questionable if results can be generalized to other sites outside the study area) Here, confidence in the inference comes from replication outside the given study area. The rule of thumb is simple: randomize whenever possible.

Replication—Replication is needed to estimate "experimental error," which is the basic unit of measurement for assessing statistical significance or for determining confidence limits. Replication is the means by which natural variability is accounted for in interpreting results. The only way to assess variability is to have more than one replicate for each treatment, including the controls (see Section 3). In the absence of replication, there is no way, without appealing to non-statistical arguments, to assess the importance of observed differences among experimental units. Depending on the objectives of the study, spatial and/or temporal replication may be necessary.

Independence—It is important that the investigator select replicates that are spatially and temporally independent. A lack of independence can confound the study and lead to "pseudoreplication" (Hurlbert 1984). The basic statistical problem of pseudoreplication is that replicates are not independent, and the first assumption of statistical inference is violated. The simplest and most common type of pseudoreplication occurs when the investigator only selects one replicate per treatment. It can be argued that case studies, where a single stream or watershed has been monitored for several years, suffer from pseudoreplication. Therefore, one might conclude that no inference is possible. However, the motive behind a single-replicate case study is different from that behind statistical inference. The primary purpose of a case study is to reveal information about biological or physical processes in the system. This information can then be used to formulate and test hypotheses using real statistical replicates. Indeed, case studies provide the background information necessary to identify appropriate management actions and to monitor their effectiveness.

Investigators need to be aware of spatial pseudoreplication and how to prevent it or deal with it. Spatial pseudoreplication can occur when sampling units are spaced close together. Sampling units close together are likely to be more similar than those spaced farther apart. (A common concern of selecting sampling units randomly is that there is a chance that some sampling units will be placed next to each other and therefore will lack independence. Although this is true, if the investigator has designed the study so that it accounts for the obvious sources of variation, then randomization is always worthwhile as a safeguard against the effects of unknown factors.) Spatially dependent sites are "subsamples" rather than replicates and should not be treated as independent replicates. Confounding also occurs when control sites are not independent of treatment sites. This is most likely to occur when control sites are placed downstream from treatments sites (although the reverse can also occur; see Underwood 1994). Understandably, there can be no detection of a management action if the treatment affects both the test and control sites similarly.

Similar, although less often recognized problems occur with temporal replication. In many monitoring studies it is common for sampling to be done once at each of several years or seasons. Any differences among samples may then be attributed to differences among years or seasons. This could be an incorrect inference because a single sample collected each year or season does not account for within year or season variability. Take for example the monitoring of fine sediments in spawning gravels in, say, the Chiwawa River. An investigator measures fine sediments at five random locations (spatial replication) during six consecutive years during the second week of July. A simple statistical analysis of the data could indicate that mean percentages of fine sediments decreased significantly during the latter three years. The investigator may then conclude that fines differed among years.

The conclusion may be incorrect because the study lacked adequate temporal replication. Had the investigator taken samples several times during each year (thereby accounting for within year variability), the investigator may have found no difference among years. A possible reason for the low values during the last three years is because the investigator collected samples before the stream had reached baseflow (i.e., there was a delay in the time that the stream reached baseflow during the last three years compared to the first three years). The higher flows during the second week of July in the last three years prevented the deposition of fines in spawning gravels. An alternative to collecting several samples within years or seasons is to collect the annual sample during a period when possible confounding factors are the same among years. In this case, the investigator could have collected the sample each year during baseflow. The results, however, would apply only to baseflow conditions.

The use of some instruments to monitor physical/environmental indicators may actually lead to pseudoreplication in monitoring designs. This can occur when a "destructive" sampling method is used to sample the same site repeatedly. To demonstrate this point one can look at fine-sediment samples collected repeatedly within the same year. In this example, the investigator designs a study to sample five, randomly-selected locations once every month from June through November (high flows or icing preclude sampling during other months). The investigator randomly selects the week in June to begin sampling, and then samples every fourth week thereafter (systematic sampling). To avoid systematic bias, the same well-trained worker using the same equipment (McNeal core sampler) collects all samples. After compiling and analyzing the data, the investigator may find that there is no significant difference in percent fines among replicates within the year. This conclusion is tenuous because the sampling method (core sampler) disturbed the five sampling locations, possibly reducing fines that would have been measured in following surveys. A more appropriate method would have been to randomly select five new sites (without replacement) during each survey period.

Although replication is an important component of monitoring and should be included whenever possible, it is also important to understand that using a single observation per treatment, or replicates that are not independent, is not necessarily wrong. Indeed, it may be unavoidable in some field studies. What is wrong is to ignore this in the analysis of the data. There are several analyses that can be used to analyze data that are spatially or temporally dependent (see Manly 2001). Because it is often difficult to distinguish between true statistical replicates and subsamples, even with clearly defined objectives, investigators should consult with a professional statistician during the development of monitoring studies.

Controls—Controls are a necessary component of effectiveness research because they provide observations under normal conditions without the effects of the management action or treatment. Thus, controls provide the standard by which the results are compared. (Lee (1993, pg 205) offers a quote that adequately describes the importance of controls in study designs. (Lee writes, "One day when I was a junior medical student, a very important Boston surgeon visited the school and delivered a great treatise on a large number of patients who had undergone successful operations for vascular reconstruction. At the end of the lecture, a young student at the back of the room timidly asked, 'Do you have any controls?' Well, the great surgeon drew himself up to his full height, hit the desk, and said, 'Do you mean did I not operate on half of the patients?' The hall grew very quiet then. The voice at the back of the room very hesitantly replied, ‘Yes, that’s what I had in mind.’ Then the visitor’s fist really came down as he thundered, ‘Of course not. That would have doomed half of them to their death.’ God, it was quiet then, and one could scarcely hear the small voice ask, ‘Which half?’ (Tufte 1974, p.4--attributed to Dr. E. Peacock, Jr., chairman of surgery, University of Arizona College of Medicine, in Medical World News, Sept. 1, 1974, p. 45.)”) The exact nature of the controls will depend on the hypothesis being tested. For example, if an investigator wishes to implement a rest-rotation grazing strategy along a stream with heavy grazing impacts, the investigator would monitor the appropriate physical/environmental indicators in both treatment (modified grazing strategy) and control (unmodified intensive grazing) sites. Because stream systems are quite variable, the study should use “contemporaneous controls.” That is, both control and treatment sites should be measured at the same time.

Temporal controls can be used to increase the “power” of the statistical design. In this case the treatment sites would be measured before and after the treatment is applied. Thus, the treatment sites serve as their own controls. However, unless there are also contemporaneous controls, all before-after comparisons must assume homogeneity over time, a dubious assumption that is invalid in most ecological studies (Green 1979). Examples where this assumption *is* valid include activities that improve fish passage at irrigation diversions or screen intake structures. These activities do not require contemporaneous controls. However, a temporal control is needed to describe the initial conditions. Therefore, a before-after comparison is appropriate. The important point is that if a control is not present, it is impossible to conclude anything definite about the effectiveness of the treatment.

It should be clear that the minimum requirements of valid monitoring include randomization, replication, independence, and controls. In some instances monitoring studies may lack one or more of these ingredients. Such studies are sometimes called “quasi-experiments.” Although these studies are often used in environmental science, they have inherent problems that need to be considered during data analysis. There is no space here to discuss these problems; however, many of them are fairly obvious. The reader should consult Cook and Campbell (1979) for a detailed discussion of quasi-experimental studies.

8.2.2 Recommended Statistical Designs

A perfect study design would take into account all sources of variability associated with fluctuations in indicator variables. In the absence of perfection, the best approach is to use a design that accounts for all known sources of variation not directly associated with treatment (management action) differences. A reasonable rule is to use the simplest design that provides adequate control of variability. The design should also provide the desired level of precision with the smallest expenditure of time and effort. A more complex design has little merit if it does not improve the performance of statistical tests or provide more precise parameter estimates. Furthermore, an efficient design usually leads to simpler data analysis and cleaner inferences. Below I describe valid designs for both effectiveness and status/trend monitoring.

Effectiveness Monitoring—Because effectiveness monitoring attempts to explain cause-and-effect relationships (e.g., effect of a tributary project on fish abundance), it is important to include as many of the elements of valid statistical design as possible. An appropriate design recommended by the Action Agencies/NOAA Fisheries (2003), ISAB (2003), and WSRFB

(2003) is the Before-After-Control-Impact or BACI design (Stewart-Oaten et al. 1986, 1992; Smith et al. 1993). This type of design is also known as a Control-Treatment Paired or CTP design (Skalski and Robson 1992), or Comparative Interrupted Time Series design (Manly 1992). Although names differ, the designs are essentially the same. That is, they require data collected simultaneously at both treatment and control sites before and after treatment. These data are paired in the sense that the treatment and control sites are as similar as possible and sampled simultaneously. Replication comes from collecting such paired samples at a number of times (dates) both before and after treatment. Spatial replication is possible if the investigator selects more than one treatment and control site. (The use of several test and control sites is recommended because it reduces spatial confounding. In some instances it may not be possible to replicate treatments, but the investigator should attempt to replicate control sites. These “Beyond BACI” designs and their analyses are described in more detail in Underwood (1996).) The pretreatment sampling serves to evaluate success of the pairings and establishes the relationship between treatment and control sites before treatment. This relationship is later compared to that observed after treatment.

The success of the design depends on indicator variables at treatment and control sites "tracking" each other; that is, maintaining a constant proportionality. The design does not require exact pairing; indicators simply need to "track" each other. Such synchrony is likely to occur if similar climatic and environmental conditions equally influence sampling units. Precision of the design can be improved further if treatment and control stream reaches are paired according to a hierarchical classification approach (see Section 4). Thus, indicator variables in stream reaches with similar climate, geology, geomorphology, and channel types should track each other more closely than those in reaches with only similar climates.

It is important that control and treatment sites be independent; treatment at one site cannot affect indicators in another site. The NRC (1992) recommends that control data come from another stream or from an independent reach in the same stream. After the pretreatment period, sites to be treated should be selected randomly. (As noted later, in most cases treatments will not be randomly assigned to sites. Thus, the studies will be “causal-comparative,” rather than “true” experimental studies.) Randomization eliminates site location as a confounding factor and removes the need to make model-dependent inferences (Skalski and Robson 1992). Hence, conclusions carry the authority of a “true” experiment and will generally be more reliable and less controversial. Post-treatment observations should be made simultaneously in both treatment and control sites.

Several different statistical procedures can be used to analyze BACI designs. Manly (1992) identified three methods: (1) a graphical analysis that attempts to allow subjectively for any dependence among successive observations, (2) regression analysis, which assumes that the dependence among successive observations in the regression residuals is small enough to ignore, and (3) an analysis based on a time series model that accounts for dependence among observations. Cook and Campbell (1979) recommend using autoregressive integrated moving average models and the associated techniques developed by Box and Jenkins (1976). Skalski and Robson (1992) introduced the odd's-ratio test, which looks for a significant change in dependent variable proportions in control-treatment sites between pretreatment and post-treatment phases. A common approach, recommended by WSRFB (2003), includes analysis of difference scores. Differences are calculated between paired control and treatment sites. These differences are then analyzed for a before-after treatment effect with a two-sample t-test, Welch modification of the t-test, or with nonparametric tests like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test (Stewart-Oaten et al. 1992; Smith et al. 1993). Choice of test depends on the type of data collected and whether those data meet the assumptions of the tests.

In some cases, the investigator will not be able to randomly assign treatments to sampling locations. Despite a lack of randomization of treatment conditions, if the treatment conditions are replicated spatially or temporally, a sound inference to effects may be possible. Although valid statistical inferences can be drawn to the sites or units, the authority of a randomized design is not there to "prove" cause-effect relationships. Skalski and Robson (1992) describe in detail how to handle BACI designs that lack randomization.

Status/Trend Monitoring—Because the intent of status/trend monitoring is simply to describe existing conditions and document changes in conditions over time, it does not require all the elements of valid statistical design found in effectiveness monitoring studies. For example, controls are not required in status/trend monitoring. Controls would be important if one desires to assess cause-and-effect relationships (goal of effectiveness monitoring), which is not the purpose of status/trend monitoring. However, status/trend monitoring does require temporal and spatial replication and probabilistic sampling.

Monitoring the status and trends of Evolutionarily Significant Units (ESUs), populations, subpopulations, and habitat characteristics is an important component of the Action Agencies/NOAA Fisheries RME Plan, which will be implemented within the Wenatchee Basin. The Plan calls for the implementation of the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) design, which is a spatially-balanced, site-selection process developed for aquatic systems. The state of Oregon has successfully implemented an EMAP-based program for coastal coho salmon (Moore 2002). The monitoring program as implemented in Oregon is spatially explicit, unbiased, and has reasonably high power for detecting trends. The design is sufficiently flexible to use on the scale of multiple large river basins and can be used to estimate the numbers of adult salmon returning each year, the distribution and rearing density of juvenile salmon, productivity and relative condition of stream biota, and freshwater habitat conditions. In addition, the EMAP site-selection approach supports sampling at varying spatial extents.

Specifically, EMAP is a survey design that was developed to describe current status and to detect trends in a suite of indicators. These two objectives have conflicting design criteria; status is ordinarily best assessed by including as many sample units as possible, while trend is best detected by repeatedly observing the same units over time (Overton, et al. 1990). EMAP addresses this conflict by using rotating panels (Stevens 2002). Each panel consists of a collection of sites that will have the same revisit schedule over time. For example, sites in one panel could be visited every year, sites in another revisited every five years, and sites in still another revisited every ten years. As a starting point for the Wenatchee Basin, it is recommended that the design include six panels, with one panel defining sites visited every year and five panels defining sites visited on a five-year cycle (Table 83). The process by which sites are selected for each panel and the statistical methods used to analyze data are described in Section 3.

Table 83. Years sites are sampled

Panel	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2	■					■					■					■				
3		■					■					■					■			
4			■					■					■					■		
5				■					■					■					■	
6					■					■					■					■

Shading indicates the years in which sites within each panel are sampled in the Wenatchee Basin. For example, sites in panel 1 are visited every year, while sites in panel 2 are visited only in years 1, 6, 11, and 16, assuming a 20-year sampling frame.

8.3 Sampling Design

Once the investigator has selected a valid statistical design, the next step is to select "sampling" sites. *Sampling* is a process of selecting a number of units for a study in such a way that the units represent the larger group from which they were selected. The units selected comprise a *sample* and the larger group is referred to as a *population*. (This definition makes it clear that a "*population*" is not limited to a group of organisms. In statistics, it is the total set of elements or units that are the target of our curiosity.) All the possible sampling units available within the area (population) constitute the *sampling frame*. (The *sampling frame* is a "list" of all the available units or elements from which the sample can be selected. The sampling frame should have the property that every unit or element in the list has some chance of being selected in the sample. A sampling frame does not have to list all units or elements in the population.) The purpose of sampling is to gain information about a population. If the sample is well selected, results based on the sample can be generalized to the population. Statistical theory assists in the process of drawing conclusions about the population using information from a sample of units.

Defining the population and the sample units may not always be straightforward, because the extent of the population may be unknown, and natural sample units may not exist. For example, a researcher may exclude livestock grazing from sensitive riparian areas in a watershed where grazing impacts are widespread. In this case the management action may affect aquatic habitat conditions well downstream from the area of grazing. Thus, the extent of the area (population) that might be affected by the management action may be unclear, and it may not be obvious which sections of streams to use as sampling units.

When the population and/or sample units cannot be defined unambiguously, the investigator must subjectively choose the potentially affected area and impose some type of sampling structure. For example, sampling units could be stream habitat types (e.g., pools, riffles, or glides), fixed lengths of stream (e.g., 100-m long stream reaches), or reach lengths that vary according to stream widths (e.g., see Simonson et al. 1994). Before selecting a sampling method, the investigator must define the population, size and number of sample units, and the sampling frame.

8.3.1 Methods of Selecting a Sample

Selection of a sample is a crucial step in monitoring fish populations and physical/environmental conditions in streams. The “goodness” of the sample determines the generalizability of the results. Because monitoring studies usually require a large amount of time and money, non-representative results are wasteful. Therefore, it is important to select a method or combination of methods that increases the degree to which the selected sample represents the population. Below I describe the five most commonly used methods for monitoring fish populations and physical/environmental conditions: random sampling, stratified sampling, systematic sampling, cluster sampling, and multi-stage sampling. See Scheaffer et al. (1990) for a more detailed discussion of sampling methods.

Random sampling—A simple random sample is one that is obtained in such a way that all units in the defined sampling frame have an equal and independent chance of being selected. Stated differently, every unit has the same probability of being selected and the selection of one unit in no way affects the selection of another unit. Random sampling is the best single way to obtain a representative sample. (No sampling technique guarantees a representative sample, but the probability is higher for random sampling than for other methods.) Random sampling should lead to small and unsystematic differences between the sample and the population because differences are a function of chance and not the result of any conscious or unconscious bias on the part of the investigator. Random sampling is also required by inferential statistics. This is important because statistics permit the researcher to make inferences about populations based on the behavior of samples. If samples are not randomly selected, then one of the major assumptions of inferential statistics is violated, and inferences are correspondingly tenuous.

The process of selecting a random sample involves defining the sampling frame, identifying each unit within the frame, and selecting units for the sample on a completely chance basis. If the sampling frame contains units numbered from 1 to **N**, then a simple random sample of size **n** is obtained without replacement by drawing **n** numbers one by one in such a way the each choice is equally likely.

Stratified sampling—Stratified sampling is the process of selecting a sample in such a way that identified strata in the sampling frame are represented in the sample. (The number of units selected from each strata could be equal (i.e., n is the same for all strata), or the number could be proportional to the size of the strata. Equal-sized samples would be desired if one wanted to compare the performance of different strata.) This sampling method addresses the criticism that simple random sampling leaves too much to chance, so that the number of sampling units in different parts of the population may not match the distribution in the population.

Stratified sampling involves dividing the units in the sampling frame into non-overlapping strata, and selecting an independent random sample from each of the strata. An example would be to stratify a stream based on habitat types (i.e., pools, riffles, glides, etc.) and then randomly select **n** units within each habitat type. This would ensure that each habitat type is represented in the sample. There are a couple of advantages of stratified sampling: (1) if the sampling units within the strata are more similar than units in general, the estimate of the overall population mean will have a smaller standard error than a mean calculated with simple random sampling; and (2) there may be value in having separate estimates of population parameters for the different strata. Stratification requires the investigator to consider spatial location, areas within which the population is expected to be uniform, and the size of sampling units. Generally, the choice of how to stratify is just a question of common sense.

In some situations there may be value in analyzing a simple random sample as if it were obtained by stratified random sampling. That is, one takes a simple random sample and then places the units into strata, possibly based on information gathered at the time of sampling. The investigator then analyzes the sample as if it were a stratified random sample. This procedure is known as *post-stratification*. Because a simple random sample should place sample units in different strata according to the size of those strata, post-stratification should be similar to stratified sampling with proportional allocation, provided the total sample size is reasonably large. This may be valuable particularly when the data may be used for a variety of purposes, some of which are unknown at the time of sampling.

Systematic sampling—Systematic sampling is sampling in which units are selected from a list by taking every k^{th} unit. If k = 4, one would sample every 4^{th} unit; if k = 10, one would sample every 10^{th} unit. The value of **k** depends on the size of the sampling frame (i.e., the total number of units) and the desired sample size. The major difference between systematic sampling and the methods discussed above is that all units of the population do not have an independent chance of being selected. Once the first unit is selected, all remaining units to be included in the sample are automatically determined. Nevertheless, systematic sampling is often used as an alternative to simple random sampling or stratified sampling for two reasons. First, the process of selecting sample units is simpler for systematic sampling. Second, under certain circumstances, estimates for systematic sampling may be more precise because the population is covered more evenly. Systematic sampling is not recommended if the population being sampled has some cyclic variation (e.g., regular occurrence of pools and riffles along the course of a stream). Simple random sampling and stratified sampling are not affected by patterns in the population.

Cluster sampling—Cluster sampling is sampling in which groups, not individual units, are randomly selected. Thus, cluster sampling involves sampling clusters of units rather than single units. All units of selected groups have similar characteristics. For example, instead of randomly selecting pools throughout a watershed, one could randomly select channel bed-form types (e.g., plane-bed, step-pool, etc.) within the watershed and use all the pools within those randomly-selected channel types. Cluster sampling is more convenient when the population is very large or spread out over a wide geographic area. This advantage is offset to some extent by the tendency of sample units that are close together to have similar measurements. Therefore, in general, a cluster sample of **n** units will give estimates that are less precise than a simple random sample of **n** units. Cluster sampling can be combined with stratified sampling (see Scheaffer et al. 1990 for more details).

Multi-Stage Sampling—Multi-stage sampling is sampling in which clusters or stages (and clusters within clusters) are randomly selected and then sample units are randomly selected from each sampled cluster. With this type of sampling, one regards sample units as falling within a hierarchical structure. The investigator randomly samples at each of the various levels within the structure. For example, suppose that an investigator is interested in describing changes in fine sediments in stream riffles after livestock grazing is removed from sensitive riparian areas in a large watershed. The investigator may be able to divide the watershed into different geological/geomorphic units (primary sampling units) and then divide each geological/geomorphic unit into channel types (secondary sampling unit). Finally, the investigator may divide each channel type into habitat types (e.g., pools, riffles, glides, etc.). The investigator would obtain a "three-stage" sample of riffle habitats by first randomly selecting several primary sampling units (geological/geomorphic units), next randomly selecting one or more channel types (second-stage units) within each sampled primary unit, and finally randomly selecting one or more riffles (third-stage units) from each sampled channel type. This type of sampling is useful when a hierarchic structure exists, or when it is simply convenient to sample at two or more levels.

It is important to note that some monitoring programs include a combination of sampling designs. As you will see later in this section, the EMAP approach is a combination of random and systematic sampling. Juvenile fish monitoring in the Chiwawa Basin included a combination of stratified random sampling and two-stage sampling (Hillman and Miller 2002). These complex sampling designs require an understanding of the more basic designs.

Choosing Sample Size

I now address the question, "to have a high probability of detecting a management (treatment) effect (effectiveness monitoring) or a change in current conditions (status/trend monitoring), what sample size should the investigator use?" This is one of the most important questions of a monitoring plan. If the sample is too small, the results of the study may not be generalizable to the population. In addition, the wrong decision may be made concerning the validity of the hypothesis. Therefore, it is important that the investigator select a sample size that will increase the validity of the hypothesis. Fortunately, there are a number of equations and tables that can assist in selecting sample sizes. Before I consider these, it is appropriate to discuss the factors that one needs to consider when selecting a total sample size.

In general, the total sample size for status/trend monitoring depends upon the population size (total number of units in the sampling frame), population variance or standard deviation, and the level of error that the investigator considers acceptable. Quite often the population standard deviation is unknown. In this situation, the investigator can replace the population standard deviation with the sample standard deviation, which may be available from previous studies (an informal "meta-analysis"). Scheaffer et al. (1990) and Browne (2001) describe methods for guessing the population standard deviation when little prior information is available. (For simple random sampling, the guess is one-fourth the range of possible values. The idea being that for many distributions the effective range is the mean plus and minus about two standard deviations. This type of approximation is often sufficient because it is only necessary to get the sample size roughly right.) The level of error is selected by the investigator and should be based on the objectives of the study. Many studies set the error at 0.05. Scheaffer et al. (1990) provide equations for estimating sample sizes for simple random, stratified, systematic, and cluster sampling. There are also a number of computer packages that can be used to estimate sample sizes, such as PASS 2000 (Power Analysis and Sample Size), which is produced by NCSS Statistical Software (2000), and Methodologist's Toolchest, which is produced by Idea Works (1997). (The use of trade or firm names in this paper is for reader information only and does not imply endorsement by an agency of any product or service.)

Effectiveness monitoring, on the other hand, almost always requires the testing of statistical hypotheses, which means that additional factors must be considered when selecting a total sample size. Indeed, statistical significance is usually the desired outcome of effectiveness monitoring (i.e., statistical significance indicates that the management action did what it was suppose to do). (As I pointed out earlier, not all effectiveness research requires the testing of statistical hypotheses. For example, improving fish passage at a culvert or irrigation diversion does not require one to test a statistical hypothesis. It does require that the results of the action comply with the desired outcome.) Therefore, when selecting a total sample size for effectiveness monitoring, the investigator must carefully evaluate all the factors that influence the validity of statistical hypotheses. These factors include significance level, effect size, variability, and statistical power. (Total sample size is also affected by the choice of experimental design and statistical analysis. Because these two factors are used to explain or partition variability, I included them in my discussion on variability and in Section 2.)What follows is a brief description of each of these factors. First, however, I briefly describe the errors of inference.

Errors of Inference—There are four possible outcomes of a statistical hypothesis test. If the hypothesis of no difference (null hypothesis) is really true, then two outcomes are possible: not rejecting the null hypothesis is a correct inference, while rejecting it constitutes a Type I error. That is, a Type I error occurs when the investigator concludes that a difference between or among treatments is real when in fact it is not. Similarly, if the null hypothesis is really false, the correct inference is to reject it, and failing to do so constitutes a Type II error. To quickly recap, a Type I error occurs when the investigator concludes that a difference is real when in fact it is not. A Type II error occurs when the investigator concludes that there is no difference when in fact a difference exists. In statistical terms, the probability of committing a Type I error is α, while the probability of a Type II error is β. The power of the test (**1-**β) is the probability of correctly rejecting the null hypothesis when it is really false.

Both types of errors can be costly in monitoring studies where management actions involve the effects of commercial activities, such as timber harvesting or road building, on stream ecosystems. For example, a Type I error may lead to unnecessary limitations on commercial activities, while a Type II error may result in the continuation of activities damaging to the stream ecosystem. While it is impossible to calculate the probability that a hypothesis is true using classical statistical tests, the probability of incurring either a Type I or a Type II error can be controlled to acceptable levels. For example, Type I error is typically limited by the conventional significance level of statistical tests to a frequency of less than five errors per 100 tests performed ("**critical** α"<0.05). In other words, a critical α of 0.05 means that if the null hypothesis was really true and the experiment was repeated many times, the null hypothesis would be rejected incorrectly in at most 5% of the replicate experiments. In contrast, "statistical power analysis" is used to estimate and limit Type II error.

Significance Level—The significance level is a critical value of α, which is the maximum probability of a Type I error that the researcher is willing to accept. When a P-value is less than 0.05 (the usual critical value of α), the researcher rejects the null hypothesis with the guarantee that the chance is less than 1 in 20 that a true null hypothesis has been rejected. Of course, this guarantee about the probability of making a Type I error is valid only if the assumptions of the test are met. The probability of a Type I error (significance level) is completely under the control of the investigator and is inversely related to total sample size. However, increasing critical α-level is not the most effective way to reduce total sample size or to gain statistical power (Lipsey 1990). Generally one increases the significance level when the cost of Type II errors is much larger than the cost of Type I errors.

Effect size—The effect size is the size of change in the parameter of interest that can be detected by an experiment. In statistical jargon, effect size is the difference between the equality components of the null and alternative hypotheses, usually chosen to represent a biologically or practically significant difference. (Often, statistical significance and biological significance differ. For example, a temperature difference of 0.2ºC may be significant statistically, but not biologically. On the other hand, a 1.0ºC may be biologically significant, but because of a small sample size, the difference is not significant statistically. It is important that the investigator design the study to assess biological or practical significance.) For example, a practical significant effect size of interest might be the difference between the maximum acceptable percentage of fine sediments in spawning gravels and the current percentage of fines in spawning gravels. The investigator must select an effect size to calculate total sample size.

Selection of significant effect size can be straightforward for some designs. In the example above, the practical significant effect size was the difference between a population mean and a known constant (e.g., maximum acceptable percentage of fines in spawning gravels). Similarly, when comparing two population means or two correlation coefficients, the estimate of effect size is simply the difference between the two values. However, formulas for effect size become more complex in designs that involve many relationships among statistical parameters, such as analysis of variance or multiple regression.

In other cases the selection of an appropriate effect size is difficult because it is very subjective. Ideally the effect size to be detected should be practically significant, but quite often this value cannot be expressed quantitatively because of a lack of information. In the absence of information, Cohen (1988) proposes small, medium, and large standardized effect sizes. Standardized effect sizes include measures of variance as well as summaries of the magnitude of treatment effects. For example, the standardized effect size for the difference between two means is expressed as the effect size (μ_1-μ_2), divided by the common standard deviation (σ). According to Cohen (1988), small effects sizes [$(\mu_1-\mu_2)/\sigma=0.2$] are subtle, medium effect sizes (0.5) are large enough to be perceived in the course of normal experience, and large effect sizes (0.8) are easily perceived at a glance. One should use caution when selecting standardized effect sizes based on Cohen. His standardized effect sizes are derived from behavioral studies, which may not represent ecological studies. In general, sample size is inversely related to effect size. In other words, a larger sample size is needed to detect a small significant effect size.

Variability—Variability is a measure of how much scores (e.g., water temperatures) differ (vary) from one another. A measure of variability simply indicates the degree of dispersion among the set of scores. If the scores are similar, there is little dispersion and little variability. If the scores are dissimilar, there is a high degree of dispersion (variability). In short, a measure of variability does nothing more than indicate the spread of scores. The variance and the standard deviation are often used to describe the variability among a group of scores. An estimate of the population variability is generally needed to calculate sample size. As we indicated earlier, if the population standard deviation is not available, one can use the sample standard deviation (from other studies or pilot studies) as an estimate of the population standard deviation, or one can guess the variability using methods described in Scheaffer et al. (1990). (If there are no estimates of variability, one can use the "signal-to-noise ratio" to estimate sample size (see Green 1994). The signal-to-noise ration is the ratio of the effect size to standard deviation. This approach may be appealing because an estimate of population variability seems to disappear, as does the need to estimate it. However, I do not recommend using this ratio to calculate sample size because it really does matter what the standard deviation is. The standard deviation is partly natural variation, but it also contains sampling and analysis error. The latter sources of error will affect the estimate of total sample size. Furthermore, to some degree the investigator can control the size of the standard deviation (by using valid designs and selecting sensitive indicators and reliable measurements). Therefore it is best to have some estimate of population standard deviation.) In general, the greater the variability the larger the sample size needed to detect a significant difference.

Statistical Power—Statistical power is the probability that a statistical test will result in statistical significance (Cohen 1988). More technically, statistical power (**1-β**) is the probability of detecting a specified treatment effect (management action) when it is present. Its complement, β, is the probability of a Type II error. Sample size is directly proportional to statistical power. That is, greater statistical power requires a larger sample size. Cohen (1988) suggested that experiments should be designed to have a power of 0.80 ($\beta = 0.20$). This comports with Peterman (1990) and Green (1994), who suggest that fisheries researchers should prefer β at least <0.2, or power ≥ 0.8. If the investigator desires to be as conservative about making Type II as Type I errors, β should equal α, or desired power = 0.95 if $\alpha = 0.05$ (Lipsey 1990).

In summary, significance level, effect size, variability, and statistical power affect the total sample size needed for most effectiveness monitoring studies. Because of the time and cost of sampling fish and physical/environmental conditions in tributary habitats, it should be the desire of the investigator to sample the minimum possible number of units. There are severalways that one can reduce sample size. One can reduce statistical power, increase effect size, decrease the variance of the observed variables, or increase the probability of making a Type I error. Although any one of these can be used to reduce the total sample size, it is not necessarily wise (or even possible) to manipulate all of them.

Alpha is completely under the control of the researcher and there may be good reasons to choose critical α-levels other than 0.05. However, changing the critical α-level is not the most effective way to reduce sample size (Lipsey 1990). In addition, it is unwise to reduce statistical power (1-β), unless there is good reason to do so. The objective of the study should guide the value of α and β. Data snooping or exploratory research, for example, will often be more cost-effective if α is set relatively high and β relatively low, because the objective is to detect previously unknown relationships. In addition, one should consider the prior probability that each hypothesis is true. A hypothesis that seems likely to be true, based on previous work, should be treated more cautiously with respect to erroneous rejection than a hypothesis that seems less credible (Lipsey 1990). Mapstone (1995) offers a method of selecting α and β based on the relative weighting of the perceived consequences of Type I and Type II errors. I recommend that investigators review the methods proposed in Mapstone (1995).

Increasing effect size and/or decreasing variability may be the most effective ways to reduce sample size. However, the investigator has little flexibility in selecting significant effect sizes.

Effect size is based on "practical significance" or the difference between some desirable condition and current conditions. It is inappropriate to "stretch" the effect size beyond what is considered practically significant. Consequently, the investigator is left primarily with reducing variability as a means of reducing sample size. Because physical/environmental variables often exhibit large variances, strategies for reducing variability are especially important for reducing sample size (and achieving high statistical power). Variability is generally reduced by improving measurement precision, selecting dependent (indicator) variables that are sensitive to the management action, and by various techniques of experimental design (e.g., blocking, (Although unreplicated random block designs are useful methods of reducing variability, I do not recommend them for monitoring tributary conditions because they fail to deal with interactions between treatments (management actions) and blocks. The assumption of no interaction is unrealistic in environmental studies (Underwood 1994).) stratification, or covariate analysis). Later I will identify sensitive indicator variables (Section 4) and reliable methods for measuring those variables (Section 5).

There are a number of aids that the investigator can use to estimate total sample size. Cohen (1988) provides tables and equations for calculating sample sizes. Various computer packages also estimate sample sizes, such as PASS 2000, SYSTAT, and Methodologist's Toolchest. I suggest that the investigator use the method that meets their particular needs.

Measurement Error

Measurements and estimates are never perfect. Indeed, most fish population and habitat variables are difficult to measure, and the errors in these measurements are often large. It is tempting to ignore these errors and proceed as though the estimates reflect the true state of the resource. One should resist this temptation because it could lead to missing a treatment effect, resulting in a waste of money and effort. Investigators need to be aware of the types of errors and how they can be identified and minimized. This is important because total sample size and statistical power are related to variability. By reducing measurement error and bias, one effectively reduces variability, resulting in greater statistical power. In this section I identify and describe the various types of errors and describe ways to minimize these errors.

In general, "error" indicates the difference between an estimated value (from a sample) and its "true" or "expected" value. The two common types of error are *random error* and *systematic error*. Random error (a.k.a. chance error) refers to variation in a score or result that displays no systematic *bias* (*Bias* is a measure of the divergence of an estimate (statistic) from the population parameter in a particular direction. The greater the divergence the greater the bias. Nonrandom sampling often produces such bias.) when taking repeated samples. In other words, random error is the difference between the estimate of a population parameter that is determined from a random sample and the true population value, absent any systematic bias. One can easily detect the presence of random errors by simply repeating the measurement process several times under similar conditions. Different results, with no apparent pattern to the variation (no bias) indicate random error. Although random errors are not predictable, their properties are understood by statistical theory (i.e., they are subject to the laws of probability and can be estimated statistically). The standard deviation of repeated measurements of the same phenomenon gauges the average size of random errors. (It is important not to confuse standard deviation with standard error. The *standard error of a sample average* gauges the average size of the fluctuation of means from sample to sample. The *sample standard deviation* gauges the average size of the fluctuations of the values within a sample. These two quantities provide different information.)

Random errors can occur during the collection and compilation of sample data. These errors may occur because of carelessness in recording field data or because of missing data. Recording errors can occur during the process of transferring information from the equipment to field data sheets. This often results from misplacing decimal points, transposing numbers, mixing up variables, or misinterpreting hand-written records. Although not always the fault of the investigator, missing data are an important source of error.

Systematic errors or bias, on the other hand, are not subject to the laws of probability and cannot be estimated or handled statistically without an independent estimate of the bias. Systematic errors are present when estimates consistently over or underestimate the true population value. An example would be a poorly calibrated thermometer that consistently underestimates the true water temperature. These errors are often introduced as a result of poorly calibrated data-recording instruments, miscoding, misfiling of forms, or some other error-generating process. They may also be introduced via interactions among different variables (e.g., turbidity is usually highest at high flows). Systematic error can be reduced or eliminated through quality control procedures implemented at the time data are collected or through careful checking of data before analysis. For convenience, I divided systematic errors into two general classes: those that occur because of inadequate procedures and those that occur during data processing. I consider each of these in turn.

<u>Biased Procedures</u>—A biased procedure involves problems with the selection of the sample, the estimation of population parameters, the variables being measured, or the general operation of the survey. For example, selecting sample units based on access can increase systematic error because the habitat conditions near access points may not represent the overall conditions of the population. Changing sampling times and sites during the course of a study can introduce systematic error. Systematic errors can grow imperceptibly as equipment ages or observers change their perspectives (especially true of "visual" measurements). Failure to calibrate equipment introduces error, as does demanding more accuracy than can be expected of the instrument or taking measurements outside the range of values for which the instrument was designed.

<u>Processing Errors</u>—Systematic errors can occur during compiling and processing data. Errors can occur during the transfer of field records to computer spreadsheets. Investigators can also introduce large systematic errors by using faulty formulas (e.g., formulas for converting variables). Processing errors are the easiest to control.

The investigator must consider all these sources of error and develop a plan (quality control plan) that minimizes measurement bias. Certainly some errors are inevitable, but a substantial reduction in systematic errors will benefit a monitoring study considerably. I offer the following guidelines for achieving this goal.

1. Measures based on counts (e.g., Redds, LWD, Pools)

    - Make sure that new personnel are trained adequately by experienced workers.

    - Reduce errors by taking counts during favorable conditions and by implementing a rigorous protocol.

- If an over or underestimate is assumed, attempt to assess its extent by taking counts of populations of known size.

2. Measures based on visual estimates (e.g., snorkel surveys, bank stability)

   - Make sure that all visual estimates are conducted according to rigorous protocols by experienced observers.
   - Attempt to assess observer bias by using trained personnel to check observations of new workers.

3. Measures based on instruments (e.g., dissolved oxygen, temperature)

   - Calibrate instruments before first use and periodically thereafter.
   - Personnel must be trained in the use of all measuring devices.
   - Experienced workers should periodically check measurements taken by new personnel.
   - Use the most reliable instruments.

4. Re-measurement of indicators

   - Use modern GPS technology and carefully marked maps and diagrams to relocate previous sampling units.
   - Guard against the transfer of errors from previous measurements.
   - Make sure that bias is not propagated through the use of previous measurements as guides to subsequent ones.

5. Handling of data

   - Record data directly into electronic form where possible.
   - Back-up all data frequently
   - Design manual data-recording forms and electronic data-entry interfaces to minimize data-entry errors.
   - Use electronic data-screening programs to search for aberrant measurements.
   - Frequently double-check the transfer of data from field data forms to computer spreadsheets.

Before leaving this discussion, it is important to describe briefly how one should handle outliers. Outliers are measurements that look aberrant (i.e., they appear to lie outside the range of the rest of the values). Because they stand apart from the others, it appears as if the investigator made some gross measurement error. It is tempting to discard them not only because they appear unreasonable, but because they also draw attention to possible deficiencies in the measurement process. Before discarding an apparent outlier, the investigator should look thoroughly at how they were generated. Quite often apparent outliers result from simple errors in data recording, such as a misplaced decimal point. On the other hand, they may be part of the natural variability of the system and therefore should not be ignored or discarded. (Another reason that outliers should be treated carefully is because they can invalidate standard statistical inference procedures. Outliers tend to affect assumptions of variability and normality.) If one routinely throws out aberrant values, the resulting data set will give false impressions of the structure of the system. Therefore, as a general rule, investigators should not discard outliers unless it is known for certain that measurement errors attend the estimates.

Recommended Sampling Designs

Using the basic tools described above, valid sampling designs can be identified for status/trend and effectiveness monitoring in the Wenatchee Basin. The recommended sampling designs, if implemented correctly, should reduce bias and error.

Effectiveness Monitoring—This plan recommends that sampling units for effectiveness monitoring be selected according to a stratified random sampling design. The plan requires that streams or stream segments to be treated with some action(s) will be classified according to a hierarchical classification system (see Section 4). Once classification identifies non-overlapping strata, sampling sites are then selected randomly within each stratum. The same process occurs within control or reference areas, which are similar to treatment areas based on classification. The number of sites selected will depend on effect size, variability, power, and significance levels. The number of sites within each stratum should be proportional to the size of the stratum. That is, a larger stratum would receive more sites than a smaller stratum.

Status/Trend Monitoring—Because the plan follows EMAP, which requires spatially balanced samples, sites will be selected according to the generalized random tessellation stratified design (GRTS) (Stevens 1997; Stevens and Olsen 1999; Stevens and Urquhart 2000; Stevens 2002). Briefly, the GRTS design achieves a random, nearly regular sample point pattern via a random function that maps two-dimensional space onto a one-dimensional line (linear space). A systematic sample is selected in the linear space, and the sample points are mapped back into two-dimensional space. The GRTS design is used to select samples for all panels (six panels for the Wenatchee Basin).

As a starting point, the plan recommends a sample size of 25 sites per panel. This means that GRTS will select a total of 150 sites (6 panels x 25 sites per panel = 150 sites). Two panels of sites will be monitored each year (see Section 2.2), resulting in a total of 50 sites sampled annually within the Wenatchee Basin. Some of the 150 sites selected may fall in areas that are physically inaccessible or cannot be accessed because of landowner denial. Therefore, GRTS will select an additional 15 sites, any one of which can replace an inaccessible site.

The sampling frame for the 150 sites will consist of all second through fifth-order streams in the Wenatchee Basin. These stream segments were selected because most spawning and rearing of ESA-listed fish species occur in these areas. Because it is unclear at this time which stream segments (orders) should receive the highest density of sampling sites, a variety of scenarios will be modeled (Table 84). The first is an equal number of sites among the stream orders, the second gives more weight (higher density of sites) to third and fourth order streams, while the last gives the greatest weight to fourth order streams. The results of these scenarios will be evaluated to see which one most closely fits the objectives of status/trend monitoring in the Wenatchee Basin.

Table 84. Proportion of sample sites distributed among stream orders

Scenario	Stream order			
	2	3	4	5
1	0.25	0.25	0.25	0.25
2	0.20	0.30	0.30	0.20
3	0.20	0.20	0.40	0.20

Data collected within the EMAP design will be analyzed according to the statistical protocols outlined in Stevens (2002). The Horvitz-Thompson or π-estimator is recommended for estimation of population status. Multi-phase regression analyses are recommended for estimating the distribution of trend statistics. These approaches are fully explained in Diaz-Ramos et al. (1996) and Stevens (2002).

Sampling at Different Spatial Scales

Because monitoring will occur at a range of spatial scales, there may be some confusion between the roles of status/trend monitoring and effectiveness monitoring. Generally, one thinks of status/trend monitoring as monitoring that occurs at coarser scales and effectiveness monitoring at finer scales. In reality, both occur across different spatial scales, and the integration of both is needed to develop a valid monitoring program (ISAB 2003; AA/NOAA Fisheries 2003; WSRFB 2003).

The scale at which status/trend and effectiveness monitoring occurs depends on the objectives of the study, the size or distribution of the target population, and the indicators that will be measured. In status/trend monitoring, for example, the objective may be to measure egg-parr survival of spring chinook salmon. Because the Wenatchee Basin consists of one population of spring chinook, the entire basin is the spatial scale at which egg-parr survival is monitored. In contrast, if the objective is to assess egg-parr survival of spring chinook in the Chiwawa Basin (a sub-population of the Wenatchee population), the spatial scale at which monitoring occurs includes only the Chiwawa Basin, a much smaller area than the entire Wenatchee Basin. Thus, status/trend monitoring can occur at various scales depending on the distribution of the population of interest.

In the same way, effectiveness monitoring can occur at different spatial scales. That is, one can assess the effect of a tributary action on a specific ESU (which may encompass several populations), a specific population (may include several sub-populations), at the sub-population level (may encompass a watershed within a basin), or at the reach scale. Clearly, the objectives and hence the indicators measured dictate the spatial scale at which effectiveness monitoring is conducted. For example, if the objective is to assess the effects of nutrient enhancement on egg-smolt survival of spring chinook in the Chiwawa Basin (a sub-population of the Wenatchee spring chinook population), then the spatial scale covered by the study must include the entire area inhabited by the eggs, fry, parr, and smolts. If, on the other hand, the objective is to assess the effects of a sediment reduction project on egg-fry survival of a local group of spring chinook (i.e., chinook within a specific reach of stream), then the study area would only encompass the reach of stream used by spawners of that local group.

In theory there might be no limit to the scale at which effectiveness monitoring can be applied, but in practice there is a limit. This is because as the spatial scale increases, the tendency for multiple treatments (several habitat actions) affecting the same population increases (Table 85). That is, at the spatial scale representing an ESU or population, there may be many habitat actions within that area. Multiple treatment effects make it very difficult to assess the effects of specific actions on an ESU (see Section 2). Even though it may be impossible to assess specific treatment effects at larger spatial scales, it does not preclude one from conducting effectiveness monitoring at this scale. Indeed, one can assess the combined or cumulative effects of tributary actions on the ESU or population. However, additional effectiveness monitoring may be needed at finer scales to assess the effects of individual actions on the ESU or population.

Table 85. Relationship between biological indicators, spatial scales, and our ability to assess effects of specific mangeament actions

Biological Indicators	Example of spatial scales	Ability to assess effects of specific tributary actions
ESU (Upper Columbia Spring Chinook)	Basins (Upper Columbia)	Low
Population (Wenatchee Spring Chinook)	Basin (Wenatchee)	
Sub-Population (Chiwawa River Spring Chinook)	Watershed (Chiwawa River)	
Local Group	Reach (5 km of the Chiwawa River)	High

Note: Examples of each scale are shown in parentheses. Source: Action Agencies/NOAA Fisheries RME Plan (2003).

Given the potential problems of multiple treatment effects, there are two general strategies for conducting effectiveness monitoring at different spatial scales. One strategy is a “project-based” approach, which addresses the effects of individual tributary projects at smaller spatial scales (e.g., stream or stream reach). This approach is identified in the Action Agencies/NOAA Fisheries Plan as the “Bottom-Up” approach. It is designed to assess the effects of specific projects in isolation of other tributary actions. That is, results from this type of effectiveness monitoring would not be confounded by actions occurring elsewhere in the basin. This approach requires that the investigator maintain control of all actions that occur within the assessment area (stream, watershed, or basin).

The second strategy is an “intensive” approach that addresses the cumulative effects of tributary actions at larger spatial scales (e.g., watershed or basin). This approach is identified in the Action Agencies/NOAA Fisheries Plan as a “Top-Down” Approach. The WSRFB (2003) refers to it as “Intensive (Validation) Monitoring.” This approach requires intensive and extensive sampling of several indicator variables within the watershed or basin. Although the effects of individual projects on fish populations may not be assessed unequivocally, their cumulative effects can be measured.

Both approaches (project-based and intensive) require valid statistical and sampling designs. That is, both approaches require controls (reference conditions), replication, and probabilistic sampling. This plan recommends the use of BACI designs (see Section 2) with stratified random sampling (see Section 3) for both approaches. Both approaches will likely be implemented within the Wenatchee Basin. Classification

Both status/trend and effectiveness monitoring require landscape classification. The purpose of classification is to describe the “setting” in which monitoring occurs. This is necessary because biological and physical/environmental indicators may respond differently to tributary actions depending on landscape characteristics. A hierarchical classification system that captures a range of landscape characteristics should adequately describe the setting in which monitoring occurs. The idea advanced by hierarchical theory is that ecosystem processes and functions operating at different scales form a nested, interdependent system where one level influences other levels. Thus, an understanding of one level in a system is greatly informed by those levels above and below it.

A defensible classification system should include both ultimate and proximate control factors (Naiman et al. 1992). Ultimate controls include factors such as climate, geology, and vegetation that operate over large areas, are stable over long time periods, and act to shape the overall character and attainable conditions within a watershed or basin. Proximate controls are a function of ultimate factors and refer to local conditions of geology, landform, and biotic processes that operate over smaller areas and over shorter time periods. These factors include processes such as discharge, temperature, sediment input, and channel migration. Ultimate and proximate control characteristics help define flow (water and sediment) characteristics, which in turn help shape channel characteristics within broadly predictable ranges (Rosgen 1996).

This plan proposes a classification system that incorporates the entire spectrum of processes influencing stream features and recognizes the tiered/nested nature of landscape and aquatic features. This system captures physical/environmental differences spanning from the largest scale (regional setting) down to the channel segment (Table 86). The Action Agencies/NOAA Fisheries RME plan proposes the same classification system. By recording these descriptive characteristics, the investigator will be able to assess differential responses of indicator variables to proposed actions within different classes of streams and watersheds. Below each classification variable is identified. Section 6, Synthesis and Interpretation, identifies recommended methods for measuring each variable.

Table 86. List of classification (stratification) variables

Spatial scale	General characteristics	Classification variable
Regional setting	Ecoregion	Bailey classification
		Omernik classification
	Physiography	Province
	Geology	Geologic districts
Drainage basin	Geomorphic features	Basin area
		Basin relief
		Drainage density
Valley segment	Valley characteristics	Valley bottom type
		Valley bottom width
		Valley bottom gradient
		Valley containment
Channel segment	Channel characteristics	Elevation
		Channel type (Rosgen)
		Bed-form type
		Channel gradient

Spatial scale	General characteristics	Classification variable
	Riparian vegetation	Riparian cover group
		Riparian community type

Source: Action Agencies/NOAA Fisheries RME Plan (2003)

This variables will be measured as part of monitoring within the Wenatchee Basin. The variables are nested according to spatial scale and their general characteristics. As noted, all watersheds that will be monitored will be classified according to their landscape characteristics. Table 86 lists the “core” set of classification variables. Section 6 provides a description of measurement protocols. Here is only a general description of each classification variable.

8.4 Regional Setting

8.4.1 Ecoregions

Ecoregions are relatively uniform areas defined by generally coinciding boundaries of several key geographic variables. Ecoregions have been defined holistically using a set of physical and biotic factors (e.g., geology, climate, landform, soil, vegetation, and water). Of the systems available, this plan includes the two most commonly used ecoregion systems, Bailey (1978) and Omernik (1987). Bailey’s approach uses macroclimate and prevailing plant formations to classify the continent into various levels of detail. Bailey’s coarsest hierarchical classifications include domains, divisions, provinces, and sections. These regional classes are based on broad ecological climate zones and thermal and moisture limits for plant growth (Bailey 1998). Specifically, domains are groups of related climates, divisions are types of climate based on seasonality of precipitation or degree of dryness or cold, and provinces are based on macro features of vegetation. Provinces include characterizations of land-surface form, climate, vegetation, soils, and fauna. Sections are based on geomorphology, stratigraphy and lithology, soil taxa, potential natural vegetation, elevation, precipitation, temperature, growing season, surface water characteristics, and disturbance. Information from domains, divisions, and provinces can be used for modeling, sampling, strategic planning, and assessment. Information from sections can be used for strategic, multi-forest, statewide, and multi-agency analysis and assessment.

The system developed by Omernik (1987) is used to distinguish regional patterns of water quality in ecosystems as a result of land use. Omernik’s system is suited for classifying aquatic ecoregions and monitoring water quality because of its ecological foundation, its level of resolution, and its use of physical, chemical, and biological information. Like Bailey’s system, this system is hierarchical, dividing an area into finer regions in a series of levels. These levels are based on characterizations of land-surface form, potential natural vegetation, land use, and soils. Omernik’s system has been extensively tested and found to correspond well to spatial patterns of water chemistry and fish distribution (Whittier et al. 1988).

Physiographic Province

Physiographic province is the simplest division of a land area into hierarchical natural regions. In general, delineation of physiographic provinces is based on topography (mountains, plains, plateaus, and uplands) and, to a lesser extent, climate, which governs the processes that shape the landscape (weathering, erosion, and sedimentation). Specifically, provinces include descriptions of climate, vegetation, surficial deposits and soils, water supply or resources, mineral resources, and additional information on features particular to a given area (Hunt 1967). Physiographic provinces and drainage basins have traditionally been used in aquatic research to identify fish distributions (Hughes et al. 1987; Whittier et al. 1988).

Geology

Geologic districts are areas of similar rock types or parent materials that are associated with distinctive structural features, plant assemblages, and similar hydrographic character. Geologic districts serve as ultimate controls that shape the overall character and attainable conditions within a watershed or basin. They are corollary to subsections identified in the U.S. Forest Service Land Systems Inventory (Wertz and Arnold 1972). Watershed and stream morphology are strongly influenced by geologic structure and composition (Frissell et al. 1986; Nawa et al. 1988). Structural features are the templates on which streams etch drainage patterns. The hydrologic character of landscapes is also influenced by the degree to which parent material has been weathered, the water-handling characteristics of the parent rock, and its weathering products. Like ecoregions, geologic districts do not change to other types in response to land uses.

Drainage Basin

Geomorphic Features

This plan includes three important geomorphic features of drainage basins: basin area, basin relief, and drainage density. Basin area (a.k.a. drainage area or catchment area) is the total land area, measured in a horizontal plane, enclosed by a drainage divide, from which direct surface runoff from precipitation normally drains by gravity into a wetland, lake, or river. Basin relief is the difference in elevation between the highest and lowest points in the basin. It controls the stream gradient and therefore affects flood patterns and the amount of sediment that can be transported. Hadley and Schumm (1961) demonstrated that sediment load increases exponentially with basin relief. The last geomorphic feature, drainage density, is an index of the length of stream per unit area of basin and is calculated as the drainage area divided by the total stream length. This ratio represents the amount of stream necessary to drain the basin. High drainage density may indicate high water yield and sediment transport, high flood peaks, steep hills, and low suitability for certain land uses (e.g., agriculture).

Valley Segment

Valley Characteristics

The plan incorporates four important features of the valley segment: valley bottom type, valley bottom width, valley bottom gradient, and valley confinement. Valley bottom types are distinguished by average channel gradient, valley form, and the geomorphic processes that shaped the valley (Cupp 1989a,b; Naiman et al. 1992). They correspond with distinctive hydrologic characteristics, especially the relationship between stream and alluvial ground water. (Table 7.3 in Naiman et al. (1992) identifies and describes various valley bottom types.) Valley bottom width is the ratio of the valley bottom (Valley bottom is defined as the essentially flat area adjacent to the stream channel.) width to active channel width. Valley gradient is the slope or the change in vertical elevation per unit of horizontal valley distance. Valley gradient is typically measured in lengths of about 300 m (1000 ft) or more. Valley confinement refers to the degree that the valley walls confine the lateral migration of the stream channel. The degree of confinement can be classified as strongly confined (valley floor width < 2 channel widths), moderately confined (valley floor width = 2-4 channel widths), or unconfined (valley floor width > 4 channel widths).

Channel Segment

Channel Characteristics

The plan includes four important characteristics of the channel segment: elevation, channel gradient, channel type, and bed-form type. Elevation is the height of the stream channel above or below sea level. Channel gradient is the slope or the change in the vertical elevation of the channel per unit of horizontal distance. Channel gradient can be presented graphically as a stream profile.

Channel type follows the classification technique of Rosgen (1996) and is based on quantitative channel morphology indices. (Indices include entrenchment, gradient, width/depth ratio, sinuosity, and dominant channel material.) These indices result in objective and consistent identification of stream types. The Rosgen technique consists of four different levels of classification. Level I describes the geomorphic characteristics that result from the integration of basin relief, landform, and valley morphology. Level II provides a more detailed morphological description of stream types. Level III describes the existing condition or “state” of the stream as it relates to its stability, response potential, and function. Level IV is the level at which measurements are taken to verify process relationships inferred from preceding analyses. All monitoring in the Wenatchee Basin will include at least Level I (geomorphic characterization) classification.

Bed-form type follows the classification proposed by Montgomery and Buffington (1993). This technique is comprehensive and is based on hierarchies of topographic and fluvial characteristics. This system provides a geomorphic, process-oriented method of identifying valley segments and stream reaches. It employs descriptors that are measurable and ecologically relevant. Montgomery and Buffington (1993) identified three valley segment types: colluvial, alluvial, and bedrock. They subdivided the valley types into one or more stream-reach types (bed-form types) depending on whether substrates are limited by the supply of sediment or by the fluvial transport of sediment. For example, depending on sediment supply and transport, Montgomery and Buffington (1993) recognized six alluvial bed-form types: braided, regime, pool/riffle, plane-bed, step-pool or cascade. Both colluvial and bedrock valley types consist of only one bed-form type. Only colluvial bed-forms occur in colluvial valleys and only bedrock bed-forms occur in bedrock valleys.

Riparian Vegetation

Because riparian vegetation has an important influence on stream morphology and aquatic biota, the plan incorporates two characteristics of riparian vegetation: riparian cover group and riparian community type. Riparian cover group refers to the dominant vegetative cover type (Overton et al. 1997). The classification consists of two cover groups, wooded and meadow. Wooded riparian areas are characterized by streamside or upslope tree stands that have the potential to supply LWD to the stream channel. Meadow riparian areas are characterized by streamside or floodplain grasses, forbs, or shrubs (including willows) that have little potential to contribute

LWD to the stream channel. Riparian community type is a repeated and defined assemblage of riparian plant species. It requires knowledge of plant classification. Selection of Indicators

In this section I identify the "core" set of biological and physical/environmental indicator variables that will be measured within all watersheds and streams that receive status/trend and effectiveness monitoring. The "core" list of variables represents the minimum, required variables that will be measured. Investigators may elect to measure additional variables depending on their objectives and past activities.

Indicator variables identified in this plan are consistent with those identified in the Action Agencies/NOAA Fisheries RME Plan. The Action Agencies/NOAA Fisheries selected indicators based on their review of the literature (e.g., Bjornn and Reiser 1991; Spence et al. 1996; Gregory and Bisson 1997; and Bauer and Ralph 1999) and several regional monitoring programs (e.g., PIBO, AREMP, EMAP, WSRFB, and the Oregon Plan). They selected variables that met various purposes including assessment of fish production and survival, identifying limiting factors, assessing effects of various land uses, and evaluating habitat actions. Their criteria for selecting variables were based on the following characteristics:

- Indicators should be sensitive to land-use activities or stresses.
- They should be consistent with other regional monitoring programs.
- They should lend themselves to reliable measurement.
- Physical/environmental indicators would relate quantitatively with fish production.

The indicators that the Action Agencies/NOAA Fisheries selected were consistent with most of the variables identified by the NMFS (1996) and USFWS (1998) as important attributes of "properly functioning condition." Indeed, the NMFS and USFWS use these indicators to evaluate the effects of land-management activities for conferencing, consultations, and permits under the ESA.

The indicators selected by the Action Agencies/NOAA Fisheries were also consistent with "key" parameters used in the Ecosystem Diagnosis and Treatment model. Recent analyses by Mobrand Biometrics indicated that certain physical/environmental parameters have a relatively important influence on modeled salmon production. These parameters included channel configuration, gradient, pool/riffle frequency, migration barriers, flow characteristics, water temperature, riparian function, fine sediment, backwater areas, and large woody debris (LWD) (K. Malone, Mobrand Biometrics, personal communication).

Below I identify and describe the "core" set of biological and physical/environmental variables that will be monitored in the Wenatchee Basin.

8.4.2 Biological Variables

The biological variables that will be measured in the Wenatchee Basin can be grouped into five general categories: adults, redds, parr, smolts, and macroinvertebrates. Each of these general categories consists of one or more indicator variables (Table 87). These biological indicators in concert will describe the characteristics of the populations of ESA-listed fish in the Wenatchee Basin and will provide information necessary for assessing recovery of listed stocks.

Table 87. Biological indicator variables to be monitored

General characteristics	Specific indicators
Adults	Escapement/Number
	Age structure
	Size
	Sex ratio
	Origin (hatchery or wild)
	Genetics
	Fecundity
Redds	Number
	Distribution
Parr/Juveniles	Abundance
	Distribution
	Size
Smolts	Number
	Size
	Genetics
Macroinvertebrates	Export of invertebrates

Adults

Escapement

The plan includes escapement of mature adults as an important biological indicator of population health. Escapement is the total number of mature adults that enter or occur within a stream or watershed. Numbers of mature adults within a stream or watershed is a function of all the factors that affect the life history of the population.

Spawners:

The plan includes six indicators associated with the characteristics of the spawning populations: age structure, size, sex ratio, origin, genetics, and fecundity. Age structure describes the ages of adult fish within the spawning population. For anadromous species, age structure includes the number of years the fish spent in freshwater and number of years in salt water. Size describes the lengths and weights of adult fish within the spawning population. Sex ratio is the ratio of males to females within the spawning population. Origin identifies the parentage (hatchery or wild) of individuals within the spawning populations, while genetics defines not only the parentage but also within and between population variability. Fecundity is the number of eggs produced by a female. (By definition, *fecundity* refers to the number of eggs readied for spawning by a female. *Relative fecundity* is the number of eggs per unit of weight, while *total fecundity* is the number of eggs laid during the lifetime of the female. This plan refers to fecundity as the number of eggs per size (length and weight) of female.)

Redds

Abundance/Distribution

Abundance describes the number of redds (nests) of ESA-listed fish species within the Wenatchee Basin. Total numbers will be estimated for ESA-listed anadromous species, while index counts will be made for bull trout. Distribution indicates the spatial arrangement and geographic extent of redds within the basin.

Parr

Abundance/Distribution:

Abundance describes the number of juvenile fish within specified stream reaches. Distribution is the spatial arrangement of juvenile fish within populations. It also captures the geographic range of individuals within the watershed or basin.

Condition

The condition (or well-being) of fish can be assessed by measuring the length (fork length; FL) and weight of juvenile fish. The plan includes Fulton-type condition as the metric for well-being of juvenile fish (Anderson and Neumann 1996). The Fulton-type condition factor is of the form:

$$K_{FL} = (W/L^3) \times 100{,}000,$$

where K_{FL} = Fulton-type condition, W = weight in grams, and L = fork length in millimeters. The constant 100,000 is a scaling constant used to convert small decimals to mixed numbers so that the numbers can be more easily comprehended.

Smolts

Abundance

Abundance of smolts is an estimate of the total number of smolts produced within a watershed or basin. The estimate should be for an entire population or subpopulation.

Condition

The Fulton-type condition factor describes the well-being of smolts within a population or subpopulation.

Genetics

Genetic characterization (via DNA microsatellites) describes within- and between-population genetic variability of smolts.

Macroinvertebrates

Invertebrate Transport

The plan includes export of invertebrates (aquatic and terrestrial) from headwaters to habitats downstream as an important attribute of productivity. The movement of prey items among habitats has a strong influence on fish populations, food webs, community dynamics and ecosystem processes (Wipfli and Gregovich 2002).

8.4.3 Physical/Environmental Variables

The physical/environmental variables that will be measured in the Wenatchee Basin can be grouped into seven general categories: water quality, habitat access, habitat quality, channel condition, riparian condition, flow/hydrology, and watershed condition. Each of these categories consists of one or more indicator variables (Table 88). In sum, these categories and their associated indicators address watershed process and “input” variables (e.g., artificial physical barriers, road density, and disturbance) as well as “outcome” variables (e.g., temperature, sediment, woody debris, pools, riparian habitat, etc.), as outlined in Hillman and Giorgi (2002) and the Action Agencies/NOAA Fisheries RME Plan.

What follows is a brief description of each physical/environmental indicator variable. Section 6 identifies recommended methods for measuring each indicator. Unless indicated otherwise, most of the information presented below has been summarized in Meehan (1991), MacDonald et al. (1991), Armantrout (1998), Bain and Stevenson (1999), OPSW (1999), Hillman and Giorgi (2002), and the Action Agencies/NOAA Fisheries RME Plan (2003).

Table 88. Physical/environmental indicator variables to be monitored

General characteristics	Specific indicators
Water Quality	MWMT and MDMT
	Turbidity
	Depth fines
	pH
	DO
	Nitrogen
	Phosphorus
Habitat Access	Road crossings
	Diversion dams
	Fishways
Habitat Quality	Dominant substrate
	Embeddedness
	LWD (pieces/mile)
	Pools per mile
	Pool quality
	Side channels and backwaters
Channel condition	Width/depth ratio
	Wetted width
	Bankfull width
	Bank stability
Riparian Condition	Percent vegetation altered
Flows and Hydrology	Streamflow
Watershed Condition	Watershed road density
	Riparian-road index
	Equivalent clearcut area

Source: Action Agencies/NOAA Fisheries RME Plan (2003)

Water Quality

Water Temperature

The plan includes two temperature metrics that will serve as specific indicators of water temperature: maximum daily maximum temperature (MDMT) and maximum weekly maximum temperature (MWMT). MDMT is the single warmest daily maximum water temperature recorded during a given year or survey period. MWMT is the mean of daily maximum water temperatures measured over the warmest consecutive seven-day period. MDMT is measured to establish compliance with the short-term exposure to extreme temperature criteria, while MWMT is measured to establish compliance with mean temperature criteria.

Sediment and Turbidity

The plan includes two sediment-related specific indicators: turbidity and depth fines. Turbidity refers to the amount of light that is scattered or absorbed by a fluid. Suspended particles of fine sediments often increase turbidity of streams. However, other materials such as finely divided organic matter, colored organic compounds, plankton, and microorganisms can also increase turbidity of streams. Depth fines refer to the amount of fine sediment (<0.85 mm) within the streambed. Depth fines will be estimated at a depth between 6-12 inches within spawning gravels.

Contaminants and Nutrients

The plan includes four specific indicators associated with contaminants and nutrients: pH, dissolved oxygen (DO), nitrogen, and phosphorus. Most of these indicators are commonly measured because of their sensitivity to land-use activities, municipal and industrial pollution, and their importance in aquatic ecosystems.

The plan included pH and DO because these parameters are often incorporated into water quality monitoring programs (e.g., OPSW 1999; Bilhimer et al. 2003). pH is defined as the concentration of hydrogen ions in water (moles per liter). It is a measure of how acidic or basic water is—it is not a measure of acidity or alkalinity (acidity and alkalinity are measures of the capacity of water to neutralize added base or acid, respectively). The logarithmic pH scale ranges from 0 to 14. Pure water has a pH of 7, which is the neutral point. Water is acidic if the pH value is less than 7 and basic if the value is greater than 7.

DO concentration refers to the amount of oxygen dissolved in water. Its concentration is usually measured in parts per million (ppm) or mg per liter (mg/L). The capacity of water to hold oxygen in solution is inversely proportional to the water temperature. Increased water temperature lowers the concentration of DO at saturation. Respiration (both plants and animals) and biochemical oxygen demand (BOD) are the primary factors that reduce DO in water. Photosynthesis and dissolution of atmospheric oxygen in water are the major oxygen sources.

The plan includes nitrogen and phosphorus as indicators of nutrient loading in streams. Nitrogen in aquatic ecosystems can be partitioned into dissolved and particulate nitrogen. Most water quality monitoring programs focus on dissolved nitrogen, because it is more readily available for both biological uptake and chemical transformations. Both dissolved and particulate nitrogen can be separated into inorganic and organic components. The primary inorganic forms are ammonia (NH_4^+), nitrate (NO_3^-), and nitrite (NO_2^-). Nitrate is the predominant form in unpolluted waters.

Phosphorus can also be separated into two fractions, dissolved and particulate. Dissolved phosphorus is found almost exclusively in the form of phosphate ions (PO_4^{-3}), which bind readily with other chemicals. There are three main classes of phosphate compounds: orthophosphates, condensed phosphates, and organically-bound phosphates. Each can occur as dissolved phosphorus or can be bound to particulate matter. In general, biota use only orthophosphates.

Habitat Access

Artificial Physical Barriers

The plan includes three specific indicators associated with artificial physical barriers: road crossings (culverts), dams, and fishways. Roads and highways are common in the Wenatchee Basin and where they intersect streams they may block fish passage. Culverts can block passage of fish particularly in an upstream direction (WDFW 2000). In several cases, surveys have shown a difference in fish populations upstream and downstream from existing culverts, leading to the conclusion that free passage is not possible (Clay 1995). Dams and diversions that lack fish passage facilities can also block fish passage. Unscreened diversions may divert migrating fish into ditches and canals. Entrained fish can end in irrigated fields and orchards. Fishways are man-made structures that facilitate passage of fish through or over a barrier. Although these structures are intended to facilitate passage, they may actually impede fish passage (Clay 1995; WDFW 2000).

Habitat Quality

Substrate

The Plan includes two specific indicators of substrate: dominant substrate and embeddedness. Dominant substrate refers to the most common particle size that makes up the composition of material along the streambed. This indicator describes the dominant material in spawning and rearing areas. Embeddedness is a measure of the degree to which fine sediments surround or bury larger particles. This measure is an indicator of the quality of over-wintering habitat for juvenile salmonids.

Large Woody Debris

The plan includes the number of pieces of large woody debris (LWD) per stream kilometer as the one specific indicator of LWD in streams. LWD consists of large pieces of relatively stable woody material located within the bankfull channel and appearing to influence bankfull flows. LWD is also referred to as large organic debris (LOD) and coarse woody debris (CWD). The plan follows the definition of Armantrout (1998), who defined LWD as any piece of wood with a diameter greater than 10 cm and a length greater than 1 m. LWD can occur as a single piece (log), an aggregate (two or more clumped pieces, each of which qualifies as a single piece), or as a rootwad.

Pool Habitat:

The plan includes two specific indicators associated with pool habitat number of pools per kilometer and pool quality. To be counted, a pool must span more than half the wetted width, be longer than it is wide, and include the thalweg. Pool quality refers to the ability of a pool to support the growth and survival of fish. Pool size (diameter and depth) and the amount and quality of cover determine overall pool quality. Pool cover is any material or condition that conceals or protects fish from predators or competitors and may consist of logs, organic debris, overhanging vegetation, cobble, boulders, undercut banks, or water depth.

Off-Channel Habitat:

Off-channel habitat consists of side-channels, backwater areas, alcoves or sidepools, off-channel pools, off-channel ponds, and oxbows. A side channel is a secondary channel that contains a portion of the streamflow from the main or primary channel. Backwater areas are secondary channels in which the inlet becomes blocked but the outlet remains connected to the main channel. Alcoves are deep areas along the shoreline of wide and shallow stream segments. Off-channel pools occur in riparian areas adjacent to the stream channels and remain connected to the channel. Off-channel ponds are not part of the active channel but are supplied with water from over bank flooding or through a connection with the main channel. These ponds are usually located on flood terraces and are called wall-based channel ponds when they occur near the base of valley walls. Finally, oxbows are bends or meanders in a stream that become detached from the stream channel either from natural fluvial processes or anthropogenic disturbances.

Channel Condition

Width/Depth Ratio

The width/depth ratio is an index of the cross-section shape of a stream channel at bankfull level. The ratio is a sensitive measure of the response of a channel to changes in bank conditions. Increases in width/depth ratios, for example, indicate increased bank erosion, channel widening, and infilling of pools. Because streams almost always are several times wider than they are deep, a small change in depth can greatly affect the width/depth ratio.

Wetted Width

Wetted width is the width of the water surface measured perpendicular to the direction of flow.

Bankfull Width

Bankfull width is the width of the channel between the tops of the most pronounced banks on either side of a stream site or reach.

Streambank Condition

The plan includes streambank stability as the one specific indicator of streambank condition. Streambank stability is an index of firmness or resistance to disintegration of a bank based on the percentage of the bank showing active erosion (alteration) and the presence of protective vegetation, woody material, or rock. A stable bank shows no evidence of breakdown, slumping, tension cracking or fracture, or erosion (Overton et al. 1997). Undercut banks are considered stable unless tension fractures show on the ground surface at the bank of the undercut.

Riparian Condition

Riparian Habitat

The plan includes percent altered vegetation as the one specific indicator of riparian condition. Percent altered vegetation refers to the percentage of riparian vegetation along the stream channel that has been removed or altered by disturbance (includes both land-use activities and natural disturbances such as fires, floods, etc.).

Flows and Hydrology

Streamflows

The plan includes three specific indicators of streamflows: change in peak flow, change in base flow, and change in timing of flow. Peak flow is the highest or maximum streamflow recorded within a specified period of time. Base flow is the streamflow sustained in a stream channel and is not a result of direct runoff. Base flow is derived from natural storage (i.e., outflow from groundwater, large lakes, or swamps), or sources other than rainfall. Timing of flow refers to the time when peak and base flows occur and the rate of rises and falls in the hydrograph. These indicators are based on "annual" flow patterns.

Watershed Conditions

Road Density

A road is any open way for the passage of vehicles or trains. The plan includes both road density and the riparian-road index (RRI) as indicators of roads within watersheds. Road density is an index of the total miles of roads within a watershed. It is calculated as the total length of all roads (miles) within a watershed divided by the area of the watershed (miles^2). The RRI is expressed as the total mileage of roads within riparian areas divided by the total number of stream miles within the watershed (WFC 1998). For this index, riparian areas are defined as those falling within the federal buffers zones; that is, all areas within 300 ft of either side of a fish-bearing stream, within 150 ft of a permanent nonfish-bearing stream, or within the 100-year floodplain.

Watershed Disturbance

The plan includes "equivalent clearcut area" (ECA) as the single indicator of watershed disturbance. ECA is defined as the area of a watershed that has been disturbed by timber harvest, roads, and fires, with an adjustment factor to account for the hydrologic recovery resulting from forest regeneration (USFS 1974; King 1989). The adjustment is based on regeneration (size of trees) and elevation.

Recommended Indicators

As noted earlier, the biological and physical/environmental indicators identified in this section represent a "core" list of variables that will be measured in the Wenatchee Basin. This plan does not preclude the investigator from measuring other indicator variables. Which variables will be measured depends on the type of monitoring (status/trend vs. effectiveness), the target fish species, and the type of tributary action implemented. Below I identify the appropriate indicators for each type of monitoring.

Effectiveness Monitoring—This plan does not recommend that all the indicators listed in Tables 87 and 88 be measured for each tributary action. Different biological indicators will be measured depending on the fish species of interest (Table 89). All biological indicators identified in Table 87 will be measured for actions that affect anadromous species (spring chinook, summer/fall chinook, steelhead, and sockeye salmon). For resident species (bull trout and cutthroat trout), however, indicators related to smolts and origin will not be measured.

The plan recommends that only those physical/environmental indicators that are linked directly to the proposed action be measured. In other words, the most useful indicators are likely to be those that represent the first links of the cause-and-effect chain. Because different projects have different objectives and desired effects, the investigator only needs to measure those indicators directly influenced on the chain of causality between the habitat action and the effect (Table 90). This approach differs from the Action Agencies/NOAA Fisheries Plan, which requires all indicators be measured, regardless of the type of habitat action implemented.

Status/Trend Monitoring—All the physical/environmental indicators identified in Table 88 will be measured as part of status/trend monitoring in the Wenatchee Basin. In contrast, different biological indicators will be measured depending on the target fish species (Table 89), which are anadromous—spring chinook, summer/fall chinook, steelhead, and sockeye salmon— and resident —bull trout and cutthroat trout. As with effectiveness monitoring, all biological indicators identified in Table 87 will be measured for anadromous species. Indicators related to smolts and origin will not be measured for resident species.

Table 89. Biological indicator variables measured anadromous and resident fish during status/trend and effectiveness monitoring

General characteristics	Specific indicators	Anadromous species	Resident species
Adults	Escapement/Number	X	X
	Age structure	X	X
	Size	X	X
	Sex ratio	X	X
	Origin (hatchery or wild)	X	
	Genetics	X	X
	Fecundity	X	
Redds	Number	X	X
	Distribution	X	X
Parr/Juveniles	Abundance	X	X
	Distribution	X	X
	Size	X	X
Smolts	Number	X	
	Size	X	
	Genetics	X	
Macroinvertebrates	Export of invertebrates	X	X

Note: X indicates measured

Table 90 ranks the usefulness of physical/environmental indicators to the monitoring effects of different tributary habitat actions. Rankings vary from 1 = highly likely to be useful; 2 = moderately likely to be useful; and 3 = unlikely to be useful or little relationship, although the indicator may be useful under certain conditions or may help interpret data from a primary indicator. The different classes of habitat actions are from the Action Agencies/NOAA Fisheries RME Plan.

Table 90. Utility of indicators to different habitat actions

General characteristics	Specific indicators	Different classes of habitat actions							
		Diversion screens	Barrier removal	Sediment reduction	Water quality	Nutrient enhancem	Instream flows	Riparian habitat	Instream structure
Water quality	MWMT/MDMT	3	2	3	1	2	1-2	1	3
	Turbidity	3	1-2	1	1	1	1-2	2	3
	Depth fines	3	1-2	1	1-2	2	2	2	1-2
	pH	3	3	3	1	1	3	2-3	3
	DO	3	2-3	2-3	1	1	1-2	2-3	3
	Nitrogen	3	3	3	1	1	3	2	3
	Phosphorus	3	3	3	1	1	3	2	3
Habitat access	Road crossings	3	1	3	3	3	3	3	3
	Diversion dams	1-2	1	3	3	3	2	3	3
	Fishways	2-3	1	3	3	3	3	3	3
Habitat quality	Dominant substrate	3	2	1	3	3	1-2	2	1-2
	Embeddedness	3	1-2	1	1-2	3	1-2	2	1-2
	LWD	3	3	3	3	3	2	1	1
	Pool frequency	3	1-2	1-2	3	3	1-2	1-2	1
	Pool quality	3	1-2	1	2	3	1	1-2	1
	Off-channel habitat	3	2	2	3	3	1	1-2	1
Channel condition	Width/depth	3	1-2	1-2	3	3	1-2	1-2	1
	Wetted width	3	1-2	1-2	3	3	1-2	1-2	1
	Bankful width	3	1-2	1-2	3	3	1-2	1-2	1
	Bank stability	3	2	1-2	3	3	2	1	1
Riparian condition	Percent veg altered	3	3	2	3	3	2	1	1-2
Flows/hydrology	Streamflows	3	1-2	3	3	3	1	2	1-2

General characteristics	Specific indicators	Different classes of habitat actions							
		Diversion screens	Barrier removal	Sediment reduction	Water quality	Nutrient enhancem	Instream flows	Riparian habitat	Instream structure
Watershed condition	Road density	3	3	1-2	2	3	2-3	2-3	2
	Riparian-road index	3	3	1-2	2	3	2-3	1	2
	Equivalent clearcut	3	3	1-2	2	3	1	2	2

Source: Modified from Hillman and Giorgi (2002)

8.5 Measuring Protocols

An important component of the regional monitoring strategies (ISAB, Action Agencies/NOAA Fisheries, and WSRFB) is that they all recommend that the same measurement method be used to measure a given indicator. The reason for this is to allow comparisons of biological and physical/environmental conditions within and among watersheds and basins. In this section I identify methods to be used to measure biological and physical/environmental indicators. The methods identified in this plan are consistent with those described in the Action Agencies/NOAA Fisheries RME Plan.

The Action Agencies/NOAA Fisheries monitoring group reviewed several publications, including the work of Johnson et al. (2001) that describe methods for measuring indicators. Not surprisingly, there can be several different methods for measuring the same variable. For example, channel substrate can be described using surface visual analysis, peddle counts, or substrate core samples (either McNeil core samples or freeze-core samples). These techniques range from the easiest and fastest to the most involved and informative. As a result, one can define two levels of sampling methods. Level 1 (extensive methods) involves fast and easy methods that can be completed at multiple sites, while Level 2 (intensive methods) includes methods that increase accuracy and precision but require more sampling time. The Action Agencies/NOAA Fisheries monitoring group selected primarily Level 2 methods, which minimize sampling error.

Before I identify measuring protocols, it is important to define a few terms. These terms are consistent with the Action Agencies/NOAA Fisheries RME Plan.

Reach (effectiveness monitoring) – for effectiveness monitoring, a stream reach is defined as a relatively homogeneous stretch of a stream having similar regional, drainage basin, valley segment, and channel segment characteristics and a repetitious sequence of habitat types. Reaches are identified by using a list of classification (stratification) variables (from Table 86). Reaches may contain one or more sites. The starting point and ending point of reaches will be measured with Global Positioning System (GPS) and recorded as Universal Transverse Mercator (UTM).

Reach (status/trend monitoring) – for status/trend monitoring, a reach is a length of stream (20 times the average bankfull width, but not less than 150 m long) (This reach length differs from the EMAP protocol, which recommends a reach length of 40 times the average channel width (Lazorchak et al. 1998). The use of 20 times the average bankfull width is consistent with the

Action Agencies/NOAA Fisheries RME Plan and the length of effectiveness monitoring sites.) selected with a systematic randomized process (GRTS design). GRTS selects a point on the "blue-line" stream network represented on a USGS map. This point is referred to as the "X-site." The X-site identifies the midpoint of the reach. That is, the sampling reach extends a distance of 10 times the average bankfull width upstream and downstream from the X-site. Biological and physical/environmental indicators are measured within the reach. The X-site and the upstream and downstream ends of the reach will be measured with GPS and recorded as UTM.

***Site (effectiveness monitoring)* –** a site is an area of the effectiveness monitoring stream reach that forms the smallest sampling unit with a defined boundary. Site length depends on the width of the stream channel. Sites will be 20 times the average bankfull width with a minimum length of 150 m and a maximum length of 500 m. The upstream and downstream boundaries of the site will be measured with GPS and recorded as UTM.

***Transect* –** a transect is a straight line across a stream channel, perpendicular to the flow, along which habitat features such as depth or substrate are measured at pre-determined intervals. Effectiveness monitoring sites and status/trend monitoring reaches will be divided into 11 evenly-spaced transects by dividing the site into 10 equidistant intervals with "transect 1" at the downstream end of the site or reach and "transect 11" at the upstream end of the site or reach.

8.5.1 Classification Variables

As indicated in Section 5, all watersheds that will be monitored will be classified according to their landscape characteristics. Table 91 identifies classification variables and recommended protocols for measuring them. Because time and space do not allow me to describe methods in detail, I only identify recommended methods and instruments. I refer the reader to the cited documents for detailed descriptions of methods and measuring instruments.

Regional Setting

Ecoregions

The plan includes the two most commonly used ecoregion systems, Bailey (1978) and Omernik (1987). Until there is a better understand of the relationships between fish abundance and distribution and the two classes of ecoregions, investigators should use both classifications (Bailey's and Omernik's). Chapter 3 in Bain and Stevenson (1999) outlines protocols for describing ecoregions. Published maps of ecoregions are available to assist with classification work. This work will be updated once every 20 years.

Physiographic Province

Investigators will describe physiographic provinces for all watersheds that will be monitored. Chapter 3 in Bain and Stevenson (1999) outlines methods for describing this variable. Physiographic maps are available to aid classification work. Investigators will update physiographic provinces once every 20 years.

Table 91. List of classification (stratification) variables, corresponding measurement protocols, and sampling frequency

Spatial scale	General characteristics	Classification variable	Recommended protocol	Sampling frequency (years)
Regional setting	Ecoregion	Bailey classification	Bain and Stevenson (1999)	20
		Omernik classification	Bain and Stevenson (1999)	20
	Physiography	Province	Bain and Stevenson (1999)	20
	Geology	Geologic districts	Overton et al. (1997)	20
Drainage basin	Geomorphic features	Basin area	Bain and Stevenson (1999)	20
		Basin relief	Bain and Stevenson (1999)	20
		Drainage density	Bain and Stevenson (1999)	20
Valley segment	Valley characteristics	Valley bottom type	Cupp (1989); Naiman et al. (1992)	20
		Valley bottom width	Naiman et al. (1992)	20
		Valley bottom gradient	Naiman et al. (1992)	20
		Valley containment	Bisson and Montgomery (1996)	20
Channel segment	Channel characteristics	Elevation	Overton et al. (1997)	10
		Channel type (Rosgen)	Rosgen (1996)	10
		Bed-form type	Bisson and Montgomery (1996)	10
		Channel gradient	Overton et al. (1997)	10
	Riparian vegetation	Riparian cover group	Overton et al. (1997)	5
		Riparian community type	Overton et al. (1997)	5

Table is from the Action Agencies/NOAA Fisheries RME Plan.

Geology

Geologic districts are areas of similar rock types or parent materials that are associated with distinctive structural features, plant assemblages, and similar hydrographic character. Geologic districts can be identified following the methods described in Overton et al. (1997). Published geology maps aid in the classification of rock types. This work will be updated once every 20 years.

Drainage Basin

Geomorphic Features

Basin area, basin relief, and drainage density describe the geomorphic features of a watershed. Chapter 4 in Bain and Stevenson (1999) outlines standard methods for estimating these parameters. Investigators will use USGS topographic maps (1:24,000 scale) and GIS to estimate these parameters. This work will be updated once every 20 years.

Valley Segment

Valley Characteristics

The plan includes four important features of the valley segment: valley bottom type, valley bottom width, valley bottom gradient, and valley confinement. Investigators will follow the methods of Cupp (1989a,b) and Naiman et al. (1992) to describe valley bottom types. Naiman et al. (1992) describes methods for measuring valley bottom width and valley bottom gradient. Bisson and Montgomery (1996) outline methods for measuring valley confinement. GIS will aid in estimating these parameters. These variables will be updated once every 20 years.

Channel Segment

Channel Characteristics

The plan includes four characteristics of the channel segment: elevation, channel gradient, channel type, and bed-form type. Each of these characteristics will be measured within each watershed that will be monitored. Overton et al. (1997) describe methods for measuring elevation and channel gradient. Bisson and Montgomery (1996) describe in detail the method for identifying channel bed-form types, while Rosgen (1996) describes methods for classifying channel types. All classification work will include at least Level I (geomorphic characterization) channel type classification. Depending on the objectives of the monitoring program, additional levels of classification may be necessary. These variables will be updated once every 10 years.

Riparian Vegetation

The Plan includes two characteristics of riparian vegetation: riparian cover group and riparian community type. Investigators will use the methods described in Overton et al. (1997) to assess cover group and riparian community classification.

8.5.2 Biological Indicators

This section identifies the methods and instruments that should be used to measure biological indicators. Table 92 identifies indicator variables, recommended protocols, and sampling frequency. I refer the reader to the cited documents for a more detailed description of each method.

Table 92. Recommended protocols and sampling frequency for biological indicator variables

General characteristics	Specific indicators	Recommended protocol	Sampling frequency
Adults	Escapement/Number	Dolloff et al. (1996); Reynolds (1996); Van Deventer and Platts (1989)	Annual
	Age structure	Borgerson (1992)	Annual
	Size	Anderson and Neumann (1996)	Annual
	Sex ratio	Strange (1996)	Annual
	Origin (hatchery or wild)	Borgerson (1992)	Annual
	Genetics	WDFW Genetics Lab	Annual
	Fecundity	Cailliet et al. (1986)	Annual
Redds	Number	Mosey and Murphy (2002)	Annual
	Distribution	Mosey and Murphy (2002)	Annual
Parr/Juveniles	Abundance/Distribution	Dolloff et al. (1996); Reynolds (1996); Van Deventer and Platts (1989)	Annual
	Size	Anderson and Neumann (1996)	Annual
Smolts	Number	Murdoch et al. (1999)	Annual
	Size	Anderson and Neumann (1996)	Annual
	Genetics	WDFW Genetics Lab	Annual
Macroinvertebrates	Export of invertebrates	Wipfli and Gregovich (2002)	Annual

Adults

Escapement

The plan includes escapement/number of mature adults as an important biological indicator of population health. Escapement of anadromous fish into the Wenatchee Basin can be estimated roughly as the difference between fish counts at Rock Island Dam and Rocky Reach Dam (with some correction for fallback). Counts at dams should be made with video operated continuously during the upstream migration of anadromous salmonids. Counts of adults at weirs are more accurate and should be used whenever possible. This method is recommended if accurate estimates of escapements into specific watersheds are necessary.

Numbers of resident adult fish should be estimated within status/trend monitoring reaches and effectiveness monitoring sites using underwater observations (snorkeling) and electrofishing surveys. Snorkeling, which is a quick, nondestructive method that is not restricted by deep water and low conductivities (Hillman and Miller (2002) reported that snorkel estimates were more accurate than electrofishing estimates in the Chiwawa River, because low conductivity (35 µmhos) in the river reduced the efficiency of electrofishing. They noted that electrofishing estimates were at best 68% of snorkel estimates), is the "primary" sampling method in this plan. Snorkel surveys will follow the protocols identified in Dolloff et al. (1996). Accurate estimates of adult bull trout may require nighttime snorkeling. However, Hillman and Chapman (1996) counted more adult bull trout during the day than at night in the Blackfoot River, Montana, because adult bull trout were unable to conceal themselves, making them readily visible to snorkelers. Both daytime and nighttime surveys should be conducted for at least two years to see which survey time (daytime or nighttime) provides the best estimate of resident adult fish.

Electrofishing is the "secondary" method and will be used within a sub-sample of snorkel sites. The plan recommends that at least two randomly-selected sites within each watershed (In the Wenatchee Basin there are nine major watersheds. If two sites are sampled within each watershed, the investigator would sample a total of 18 sites.) be sampled with both snorkeling and electrofishing. (Sampling within a site should occur within the same day and sites should be blocked to prevent movement into and out of the site during and between sampling.)The purpose for this is to establish a relationship between the methods and to collect fish for assessment of condition (length and weight), age, gender, and genetics. Electrofishing will follow the protocols outlined in Reynolds (1996). This plan recommends the removal-depletion method of electrofishing. Population numbers and 95% confidence intervals will be estimated with the maximum-likelihood formula (Van Deventer and Platts 1989).

Spawners

The plan includes six indicators associated with the characteristics of the spawning populations: age structure, size, sex ratio, origin, genetics, and fecundity. For anadromous fish, most of these characteristics will be collected from live fish trapped at weirs or from carcasses sampled during spawning surveys. Scales will be pulled from live fish and carcasses. Scales will be read to determine age structure and origin (wild or hatchery). Presence or absence of an adipose fin will also determine origin. Age analysis will be completed by methods described by Borgerson (1992). Size will be reported as both fork length (anterior tip to the median caudal fin rays) and hypural length (mid-eye to hypural plate) (Anderson and Neumann 1996). The latter is necessary because some carcasses will have decomposed to a point where fork length cannot be measured accurately. The gender of each fish sampled will be recorded (Strange 1996). Fecundity (total number of eggs produced by a given size female) will be estimated for fish collected for hatchery broodstock and from dead pre-spawn females collected during spawning surveys (Cailliet et al. 1986). Finally, genetic samples will be collected and analyzed according to the protocols being refined at the WDFW Genetics Lab. All sampled carcasses will be marked to avoid resampling.

Many of the characteristics identified above for anadromous fish will be collected from resident fish during electrofishing surveys, collection at weirs, and during spawning surveys. Characteristics such as age structure (from scales), size (fork length and mid-eye to hypural length; mm), weight (g), and genetic samples can be collected from adults trapped at weirs and during electrofishing surveys. Gender can be recorded for those fish found dead during spawning surveys. The protocols identified above can be used to measure characteristics of resident fish.

Redds

Abundance/Distribution

This plan includes abundance and distribution of salmonid redds as indicators of population health. The plan calls for a complete census of anadromous fish redds and a probabilistic sample of resident fish redds. Throughout the spawning period, investigators will conduct weekly redd surveys following the methods of Mosey and Murphy (2002). Each week new redds will be counted, mapped, and marked. (Because of inclement weather and high streamflows, surveys for steelhead redds may not be made on regularly timed intervals. Adjusting surveys to fit environmental conditions may be necessary.) Marking is needed to avoid recounting redds during subsequent surveys. The entire distribution of anadromous spawning areas will be sampled. For resident fish, index areas selected according to a probabilistic sampling design (e.g., stratified random sampling) will be surveyed for redds.

Parr

Abundance/Distribution

The plan includes the abundance and distribution of juvenile fish as an indicator of population health. Juvenile numbers will be estimated with snorkeling and electrofishing within status/trend monitoring reaches and effectiveness monitoring sites. Snorkeling is the “primary” sampling method in this plan and will follow the protocols identified in Dolloff et al. (1996). Accurate estimates of juvenile bull trout may likely require nighttime snorkeling. Therefore, both daytime and nighttime surveys should be conducted for at least two years to see which survey time (daytime or nighttime) provides the best estimate of juvenile fish.

Electrofishing is the “secondary” method and will be used within at least two randomly-selected sites within each watershed (same sites used to sample adult fish). Electrofishing will follow the protocols outlined in Reynolds (1996). This plan recommends the removal-depletion method of electrofishing. Population numbers and 95% confidence intervals will be estimated with the maximum-likelihood formula (Van Deventer and Platts 1989).

Juvenile fish collected during electrofishing will be measured (see below) and at least 5,000 juvenile chinook and 5,000 steelhead will be implanted with PIT tags. The sample size of 5,000 for anadromous populations in the Upper Columbia Basin was estimated by the Action Agencies/NOAA Fisheries Monitoring Group. This is the minimum number needed to estimate life-stage survival rates.

Condition

The plan includes Fulton-type condition as the metric for well-being of juvenile fish. Juvenile fish collected during electrofishing and with rotary traps will be measured (fork length; mm) and weighed (g). Fulton-type condition will be estimated with methods described in Anderson and Neumann (1996).

Smolts

Abundance

Abundance of smolts is an estimate of the total number of smolts produced within a watershed or basin. Investigators will use floating screw traps to collect downstream migrating smolts. Traps will operate for at least the entire period of the smolt migration. Trapping efficiency, based on mark/recapture will be estimated throughout the trapping period. Methods for operating the trap, estimating efficiency, and the frequency at which efficiency tests are conducted are described in Murdoch et al. (1999).

Condition

The Fulton-type condition factor describes the well-being of smolts within a population or subpopulation. Smolts collected with rotary traps will be measured (fork length; mm) and weighed (g). Fulton-type condition will be estimated with methods described in Anderson and Neumann (1996).

Genetics

Genetic characterization (via DNA microsatellites) describes within- and between-population genetic variability of smolts. DNA samples from a systematic sample of smolts (The total number of smolts needed to characterize within and between-population genetic variability is presently unknown. Therefore, "**k**" (i.e., the k^{th} smolt sampled) remains undefined.) will be collected and analyzed according to the protocols being refined at the WDFW Genetics Lab.

Macroinvertebrates

Invertebrate Transport

The plan includes export of invertebrates (aquatic and terrestrial) from headwaters to habitats downstream as an attribute of freshwater productivity. Investigators will follow the methods described in Wipfli and Gregovich (2002) to assess energy sources for downstream food webs. The method requires the placement of sampling stations near tributary junctions of fishless and fish-bearing streams. Specially-modified drift nets (Wipfli and Gregovich 2002) will capture invertebrates and particulate organic matter. This work will be conducted annually during base-flow conditions.

8.5.3 Physical/Environmental Indicators

In this section I identify the methods and instruments needed to measure physical/environmental indicators. Table 93 identifies indicator variables, recommended protocols for measuring indicators, and sampling frequency. There is no space here to describe each method in detail; therefore, I refer the reader to the cited documents for detailed descriptions of methods and measuring instruments. Importantly, all habitat sampling would follow fish sampling (snorkeling and electrofishing) within status/trend monitoring reaches and effectiveness monitoring sites.

Water Quality

Water Temperature

The plan includes two temperature metrics that will serve as specific indicators of water temperature maximum daily maximum temperature (MDMT) and maximum weekly maximum temperature (MWMT). Data loggers will be used to measure MWMT and MDMT. Zaroban (2000) describes pre-placement procedures (e.g., selecting loggers and calibration of loggers), placement procedures (e.g., launching loggers, site selection, logger placement, and locality documentation), and retrieval procedures. This manual provides standard methods for conducting temperature-monitoring studies associated with land-management activities and for characterizing temperature regimes throughout a watershed.

The number of loggers used will depend on the number of reaches and treatment and control sites. For effectiveness monitoring, at a minimum, at least one logger will measure water temperatures at the downstream end and one at the upstream end of each reach that contains treatment or control sites. Additional measurements may be needed within reaches (at treatment sites) if management actions directly affect water temperature (e.g., restore riparian function). For status/trend monitoring, one logger will be placed at or near the X-site within the monitoring reach. Temperatures will be monitored continuously throughout the year.

Table 93. Recommended protocols and sampling frequency of physical/environmental indicator variables

General characteristics	Specific indicators	Recommended protocols	Sampling frequency
Water Quality	MWMT/MDMT	Zaroban (2000)	Continuous
	Turbidity	OPSW (1999)	High and base-flow periods (2 times/yr)
	Depth fines	Schuett-Hames (1999)	Annual
	pH	OPSW (1999)	High and base-flow periods (2 times/yr)
	DO	OPSW (1999)	High and base-flow periods (2 times/yr)
	Nitrogen	OPSW (1999)	High and base-flow periods (2 times/yr)
	Phosphorus	OPSW (1999)	High and base-flow periods (2 times/yr)
Habitat Access	Road crossings	Parker (2000); WDFW (2000)	Annual
	Diversion dams	WDFW (2000)	Annual
	Fishways	WDFW (2000)	Annual
Habitat Quality	Dominant substrate	Bunte & Abt (2001); Platts et al. (1983)	Annual
	Embeddedness	MacDonald et al. (1991)	Annual
	LWD (pieces/mile)	BURPTAC (1999)	Annual
	Pools per mile	Overton et al. (1997)	Annual
	Pool quality	Platts et al. (1983)	Annual
	Off-channels habitats	WFPB (1995)	Annual
Channel condition	Width/depth ratio	BURPTAC (1999)	Annual
	Wetted width	Bain & Stevenson (1999)	Annual
	Bankfull width	Bain & Stevenson (1999)	Annual
	Bank stability	BURPTAC (1999)	Annual
Riparian Condition	Percent veg altered	Platts et al. (1987)	Annual
Flows and Hydrology	Streamflow	Bain & Stevenson (1999)	Continuous
Watershed Condition	Watershed road density	WFC (1998); Reeves et al. (2001)	Annual
	Riparian-road index	WFC (1998)	Annual
	Equivalent clearcut area	USFS (1974); King (1989)	Annual

Source: Modified from Action Agencies/NOAA Fisheries RME Plan

Sediment and Turbidity

The plan includes two sediment-related specific indicators: turbidity and depth fines. Investigators will measure turbidity with a portable turbidimeter (calibrated on the nephelometric turbidity method) following protocols described in Chapter 11 in OPSW (1999). This guidebook provides a standardized method for measuring turbidity, data quality guidelines, equipment, field measurement procedures, and methods to store and analyze turbidity data. For effectiveness monitoring, at a minimum, turbidity will be measured at the downstream end and at the upstream end of each reach that contains treatment or control sites. Additional measurements may be needed at treatment sites within reaches if management actions directly affect turbidity (e.g., sediment reduction actions). For status/trend monitoring, turbidity should be measured at or near the X-site within the monitoring reach. Turbidity will be measured during high flow (spring) and base-flow (summer) conditions.

Investigators will measure depth fines with McNeil core samplers following methods described in Schuett-Hames et al. (1999). For effectiveness monitoring, three randomly-selected samples (subsamples) will be taken from each spawning area (pool tailout or riffle) within each site (samples will not be taken from sites that lack spawning areas). For status/trend monitoring, three subsamples from one randomly-selected spawning area within a reach will be collected. The volumetric method will be used for processing samples sorted via a standard set of sieves. The volumetric method measures the millimeters of water displaced by particles of different size classes. At a minimum, the following sieves will be used to sort particles: 64.0 mm, 16.0 mm, 6.4 mm, 4.0 mm, 1.0 mm, 0.85 mm, 0.50 mm, 0.25 mm, and 0.125 mm. Fines will be measured once annually during base-flow conditions.

Contaminants and Nutrients

The plan includes four specific indicators associated with contaminants and nutrients: pH, dissolved oxygen (DO), nitrogen, and phosphorus. The procedures described by OPSW (1999) will be used to measure pH, dissolved oxygen, nitrogen, and phosphorus. The guidebook provides a standardized method for measuring pH (pH meter—Chapter 8), DO (Winkler Titration Method—Chapter 7) (According to OPSW (1999), the Winkler Titration Method is the most accurate method for measuring DO concentration. Although this plan recommends the Winkler Titration Method, calibrated DO meters with an accuracy of ±0.2 mg/L can be used in place of the chemical method.), and nitrate/nitrites, Kjeldahl nitrogen, total phosphorous, and orthophosphates (Chapter 10), including criteria for data quality guidelines, equipment, field measurement procedures, and methods to store and analyze water quality data. For effectiveness monitoring, at a minimum, these indicators will be measured at the downstream end and upstream end of each reach that contains treatment or controls sites. Additional measurements may be needed at treatment sites within reaches if management actions directly affect these water-quality parameters (e.g., nutrient enhancement). For status/trend monitoring, samples should be collected at or near the X-site within the monitoring reach. These indicators will be measured once during high flow (spring) and during base flow (summer).

Habitat Access

Artificial Physical Barriers:

The plan includes three specific indicators associated with artificial physical barriers: road crossings (culverts), dams, and fishways. The WDFW (2000) manual provides guidance and methods on how to identify, inventory, and evaluate culverts, dams, and fishways that impede fish passage. WDFW (2000) also provides methods for estimating the potential habitat gained upstream from barriers, allowing prioritization of restoration projects. The manual by Parker (2000) focuses on culverts. The methods outlined in this manual assess connectivity of fish habitats on a watershed scale. These manuals will be used to identify all fish passage barriers within monitoring reaches. Assessment of fish passage barriers will occur once annually during base-flow conditions.

Habitat Quality

Substrate

The plan includes two specific indicators of substrate: dominant substrate and embeddedness. Pebble counts will be used to identify substrate composition. Investigators will measure substrate at five equidistant points along each of the 11 transects. Following Bunte and Abt (2001), a 60 x 60-cm sampling frame will be used to sample substrate at each point along a transect. The sampling frame will be divided into four grid points by spacing the elastic bands 30 cm from each other. The sampling frame is intended to reduce operator influence on the selection of particle sizes. In field tests, the sampling frame produced slightly coarser size distributions than the traditional heel-to-toe walk. The sampling frame also produced more similar sampling results between two investigators than heel-to-toe walks. Classification of bed material by particle size will follow Table 4 in Platts et al. (1983).

Investigators will follow methods described in MacDonald et al. (1991) for measuring embeddedness. The method involves the use of a 60-cm-diameter hoop as the basic sample unit. The use of hoops rather than individual particles as the basic sampling unit substantially increases the number of particles that must be measured, but reduces the variability among sample units. This makes it easier to detect change and results in an embeddedness value that more closely represents the condition of the stream reach. Embeddedness will be collected within riffles in the lower and upper portions of each sampling reach. For effectiveness monitoring, additional sampling will occur within sites that are treated with actions that directly affect embeddedness (e.g., sediment reduction activities). For status/trend monitoring, embeddedness will be measured in one randomly selected riffle within the monitoring reach. Substrate indicators will be measured once annually during base-flow stream conditions.

Large Woody Debris

Large woody debris (LWD) consists of large pieces of relatively stable woody material located within the bankfull channel and appearing to influence bankfull flows. Investigators will follow methods described in BURPTAC (1999) for estimating the number of pieces of large woody debris in forested streams. The guidelines describe procedures for dealing with single pieces and aggregates. Pieces of LWD will be counted in all monitoring reaches within forested streams. This indicator will be measured once annually during base-flow conditions.

Pool Habitat

The plan includes two indicators associated with pool habitat: number of pools per mile and pool quality. Investigators will count the number of pools throughout a monitoring reach. To be counted, a pool must span more than half the wetted width, be longer than it is wide, and include the thalweg. Overton et al. (1997) provide a good description of the various types of pools and how to identify them. Pool frequency will be measured in all monitoring reaches.

Platts et al. (1983) describe methods for estimating pool quality (see their Table 1). This plan includes a slight modification to the Platts protocol by adding residual pool depth to the criteria. Residual pool depth is the difference between the maximum pool depth and the pool crest outlet depth (Overton et al. (1997) describe methods for measuring these two depths). Residual pool depth is independent of streamflow at time of measurement and is sensitive to land-management actions. For effectiveness monitoring, pool quality will be assessed for all pools within treatment and control sites. For status/trend monitoring, pool quality will be measured for all pools within a reach. Both pool frequency and pool quality will be measured once annually during base-flow conditions.

Off-Channel Habitat

Off-channel habitat consists of side-channels, backwater areas, alcoves or sidepools, off-channel pools, off-channel ponds, and oxbows. Following the definitions for each off-channel habitat type (see Section 6), the investigator will enumerate the number of each type of off-channel habitat within a monitoring reach. This indicator is specific only to channels with gradients <3% (WFPB 1995). Sampling will occur once annually during base-flow conditions.

Channel Condition

Width/Depth Ratio

The width/depth ratio is an index of the cross-section shape of a stream channel at bankfull level. The ratio is expressed as bankfull width (geomorphic term) divided by the mean cross-section depth. To measure width/depth ratio, the investigator will follow the protocol described in BURPTAC (1999), with one exception. Rather than measure wetted width and wetted depth, the investigator will measure mean bankfull width and mean bankfull depth. BURPTAC (1999) describes methods for estimating W/D rations in both single channels and split channels. This indicator will be measured at the 11 evenly-spaced transects within each reach (for status/trend monitoring) or treatment and control site (for effectiveness monitoring). Sampling will occur once annually during base-flow conditions.

Wetted Width

Wetted width is the width of the water surface measured perpendicular to the direction of flow. Wetted width will be measured at the 11 evenly-spaced transects within each reach (for status/trend monitoring) or treatment and control site (for effectiveness monitoring) following the protocol in Bain and Stevenson (1999). Widths of multiple channels are summed to represent the total wetted width. Sampling will occur once annually during base-flow conditions.

Bankfull Width

Bankfull width is the width of the channel between the tops of the most pronounced banks on either side of a stream site or reach. Bankfull width will be measured at the 11 evenly-spaced transects within each reach (for status/trend monitoring) or treatment and control site (for effectiveness monitoring) following the protocol in Bain and Stevenson (1999). Widths of multiple channels are summed to represent the total bankfull width. Sampling will occur once annually during base-flow conditions.

Streambank Condition

The plan includes streambank stability as the one specific indicator of streambank condition. It will be measured following methods in BURPTAC (1999). Stability will be based on "natural" conditions (e.g., vegetation), not "unnatural" conditions such as car bodies, riprap, and concrete. The methods apply to both the left and right banks of the channel. Bank stability will be measured once annually during base-flow conditions at the 11 evenly-spaced transects within each reach (for status/trend monitoring) or treatment and control site (for effectiveness monitoring).

Riparian Condition

Riparian Habitat

The plan included percent altered vegetation as the one specific indicator of riparian condition. Percent altered vegetation will be measured within each reach (for status/trend monitoring) or treatment and control site (for effectiveness monitoring) following methods described in Platts et al. (1987). It is measured along both banks. Percent altered vegetation will be measured once annually during base-flow conditions.

Flows and Hydrology

Streamflows

Changes in streamflows will be assessed by collecting flow data at the downstream end of monitoring reaches and/or at the downstream end of the distribution of each population or subpopulation. Investigators will use USGS flow data where available to assess changes in peak, base, and timing of flows. For those streams with no USGS stream-gauge data, investigators will use methods described in Chapter 14 in Bain and Stevenson (1999) for measuring stream flows. Water velocities will be measured with a calibrated water-velocity meter rather than the float method.

Watershed Conditions

Road Density

The plan includes road density and the riparian-road index (RRI) as indicators of roads within watersheds. Investigators will measure the road density and riparian-road index within each watershed in which monitoring activities occur. Road density will be calculated with GIS as the total length of roads within a watershed divided by the area of the watershed. The riparian-road index will be calculated with GIS as the total mileage of roads within riparian areas divided by the total number of stream miles within the watershed. WFC (1998) provides an example of calculating the riparian-road index in the Umpqua Basin. Both road density and the riparian-road index will be updated annually.

Watershed Disturbance

The plan includes "equivalent clearcut area" (ECA) as the single indicator of watershed disturbance. It will be measured within each watershed in which monitoring activities occur. Investigators will follow methods outlined in USFS (1974) and King (1989). ECA will be updated annually.

8.5.4 Recommendations

This plan requires that the protocols identified above be used to measure biological and physical/environmental indicators. It is understood that some of these methods will differ from those currently used by entities that will be implementing this plan. Indeed, some of the entities that will implement this plan may have collected data for several years with protocols different from those identified in this plan. It is not the intent of this plan to have those entities immediately switch protocols. Rather, this plan encourages entities to use both methods for a few years. (The number of years needed to compare performance and to develop relationships between methods will be determined as data are collected. At a minimum, entities implementing this plan should expect to use both methods for at least five years (n = 5).)This will allow them to compare the performance of different methods and to develop relationships between different protocols.

8.6 Implementation

The preceding sections serve notice that considerable care must be put into the appropriate methods and logic structure of a status/trend and effectiveness monitoring plan. My intent in this section is to distill the information presented in this document into a concise outline that an investigator can follow to develop a statistically-valid monitoring plan. For convenience, I offer this summary as a checklist of steps that will aid the investigator in developing a valid monitoring program. Although these steps are generic, the investigator should address each one in order to demonstrate complete understanding of status/trend and effectiveness monitoring.

I divided this section into three parts. The first part outlines the steps needed to setup and implement the monitoring plan. The second and third parts outline the steps needed to design status/trend monitoring studies and effectiveness monitoring studies, respectively.

8.6.1 Program Setup

In order to setup the monitoring program, it is important to follow a logical sequence of steps. By walking through each step, the investigator will better understand the goals of monitoring and its strengths and limitations. These steps should aid the investigator in implementing a valid monitoring program that reduces duplication of sampling efforts, and thus overall costs, but still meets the needs of the different entities. The plan assumes that all entities involved with implementing the plan will cooperate and freely share information.

Setup Steps

- Identify the populations and/or subpopulations of interest (e.g., spring chinook, steelhead, bull trout).
- Identify the geographic boundaries (areas) of the populations or subpopulations of interest.
- Describe the purpose for selecting these populations or subpopulations (what are the concerns?).
- Identify the objectives for monitoring.
- Select the appropriate monitoring approach (status/trend or effectiveness monitoring or both) for addressing the objectives.
- Identify and review existing monitoring and research programs in the area of interest.
- Determine if those programs satisfy the objectives of the proposed program.
- If data gaps exist, implement the appropriate monitoring approach by following the criteria outlined below.
- Classify the landscape and streams in the area of interest (see Section 5).
- Describe how data collection efforts will be shared among the different entities.
- Identify a common database for storing biological and physical/environmental data.
- Estimate costs of implementing the program.

- Identify cost-sharing opportunities.

8.6.2 Status/Trend Monitoring

If the objective of the monitoring program is to assess the current status of populations and/or environmental conditions, or to assess long term trends in these parameters, then the following steps will help the investigator design a valid status/trend monitoring program.

Problem Statement and Overarching Issues

- Identify and describe the problem to be addressed.
- Identify boundaries of the study area.
- Describe the goal or purpose of the study.
- List hypotheses to be tested.

Statistical Design (see Section 2)

- Describe the statistical design to be used (e.g., EMAP design).
- List and describe potential threats to external validity and how these threats will be addressed.
- If this is a pilot test, explain why it is needed.
- Describe descriptive and inferential statistics to be used and how precision of statistical estimates will be calculated.

Sampling Design (see Sections 3 & 4)

- Describe the statistical population(s) to be sampled.
- Define and describe sampling units.
- Identify the number of sampling units that make up the sampling frame.
- Describe how sampling units will be selected (e.g., random, stratified, systematic, etc.).
- Describe variability or estimated variability of the statistical population(s).
- Define Type I and II errors to be used in statistical tests (the plan recommends no less than 0.80 power).

Measurements (see Sections 6 & 7)

- Identify indicator variables to be measured.
- Describe methods and instruments to be used to measure indicators.
- Describe precision of measuring instruments.

- Describe possible effects of measuring instruments on sampling units (e.g., core sampling for sediment may affect local sediment conditions). If such effects are expected, describe how the study will deal with this.
- Describe steps to be taken to minimize systematic errors.
- Describe QA/QC plan, if any.
- Describe sampling frequency for field measurements.

Results

- Explain how the results of this study will yield information relevant to management decisions.

8.6.3 Effectiveness Monitoring

If the objective of the monitoring program is to assess the effects of tributary habitat actions (e.g., improve stream complexity), then the following steps will help the investigator design a valid effectiveness monitoring program (these steps are modified from Paulsen et al. 2002). Because effectiveness monitoring encompasses the essence of cause-and-effect research (i.e., attempts to control for sources of invalidity), the steps below are more extensive and intensive than those in the status/trend monitoring program.

Problem Statement and Overarching Issues

- Identify and describe the problem to be improved or corrected by the action being monitored.
- Describe current environmental conditions at the project site.
- Describe factors contributing to current conditions (e.g., roads crossing causing increased siltation).
- Identify and describe the habitat action(s) (treatments) to be undertaken to improve existing conditions.
- Describe the goal or purpose of the habitat action(s).
- Identify the hypotheses to be tested.
- Identify the independent variables in the study.

Statistical Design (see Section 2)

- Describe the statistical design to be used (e.g., BACI design).
- Describe how treatments (habitat actions) and controls will be assigned to sampling units (e.g., random assignment).
- Show whether or not the study will include “true” replicates or subsamples.
- Describe how temporal and spatial controls will be used and how many of each type will be sampled.

- Describe the independence of treatment and control sites (are control sites completely unaffected by habitat actions?).
- Identify covariates and their importance to the study.
- Describe potential threats to internal and external validity and how these threats will be addressed.
- If this is a pilot test, explain why it is needed.
- Describe descriptive and inferential statistics to be used and how precision of statistical estimates will be calculated.

Sampling Design (see Sections 3 & 4)

- Describe the statistical population(s) to be sampled.
- Define and describe sampling units.
- Describe the number of sampling units (both treatment and control sites) that make up the sampling frame.
- Describe how sampling units will be selected (e.g., random, stratified, systematic, etc.).
- Define “practical significance” (e.g., environmental or biological effects of the action) for this study.
- Describe how effect size(s) will be detected.
- Describe the variability or estimated variability of the statistical population(s).
- Define Type I and II errors to be used in statistical tests (the plan recommends no less than 0.80 power).

Measurements (see Sections 6 & 7)

- Identify and describe the indicator (dependent) variables to be measured.
- Describe methods and instruments to be used to measure indicators.
- Describe the precision of measuring instrument(s).
- Describe possible effects of measuring instruments on sampling units (e.g., core sampling for sediment may affect local sediment conditions). If such effects are expected, describe how the study will deal with this.
- Describe steps to be taken to minimize systematic errors.
- Describe QA/QC plan, if any.
- Describe sampling frequency for field measurements.

Results

- Explain how the results of this study will yield information relevant to management decisions.

These steps should be considered when designing a monitoring plan to assess the effectiveness of any habitat action, regardless of how simple the proposed action may be. Even monitoring the effectiveness of irrigation screens requires careful consideration of all steps in the checklist. In some cases, the investigator may not be able to address all steps with a high degree of certainty, because adequate information does not exist. For example, the investigator may lack information on population variability, effect size, “practical significance,” or instrument precision, which makes it difficult to design studies and estimate sample sizes. In this case the investigator can address the statements with the best available information, even if it is based on professional opinion, or design a pilot study to answer the questions.

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10 Acronyms and Abbreviations

ACOE	US Army Corps of Engineers
AF	Acre feet
AFWP	Agriculture Fish and Wildlife Program
BLM	Bureau of Land Management
BPA	Bonneville Power Administration
BOR	Bureau of Reclamation
BiOP	Biological opinion
BRT	Biological review team
CAA	Clean Air Act
CBFWA	Columbia Basin Fish and Wildlife Authority
CCCD	Chelan County Conservation District
CCD	County Conservation District
CCP	Columbia Cascade Province
CCRP	Continuous Conservation Reserve Program
cfs	Cubic feet per second
Colville Tribes	Confederated Tribes of the Colville Reservation
CP	Cover practices
CREP	Conservation Reserve Enhancement Program
CRITFC	Columbia River Inter-Tribal Fish Commission
CRMP	Columbia River Management Plan
CRP	Conservation Reserve Program
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DBH	Diameter at breast height
DPS	Distinct population segment
EA	Environmental Assessment
EDT	Ecosystem Diagnostic & Treatment
EIS	Environmental Impact Statement

EPA	US Environmental Protection Agency
EQUIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ESU	Ecologically Significant Unit
FCRPS	Federal Columbia River Operating System
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FIP	Forest Incentive Program
FLIR	Forward looking infrared
FLPMA	Federal Land Policy and Management Act
FSA	Farm Services Administration
GAP	Gap Analysis Program
GCFMP	Grand Coulee Fish Management Plan
GCDFMP	Grand Coulee Dan Fish Maintenance Project
gpm	Gallons per minute
GIS	Geographic Information System
GMA	Growth Management Act
HEP	Habitat Evaluation Procedure
HGMP	Hatchery Genetic Management Plan
HSI	Habitat Suitability Indices
IFIM	instream flow incremental methodology
ISAB	Independent Scientific Advisory Board
IBIS	Interactive Biological Information System
ICBEMP	Interior Columbia Basin Ecosystem Mgmt. Project
ICBTRT	Interior Columbia Basin Technical Recovery Team
ISG	Independent Scientific Group
ISRP	Independent Scientific Review Panel
LFA	Limiting factors analysis
LWD	Large woody debris

MCMCP	Mid-Columbia Mainstem Conservation Plan
M&E	Monitoring and evaluation
MPRSA	Marine Protection, Research, and Sanctuaries Act
MYS	Maximum sustained yield
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NF	National Forest
NFMA	National Forest Management Act
NFN	National Fish Hatchery
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPPC	Northwest Power Planning Council
NRC	National Research Council
NRCS	Natural Resources Conservation Service
ORVs	Off-road recreational vehicles
PPA	Pollution Prevention Act
PHS	Priority habitats and species
PMU	Population management unit
PUD	Public Utility District
QHA	Qualitative Habitat Assessment
RM	River mile
RME	Research, Monitoring, and Evaluation
RMP	Resource Management Plan
ROD	Record of Decision
RPA	Reasonable and Prudent Alternatives
RTT	Regional Technical Team
SASSI	Washington State Salmon and Steelhead Stock Inventory

SOR	Systems operation review
TAC	Technical Advisory Committee
TMDL	Total maximum daily load
TRT	Technical Recovery Team
Upper Columbia RUT	Upper Columbia Recovery Unit Team
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
USDOI	United States Department of Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VOR	Visual obstruction readings
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WCC	Washington Conservation Commission
WDOE	Washington Department of Ecology
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WDW	Washington Department of Wildlife
WHIP	Wildlife Habitat Improvement Program
WPA	Watershed Planning Act
WPU	Wenatchee Planning Unit
WQI	Water quality index
WRIA	Water Resource Inventory Area
WRP	Wetlands Reserve Program
Yakama Nation	Confederated Tribes and Bands of the Yakama Nation

11 Appendices

Appendix A. Ashley, Paul and Stacy Stovall. 2004. Wenatchee Wildlife Assessment. WDFW. Olympia.

Appendix B. Hillman, Tracy. 2003. Monitoring Strategy for the Wenatchee River Basin. Draft Report prepared for the Upper Columbia Regional Technical Team, Upper Columbia River Salmon Recovery Board. BioAnalysts, Inc. Eagle, Idaho. [This report is also the monitoring section in the subbasin plan.]

Appendix C. BioAnalysts. April 2004. Effects of Hydroelectric Dams on Viability of Wild Fish.

Appendix D. Summary of Artificial Production In the Wenatchee Subbasin

Appendix E. Pevan et al. 2004 Hatchery Information for Subbasin Planning