SALMON AND STEELHEAD HABITAT LIMITING FACTORS ASSESSMENT WATERSHED RESOURCE INVENTORY 49: OKANOGAN WATERSHED

Prepared for:

CONFEDERATED TRIBES OF THE COLVILLE RESERVATION
Okanogan, WA

Prepared by:

ENTRIX, INC.
Seattle, WA

&

Golder Associates
Redmond, WA

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5-20. NINEMILE CREEK LIMITING FACTORS ASSESSMENT **5-110**

This Habitat Limiting Factors Report for the Okanogan Watershed, watershed resource inventory area (WRIA) 49, summarizes current understanding of habitat conditions in the Okanogan River and its tributaries that may affect the opportunity and ability of anadromous salmonid fishes to reproduce and thrive naturally. It represents a snapshot in time based on the data and published material available, and the professional knowledge of the Technical Advisory Group (TAG) that participated in the production of this report. The assessment of habitat factors limiting salmonid production emphasizes anadromous stocks, and considers both natural and anthropogenic sources of habitat impairment in its conclusions. Habitat data from the Okanogan watershed are extremely limited and are generally focused on public or tribal lands, often upstream of the anadromous zone. Thus, the Okanogan TAG relied heavily on its combined professional knowledge to assess the extent to which habitat conditions affect salmon production throughout the Okanogan watershed. In so doing, the TAG considered accepted habitat-forming processes, and literature on salmonid habitat needs as the basis for drawing conclusions in this report.

In the late 1800's, overfishing on the lower Columbia River severely depleted salmon runs to upper Columbia River tributaries (Chapman et al. 1994a). Later, a hydroelectric dam across the Okanogan River at Pateros blocked all fish passage between 1915 and 1929. By the time the dam was removed, the Okanogan River run of coho was extinct, and spring and summer chinook runs, as well as steelhead were severely depressed. In 1939, a massive hatchery program was launched to offset the loss of access and mitigate for impacts created by the soon to be completed Grand Coulee Dam. Despite ongoing hatchery programs, resource managers have not been able to reestablish salmon and steelhead populations to self-sustaining levels. This failure can be attributed to a number of factors including, passage problems and mortality associated with nine hydroelectric facilities on the mainstem Columbia River, unfavorable ocean conditions, harvest pressures, and degradation of ecological processes and habitat within the Okanogan watershed (Columbia Basin System Planning 1990; Peven 1992; Caldwell and Catterson 1992; WDFW 1993; Williams et al. 1996). Atop these issues, the climatic conditions of the Okanogan naturally restrict habitat use by imposing thermal and flow barriers that can affect the overall production in the watershed.

Natural environmental conditions limit natural production of salmonids in the Okanogan watershed. In particular, low stream flows in the summer and winter, and high ambient summer temperatures restrict or limit access to habitats otherwise suitable in many of the sub-basins at other times of the year. Extreme winter conditions - the result of latitude, elevation and the influence of the Cascade mountain range on marine and arctic air masses - combine to create extreme winter conditions that can reduce fish growth and activity (Mullan et al. 1992). In years when moisture availability is limited, dewatered reaches are not uncommon. These conditions restrict salmonid access to habitat, dewater redds, and may strand juveniles, resulting in direct mortality to salmonids.

In some portions of the Okanogan watershed, human alterations to the landscape have exacerbated the naturally limiting conditions by further reducing habitat quality and quantity available for salmonids to satisfy specific life history strategies. These alterations have primarily occurred in the lower gradient, lower reaches of subwatersheds. These impacts are mostly the result of past timber harvest operations, road building and placement, and grazing.

Providing that habitat rehabilitation and protection of aquatic systems continues on federally owned land as per current standards and guidelines (USDA, USDI 1995), it is the professional opinion of the TAG that habitat conditions in the upper portions of the Okanogan watershed are sufficiently intact to support and improve self-sustaining populations of salmonids given the following: 1) no further reduction in habitat quality and quantity elsewhere in the watershed; 2) removal of artificial fish passage barriers and installation of approved screening devices on water diversions; 3) rehabilitation of stream functions in the lower reaches of certain tributaries and portions of the mainstem; 4) instream flows sufficient so as not to impede adult fish passage and salmonid rearing during dry years; 5) and sufficient numbers of returning wild anadromous salmon and steelhead from the Columbia River.

The TAG's action item recommendations that apply to the Okanogan watershed as a whole can be summarized as follows:

1. **Protect habitat that is currently functional for salmonids**. Preservation of properly functioning habitat is essential to ensure the existing production of naturally-producing, anadromous salmonids in the Okanogan watershed continues—assuming an adequate escapement of spawners.

2. **Restore access to fish habitat obstructed by human-caused physical and/or water quality barriers** Concurrent with habitat protection, restoring fish passage at critical fish passage barriers and installing screens on water diversions is a necessary action to ensure the sustainability of naturally-producing, anadromous salmonids in the Okanogan watershed. To implement a strategy of fish passage restoration in a logical and sequential manner, a single data set of inventoried fish passage barriers with the quantity and quality of habitat upstream of the barriers is needed. Currently, the Forest Service maintains the locations of all water diversions in a Geographic Information Services (GIS) database. The WDFW Salmonid Screening, Habitat Enhancement and Restoration (SSHEAR) Division also maintains a database of water diversions and screen conditions for which they have an installation or maintenance agreements. These two databases should be combined and inconsistencies reconciled. A field inventory of unidentified water diversions and screen conditions on private lands is then needed to fill in gaps in knowledge. Public funding should support the restoration of fish passage to practicable conditions, irrespective of land ownership.

3. **Restore natural hydrological regimes in Okanogan sub-basins** Given the arid conditions prevailing over much of the watershed, water use practices have significantly altered the water balance in many of the sub-basins. Many of these alterations have contributed to habitat impairments throughout the Okanogan watershed that limit salmonid production by precluding otherwise available habitat use. Conservation practices should be implemented throughout the watershed to increase habitat carrying capacities and foster the sustainability of naturally-producing, anadromous stocks.

4. **Restore marginal habitat in close proximity to properly functioning habitat** In the Okanogan watershed, habitat projects aimed at rehabilitating impacted habitats should be accomplished concurrently with securing habitat protection measures. Restoration efforts should be prioritized to link functioning habitats that are in close proximity as opposed to linking habitats that are separated by great distances. This focus recognizes the importance of maintaining and increasing existing "salmon strongholds", and is consistent with the goals of the Governors Salmon Recovery Board. All structural improvement projects should be designed so the placement is appropriate for the hydrogeomorphological characteristics of the reach. Except where temporary remediation measures are essential for stock maintenance, the focus of rehabilitation projects should address the causation of habitat degradation rather than the symptomology.

1.0 INTRODUCTION

Under the Salmon Recovery Act—RCW 75.46, passed as House Bill 2496, and later revised as Senate Bill 5595, the Washington Conservation Commission (WCC) is charged with administrating the identification of the habitat factors limiting the production of salmonids throughout the watersheds of the State of Washington. This information is intended as a tool to guide Lead Entity groups and the Salmon Recovery Funding Board (SRFB) in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Specifically, ESHB 2496 in part:

- directs the WCC, in consultation with local government and the tribes, to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group (section 090, subsection 1, RCW 75.46);

- directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 070 subsection 2 of this act (section 090, subsection 3, RCW 75.46);

- defines limiting factors as “conditions that limit the ability of habitat to fully sustain populations of salmon.” (section 010, subsection 5, RCW 75.46);

- defines salmon as “all members of the family Salmonidae that are capable of self-sustaining, natural production.” (section 010, subsection 7, RCW 75.46).

The overall goal of the limiting factors assessments overseen by the WCC throughout the state is to identify habitat factors limiting production of anadromous salmonids in Washington’s major watersheds. The responsibilities assigned to the WCC under ESHB 2496 do not constitute a full limiting factors analysis, as the hatchery, hydro and harvest segments of a watershed that potentially affect salmonid production are addressed through collateral watershed planning efforts detailed under ESHB 2514.

Beginning in October 2000, a technical advisory group (TAG) consisting of persons with technical/professional knowledge of the Okanogan watershed was convened. Through a series of meetings held between late 2000 and July 2001, input was solicited from TAG participants regarding existing data, published reports, and their professional knowledge of habitat conditions in the watershed. The information was then assembled into draft chapters of the report and circulated for review and comments. The TAG was then reconvened in August 2001 to critique the draft final document, consider limiting factor ratings on the sub-basin level, and develop associated action item recommendations.

Given the limited data on fish habitat conditions in the Okanogan watershed, professional knowledge was heavily relied upon in rating habitat at the sub-basin and/or reach level. Sub-basin habitat conditions were rated as “Good”, “Fair” or “Poor” based on criteria outlined in chapter 4 of this document. A quantitative reach-by-reach assessment of habitat conditions in most of the Okanogan sub-basins could not be performed for this current effort and is still needed to develop a coordinated, watershed-level strategy that appropriately protects and restores salmonid habitat. Coordinated on-the-ground habitat assessment and rehabilitation efforts will ultimately facilitate the sustainability of anadromous salmonids in the naturally suitable habitats of the Okanogan watershed.

1.1 THE ROLE OF HABITAT IN THE NATURAL REPRODUCTION OF SALMONIDS

Washington State anadromous salmonid populations have evolved in their specific habitats during the last 10,000 years (Miller 1965). While there continues to be debate over the specific numeric tolerance and preferences of habitat conditions required by salmonids, the following elements of habitat are generally accepted as necessary for the continued survival of all salmonid species:

- cool, clean, well-oxygenated water free of toxic pollutant concentrations;
- in-stream flows that resemble the natural hydrology of the watershed, maintaining adequate flows during low flow periods and minimizing the frequency and magnitude of peak flows (e.g., stormwater);
- clean spawning gravels with limited fine sediment embeddness, and lacking toxic materials;
- sufficient pool area and frequency to support juvenile rearing and dispersal, and resting/staging areas for returning adults;
- in-stream large woody debris or other suitable in-stream cover that is of sufficient size given a stream's channel morphology and flow to provide cover, create pools, and provide habitat diversity;
- unobstructed migration for juveniles and adults to and from their stream of origin;
- riparian stands of sufficient height and breadth to provide cover, shade, LWD recruitment, and organic enrichment, ; and
- estuarine conditions that support the production of prey organisms for juvenile outmigrants as well as for rearing and returning adults.

Water chemistry, flow, and the physical attributes unique to each stream have helped shape the characteristics of each salmonid population in Washington's waters, including those that persist in the Okanogan watershed. These unique physical attributes resulted in distinct salmonid stocks for each salmonid species throughout their range. Stocks are considered "population units" of a species that do not extensively interbreed because of run timing specificity, or because of a stream's unique chemical and physical characteristics in a stocks natal spawning grounds. Spawning ground fidelity thereby minimizes the potential for genetic drift during reproduction, thus preserving the distinctiveness of each stock.

Salmonid stock survival requires that habitat needs are met for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These needs vary slightly by species and even by stock. The most critical components of salmonid habitat include water quality, water quantity and hydrology, basin geology, fluvial geomorphology, vegetation and riparian conditions. Changes in stream flows can alter water quality by affecting temperatures, decreasing the amount of available dissolved oxygen, sediment accumulation, and concentrating toxic materials. For example, water quality can be reduced by heavy sediment loads, which in turn can result in increased channel instability and decreased spawner success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (channel complexity), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to natal grounds. They need pools with overhanging vegetative cover and in-stream structures such as root wads to provide for resting and shelter from predators. Successful spawning and incubation further requires clean, unimbedded gravel areas of appropriate patch size and diameter for each species. After entering freshwater, salmon have a limited time to migrate and spawn, sometimes as little as 2-3 weeks. Thus, delays may result in pre-spawn mortalities from disease or predation, or spawning in suboptimal locations.

During incubation floods can have great impacts on salmon populations by scouring and/embedding the gravel nests (redds) where salmon have deposited their eggs. Human activities have been shown to increase the amplitude and frequency of such flood flows whereas in undisturbed systems, upland vegetation stores water and shades snowpack slowing the rate of water runoff into the stream. A healthy river also has sinuousity with large pieces of wood contributed by an intact, mature riparian zone. The uplands and riparian areas both act to slow the speed of water downstream. Natural systems have access to floodplains where wetlands store flood water and later discharge this storage back to the river during lower flows. Under normal conditions, erosion and sediment transport are balanced to provide a constant supply of new gravel for spawning and incubation without increasing overall channel instability.

When the young fry emerge from the gravels, some species of salmonids such as chum, pink and ‘ocean-type’ chinook migrate quickly downstream toward the estuary while other species such as ‘stream-type’ chinook, coho and steelhead trout search for suitable rearing habitat within side channels and sloughs, tributaries, spring-fed "seep" areas, stream margins, or lakes (sockeye); the freshwater residency of these species may last for two years before smoltification. Quiet water margins and off channel areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. As growth continues, the juvenile salmonids (parr) will move away from the quiet shallow areas into deeper, faster water.

During the winter, salmonids require habitat that will sustain growth and protect them from predators and harsh winter conditions. Habitat use is determined by behavior changes associated with declining temperatures in the fall and winter. Behavior changes vary by species and life stage (Bjornn and Reiser 1991). In a study of seasonal habitat use of juvenile chinook salmon and steelhead in the Wenatchee River (Don Chapman Consultants 1989) juveniles were located along the stream margin in boulder zones from October to March. During the day they hid in interstitial spaces among boulders; at night both species stationed on boulders and sand adjacent to their daytime habitat. When water temperatures dropped below 50° F (10° C), juveniles were not observed in the water column during the daytime, but remained in the substrate. Adult steelhead that overwinter in the upper-Columbia region are thought to generally seek refuge in the mainstem Columbia River. Some adults will also seek refuge in deep pools of the mainstem tributaries to the Columbia River (C. Peven, personal communication) but may return to the Columbia River if instream water temperatures become too harsh (L. Brown, personal communication).

The following spring, smolts begin their seaward migration. Flows, food and cover that provides protection from predators are critical. Once again the unique natural flow regime in each river that shaped the population's characteristics through adaptation over the last 10,000 years, plays an important role in the salmonids behavior and survival. In contrast to natural flow regimes, salmonids from the upper-Columbia region must migrate through a river system that has been highly altered by hydroelectric development. Hydropower dams converted the free-flowing Columbia River to a series of reservoirs upstream from the site of Priest Rapids Dam. Subyearling summer chinook salmon produced in upper-Columbia tributaries tend now to spend several weeks in the reservoirs before they arrive at Priest Rapids Dam in August and later. This has substantially increased the mean size of subyearlings at time of passage at Priest Rapids Dam (Chapman et al. 1994a).

Once reaching the estuary, adequate natural habitat must exist to support the detritus-based food web upon which salmonids depend during the early portions of their marine life history. Habitat elements of greatest imporance to juvenile salmonids in the marine environment include eelgrass beds, mudflats, and salt marshes. The processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as woody debris and sediment loads.

The distribution, seasonal abundance and migratory behavior of salmon and steelhead exiting the estuary for the nearshore and offshore ocean environment varies considerably (Groot and Margolis 1991; Chapman et al. 1994b). The movements of chinook at sea are more complicated than those of sockeye and pink salmon. Ocean residence for spring chinook last from 2-4 years compared to 3-4 years for summer/fall chinook. First-year chinook remain along the continental shelf north to the Gulf of Alaska more than other first-year salmon species (Chapman et al. 1995). In contrast, distribution of young steelhead differ in time and space from any salmon. Steelhead do not remain along the coastal belt but move directly seaward during their first ocean summer (Chapman et al. 1994b).

In addition to the relationships between various salmonid species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years. These interactions represent a delicate balance affected by habitat quality and habitat quantity. In the Okanogan watershed, this relationship is complicated by the introduction of non-native salmonid species (brook trout), the introduction of salmonid hatchery stocks, and the extirpation of native coho and bull trout stocks. Salmon, steelhead/rainbow, and bull trout exhibit a variety of life history patterns often as a result of their adaptability to a complex and fluctuating environment (Lestelle et al. 1996). Maintaining access to sufficient quantities of high quality habitat contributes to supporting multiple life history stages for all salmonid species, thereby increasing a population’s resiliency to environmental changes whether natural or human-induced.

2.0 OKANOGAN WATERSHED CHARACTERISTICS AND CONDITIONS

2.1 WATERSHED OVERVIEW

The Okanogan River originates in British Columbia and flows through a series of six large lake systems before reaching the United States (**Figure 2-1**). It eventually flows into the Columbia River at Columbia River mile 533.5. The mainstem Okanogan River within Washington State, stretches some 79 miles from its confluence with the Columbia River to outlet of Lake Osoyoos (WDNR 1982). The watershed encompasses about 2,600 square miles within the state of Washington, and about 6,300 square miles within the Canadian province of British Columbia (WDOE 1995). Using a modified 5th field hydrologic unit scale (i.e., HUC 5), the watershed was delineated into 19 sub-basins for this LFA (Figure 2-2). Sub-basin characteristics are described in Chapter 5.

The eastern and western boundaries of the mainstem Okanogan basin are steep, jagged ridgelines at elevations ranging from 1,500 feet to more than 6,000 feet above the basin floor (WDOE 1995). The average width of the drainage area for the mainstem is approximately 35 miles, and the floodplain of the Okanogan River valley averages about a mile in width. The mainstem's elevation and descends from an elevation of about 920 feet at the international boundary to about 780 feet at the river's confluence with the Columbia River. Osoyoos Lake occupies the northernmost 4 miles of the valley floor and extends several miles into Canada. Multiple natural terraces formed mostly of glacially deposited gravel rise locally as much as 500 feet above the valley floor to the foot of, and between, the lateral ridges.

2.2 LAND OWNERSHIP AND USE

The Okanogan/Similkameen watershed is the largest and most complex of the four mid-Columbia River tributaries: Entiat, Okanogan, and Wenatchee. A large portion of the watershed within the U.S. is privately owned (**Figure 2-2**). The Colville Indian Reservation, located in the southeast part of the watershed, comprises about 25 percent of the watershed (OCD 2000). Public ownership comprises 41 percent of the watershed, including 21 percent owned by the USFS, 17 percent owned by the State of Washington, 3 percent owned by the Bureau of Land Management, and the rest owned by miscellaneous agencies (**Table 2-1**). The remaining 34 percent of the watershed is under private ownership (OCD 2000).

Land use in the Okanogan River watershed includes agriculture, range, timber, residential and recreation, and some industrial and commercial (**Table 2-2, Figure 2-3**). Forest and rangelands about equally dominate land use. The watershed contains approximately 36,000 to 40,000 acres of irrigated area. About 60 percent of that acreage (24,421 acres) is contained within irrigation districts or ditch companies (WDOE 1995): Okanogan Irrigation District represents about 20% of the irrigation district lands in the Okanogan River Basin. Timber production for the Okanogan National Forest increased from World War II until the mid-1960s (USFS 1997).

Table 2.1. Okanogan Subbasin Land Ownership

Land Owners	Approximate Acres
Department of Agriculture - Forest Service	357,000
Department of the Intenior	
Bureau of Land Management	48,000
Fish and Wildlife Service	2,750
Department of Defense	375
Federal Subtotal	*408,125*
Washington State	
Department of Natural Resources	245,000
Department of Fish & Wildlife	29,873
Department of Parks & Recreation	600
State Subtotal	*275,473*
County	300
Municipal	2,900
Total Public (federal, state, & local)	**686,798**
Tribal	422,000
Total Private	**559,000**
Total Land Area	***1,667,798***

Source: USDA Natural Resources Conservation Service GIS data, unpublished

Table 2.2. Okanogan Sub-basin Land Cover and Use

Land Use	Approximate Acres
Forest	787,070
Range	754,996
Cropland	101,930
Urban	5,737
Other	18,065
Total Land Area	***1,667,798***

Source: USDA Natural Resources Conservation Service GIS data, unpublished

2.2.1 Irrigation Districts

There are nine irrigation districts, reclamation districts and canal companies operating in the Okanogan Watershed (**Table 2-3**). These water providers comprise the bulk of irrigation water delivery from surface water sources to approximately 24,710 acres (OCD, 1989). **Table 2-4** displays information about surface and ground water rights in the basin. .

Table 2-3. Irrigation Districts of the Okanogan Basin

Irrigation District	Source	Irrigated Acres	Length	Flow
Okanogan Irrigation District	Salmon Ck, Okanogan R.	5,032	50 mi. piped. 7.6 mi. lined canal	15,000 acre ft/yr
Oroville Tonasket Irrigation Project	Similkameen R., Lk Osoyoos, Okanogan R.	10,300	110 mi. pipe 10 mi. canal	41,200 ac ft/yr
Whitestone Irrigation and Power Company	Toats Coulee	3,000	16 mi. pipe 14 mi lined canal	45 cfs max
Pleasant Valley Irrigation Project	Loup Loup Creek, Okanogan River	2,000	3 mi. pipe 3 mi. canal	17 cfs max
Helensdale Irrigation District	Loup Loup Ck., Okanogan River	225	2 mi. pipe	
Brewster Flat Irrigation Project	Columbia River @ Chief Joseph Dam	2,832	28 mi. pipe	60 cfs max
Aeneas Lk. Irrigation District	Aeneas Lake	1400	4 mi. pipe	12 cfs
Alta Vista		40	1 mi. pipe	1 cfs
Black Bear	Sinlahekin Ck	105	2.5 mi. pipe	2 cfs

Table 2-4. Summary of Water Rights in the Okanogan Basin (WDOE 1995)

Water Source	Number of permits	Quantity (acre feet)	Area (acres)	Percent used for Irrigation
Surface	470	105,414	67,443	98%
Ground	307	39,344	10,437	56%

2.3 GEOLOGY AND TOPOGRAPHY

The Okanogan River basin geology and geomorphology is influenced by the Cascade Range, Northern Rockies and Columbia Plateau Systems which border it on the west and south sides, respectively. During the Quaternary Period, glaciers sculpted the landscape below 5,000 feet, covering large areas with glacial drift and fluviolacustrine sediments. Small alpine glaciers were also active at higher elevations. Cascade volcanoes were active during the Pleistocene and into the Holocene. Deposits of volcanic ash from these eruptions occur within the area (Hansen 1998). Due to glacial activity, rock outcrops were exposed in many places and formed a complex pattern with the materials deposited by glaciation. Much of the bedrock has been weathered to shallow soils (NRCS 1980).

The erosive action at the base of the glacial ice create unconsolidated and unsorted mixtures of silt, sand, gravel, and stones. Glacial fluvial meltwater streams carried large quantities of sand and gravel, creating thick deposits of sorted materials. In areas of low gradient or local impoundment, glacial meltwater created lacustrine deposits of clay soils. Some deposits of glacial drift are mantled by volcanic ash (NRCS 1980).

2.4 SOILS AND VEGETATION

Most Okanogan County soils are formed in materials derived mainly from volcanic ash and glaciation from the last 10,000 years (**Figure 2-4**). Those soils most influenced by ash are in the northern part, at elevations above 3,000 feet (NRCS 1980). Because the Okanogan Valley is narrow with steep slopes, there is a high amount of runoff into the river. High rates of drainage are also attributed to streambank instability, which introduces a large amount of sedimentation. The most erosive soils along the Okanogan River are the Colville silt loams, and the Bosel fine sandy loams. Some factors that accelerate errosion are over grazing, mining sites, logging activities, roadwork and irrigation. The lack of woody vegetation on the streambanks along the Okanogan are increasing to the rate of severe erosion. Soils are slightly acid to extremely acid, sandy loam to silt loam soils formed in volcanic ash, glacialmaterials, and weathered granite, schist, limestone, shale and gneiss.

A semiarid climate, with dry warm summers and moderately cold winters supports such native species as big sagebrush, rabbitbrush, and bitterbrush in the valleys and on terraces (NRCS 1980). The climate is influenced bythe barrier to marine air that the Cascade Mountain Range provides, as well as by the mountain and valley formations of the region. Precipitation in the watershed ranges from morthan 40 inches in the western mountain region to approximately 8 inches at the confluence of the Okanogan and Columbia Rivers.

Where annual precipitation is 8 to 11 inches, grassland is the dominant type of vegetation. In areas where the annual precipitation is 11 to 14 inches (such as in the middle and lower reaches of the Salmon watershed), the importance of Idaho fescue and bluebunch wheatgrass in the plant community increases. Perennial grasses include bluebunch wheatgrass, and giant wildrye. Non-native plant species include wheatgrass, Russian thistle, common mullein and wooley plantain.

Okanogan County's forestlands receive approximately 75% of the total annual precipitation (Gullidge 1977) The density of the forest vegetation increases at elevations above 3,000 feet and where the annual precipitation is greater than 14 inches. Ponderosa pine dominates in areas where the annual precipitation is 14 to 16 inches (as in the upper Salmon watershed). Douglas-fir is dominant in areas where the annual precipitation is 16 to 18 inches (NRCS 1980). Forestland comprises approximately 47% of the Okanogan River Basin.

Mean annual temperature for the Okanogan Watershed is 49^0F. The average temperature for January is 21^0F. and the July average is 73^0F. Wind velocities throughout the region are calm to moderate and generally originate from the north or south. Thunderstorms occur occasionally in the watershed during late spring and early summer. Summer months see approximately five cloudy days per month compared to winter months, which average approximately 20 cloudy days per month. On average, there are 150 frost-free days each year in the main Okanogan River Valley. The number of frost-free days reaches only about 75 days in the surrounding hills and uplands (NOAA, 1994).

2.5 WATER QUANTITY/HYDROLOGY

Snowfall represents about 50-75% of the annual precipitation during the winter months. Rainfall and snowmelt runoff contribute approximately 3% to the average annual gauged streamflow of the Okanogan River at Mallot (**Figure 2-5**). Average annual runoff for the Okanogan River as measured at Mallot is 2,220,000 acre-ft. With about 2,150,000 acre-ft contributed annually from the Canadian province of British Columbia and from the Similkameen tributary (OCD 2000). Annual runoff at Mallot has ranged between a minimum of 860,000 acre-ft and maximum of 4,000,000 acre-ft. Average annual flows on the Okanogan and Similkameen Rivers have not changed significantly since gauging began in 1911 (WDOE 1995). However, seasonal low streamflows are very much affected by water usage for irrigation, water supply, and other activities.

Peak annual flows ocurr during a two or three week period in late May and early June, and on average, account for approximately one-half of the annual runoff volume. Minimum annual flows occur in early fall to mid winter (September through March). In arid climates such as the Okanogan Valley, almost all precipitation occurring during the warm months either evaporates or is absorbed by the soil layer. On average, only a very small amount of precipitation directly contributes to streamflow from late June through March outside of the spring and early summer months.

2.6 WATER QUALITY

Ecology's 1998 Section 303(d) list (Impaired and Threatened Waterbodies Requiring Additional pollution Controls) includes the Okanogan River for "failure to meet water quality standards for temperature, dissolved oxygen, pH, and fecal coliform". There is a "consistent late summer water temperature criteria violation (annual violations from 1983-1993) (**Table 2-5**). Fish within the watershed are subject to poor water quality and low flow conditions, as well as critically high water temperatures during summer months" (WDOE 1998).

Table 2.5. Okanogan Basin Water bodies on the Washington

Water Body	Parameter
Okanogan River	Temperature, DO, fecal coliform, PCB-1260, PCB-1254, 4,4'-DDE*, 4,4'-DDD
Similkameen River	Temperature, arsenic
Salmon Creek	Instream flow
NinemileCreek	DDT
Tallant Creek	DDT
Lake Osoyoos	4,4'-DDE, 4,4'-DDD*

*break-down products of DDT

2.6.1 Nitrogen

The nitrate values recorded on the Okanogan and Similkameen Rivers are well below any action level for health standards and thus acceptable for all Class A water uses. Common sources for nitrogen include on-site sewage disposal systems, discharges from municipal sewer treatment plants, irrigation system return flows, fertilizer applications for both agricultural and residential uses, waterfowl congregating on the waterbody, and atomospheric deposition.

2.6.2 Dissolved Oxygen

Dissolved oxygen (DO) in the Okanogan River system are generally at or above saturation levels at all sites, even during the summer months when the water temperatures are elevated. The Malott has the lowest saturation values. This is predictable, since the monitoring station is located downstream ofthemajor municipalities in the basin, where sewage and stormwater impacts are highest. In addition, there is very little turbulent water between the Okanogan monitoring station and the Malott station to facilitate reaeration.

2.6.3 Temperature

Okanogan River water temperatures often exceed lethal tolerance levels for salmonids in the mid-to-late summer. These exceedences are partly a result of natural phenomena (low gradient and solar radiation on the upstream lakes), but are exacerbated by sedimentation and summer low flows caused by dam operations and irrigation. High water temperatures in late summer and fall form a thermal barrier, effectively excluding juvenile salmon from rearing in most of the basin, except during the first few weeks after emergence (Chapman et al. 1994a). At times, high water temperatures in the lower Okanogan River have blocked adult anadromous salmonid passage. The most extreme example is in adult sockeye that are sometimes thermally blocked through the lower Okanogan River (downstream of Lake Osoyoos) during late July and early August (Pratt et al. 1991).

Water temperatures pose the most difficult problem for increasing survival of most ocean-type and stream-type salmonids in the basin. Chapman et al. (1994a) plotted water temperature in the Okanogan River at Oroville and Tonasket, showing that mean mid-summer daily temperatures were frequently well over 70° F in 1986 and 1987. Hansen (1993) also confirmed temperatures in that range or higher near Zosel Dam and Lake Osoyoos during 1992. Hansen (1993) speculated that the alteration of flow regimes by the upstream dam in Lake Osoyoos have exacerbated the problem of thermal barriers.

2.6.4 pH

The average pH values measured in the basin have risen approximately 0.3 points over the last 20-30 years. This puts pH at the upper limits of the desired range. This alkaline condition may exert a stabilizing effect on the heavy metals by keeping the metals sorbed onto the soil particles and sediments, and out of solution (WATERSHEDS 1997). Influences on the pH levelinclude acid mine drainage, atmospheric deposition (acid rain), calcium, calcium carbonate, effluent water and land use practices.

2.6.5 Fecal coliform

Data collected from 1977 to 1997 indicate that fecal coliformis not a concern at existing monitoring sites. The Malott station had 9 exceedances in 163 recorded samles; the Okanogan station had 5 exceedences in 128 observations; and the Oroville stations had 0 exceedences out of 190 observations on the Okanogan, and 1 exceedence out of 208 observations on the Similkameen (WDOE 1997c). These results are all well below the State waterquality standards, which allow for up to 10% of the samples to exceed the published standard as long as themean value of the samp;les is below 100 colonies per 100 ml.

2.6.6 Sedimentation

Increased sedimentation artificially forms a shallower and wider channel, which exposes more area to direct sunlight and increases the water temperature. Warm water, low velocities and heavy sedimentation in the mainstem favor non-salmonid fishes, which outcompete or interbreed with the native population. For example, the introduced brook trout population interbred with the native bull trout causing a functional extinction of the bull trout downstream of Enloe and Zosel dams (USFWS 1998). WDOE is currently in the technical assessment phase of developing Total Maximum Daily Loads (TMDLs) for PCB and DDTin the Okanogan Basin.

Roads are considered to be the greatest contributing source of sediment to streams in the basin. Sedimentation is highest at road crossings over stream channels, along roads in close proximity to streams, along cut and fill slopes, and at roads and ditches that drain to stream channels. Private roads that access multiple parcels often do not have a coordinated maintenance program, leading to incresed erosion and sedimentation.

Roads affect streams by accelerating erosion and sediment delivery, altering channel morphology, and changing the runoff characteriestics of watersheds (Furniss et al. 1991). In addition, noxious weeds tend to spread along roads, increasing erosion potential. Herbicide treatment of noxious weeds along roadsides can lead to contamination of nearby streams through accidental spills, direct runoff, or infiltration (USDA, USDI 2000). Road construction is one of the largest water pollution contributors in the basin.

Impervious Surface

Information on road density (miles per square mile) is available for two sub-basins:

- Salmon Creek 2.2 miles/sq. mile (USDA, unpublished data)
- Omak Creek 6.38 miles/sq.mile (NRCS 1995)

Road density in most sub-basins in the basin exceeds 4 miles/sq. mile. Sediment delivery is considered to be greater than natural erosion rates in exceedance of 4 miles/sq.mile (Cederholm et al. 1981). Sediment deliveryfrom roads also depends on factors such as distance from the stream (**Table 2-6, Table 2-7**), slope, vegetation cover, and precipitation.

Table 2-6. Road Miles within 200 Feet of Streams in the Okanogan Basin

Sub-watershed	Non-Forest Service	Closed Forest Service	Open Forest Service	Total
Bonaparte Creek	41.4	1.7	5.1	48.2
Mainstern Okanogan	56.0	4.7	1.5	62.2
NE Okanogan	52.4	2.4	10.7	65.5
SE Okanogan	25.4	0.9	0.7	27.0
SW Okanogan	31.1	0.1	0.7	31.9
Salmon Creek	19.6	6.6	19.9	46.1
Similkameen River	43.1	0.2	7.2	50.5

Source: Unpublished data from USFS

Table 2-7. Road Miles within 50 feet of Streams in the Okanogan Basin (USDA, USDI 2000)

Sub-watershed	Miles of road within 50 feet of stream	Road crossings over streams
Bonaparte Creek	2.9	47
NE Okanogan River	4.3	46
Okanogan mainstem	4.5	87
Salmon Creek	6.4	109
Similkameen River	0.5	16

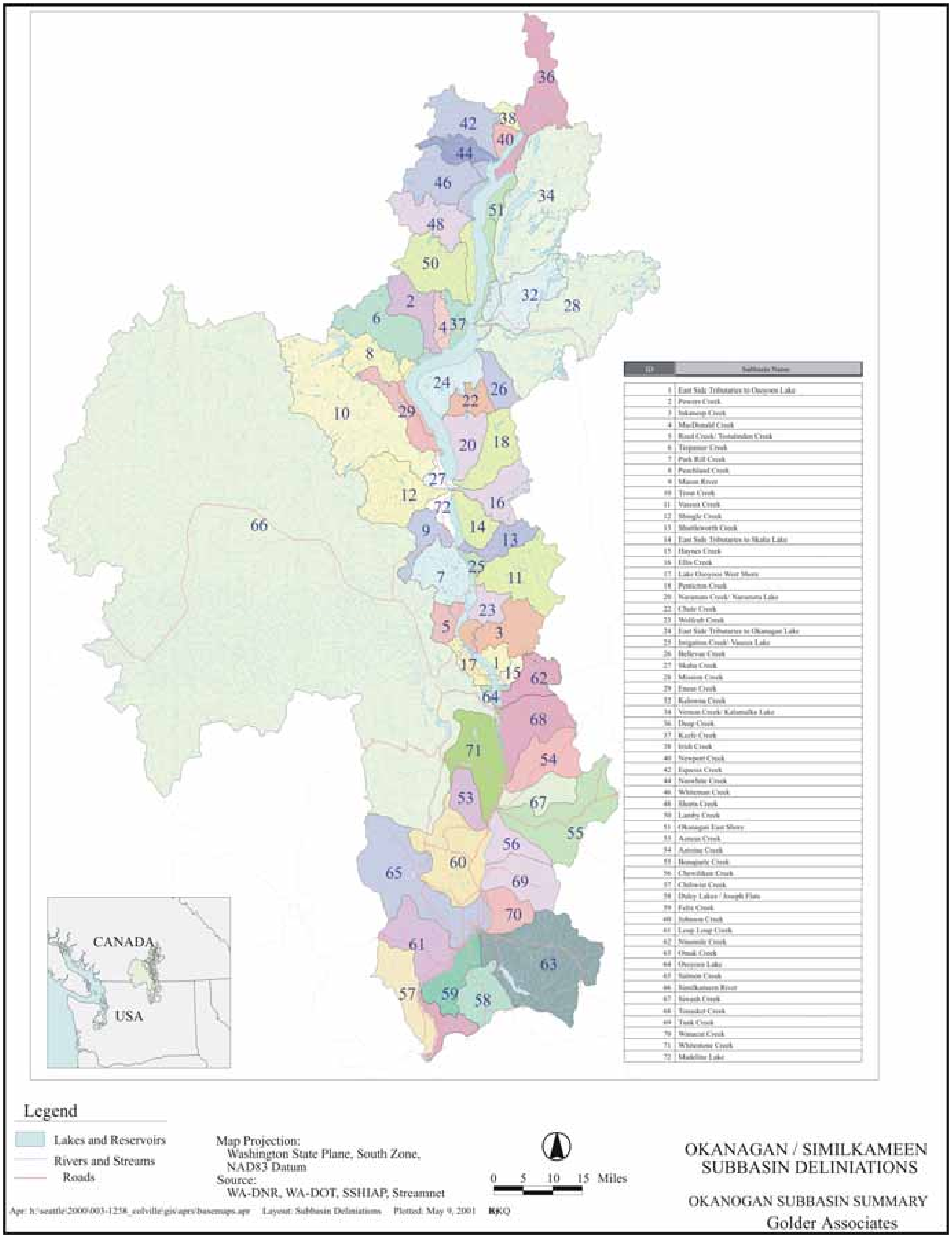


Figure 2-1. The Okanogan River Basin. Showing the Canadian and US portion of the watershed. Source: Okanogan Water Quality Management Plan, 2000)

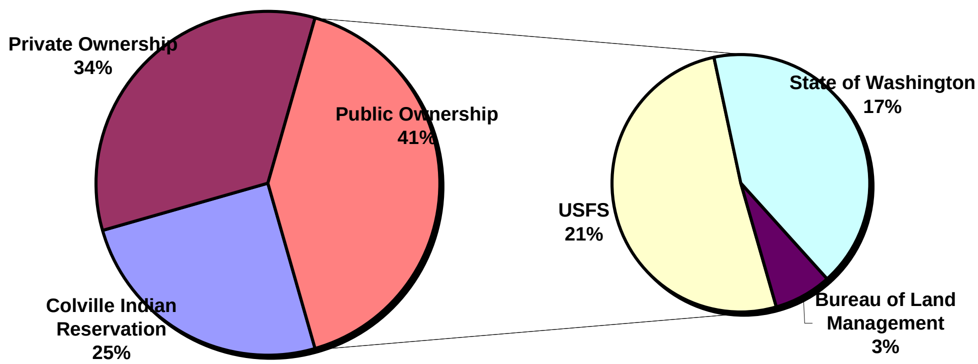


Figure 2-4. Land Ownership in the US portion of the Okanogan River Basin. Public ownership for federal and state are not listed if the percent acreage is less that 1%.

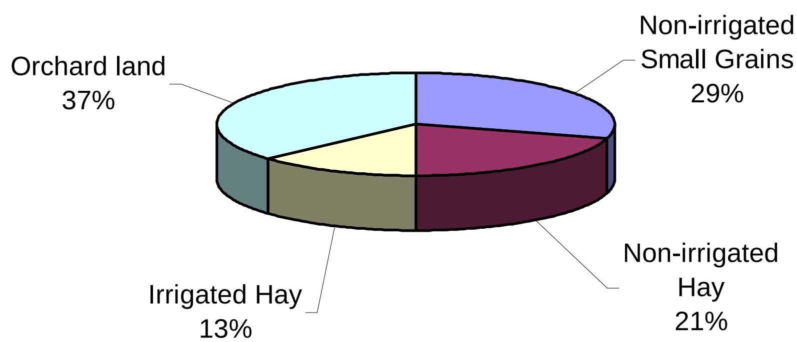


Figure 2-3: Major Crops of the Okanogan Basin (NRCS, OCD, 1998).

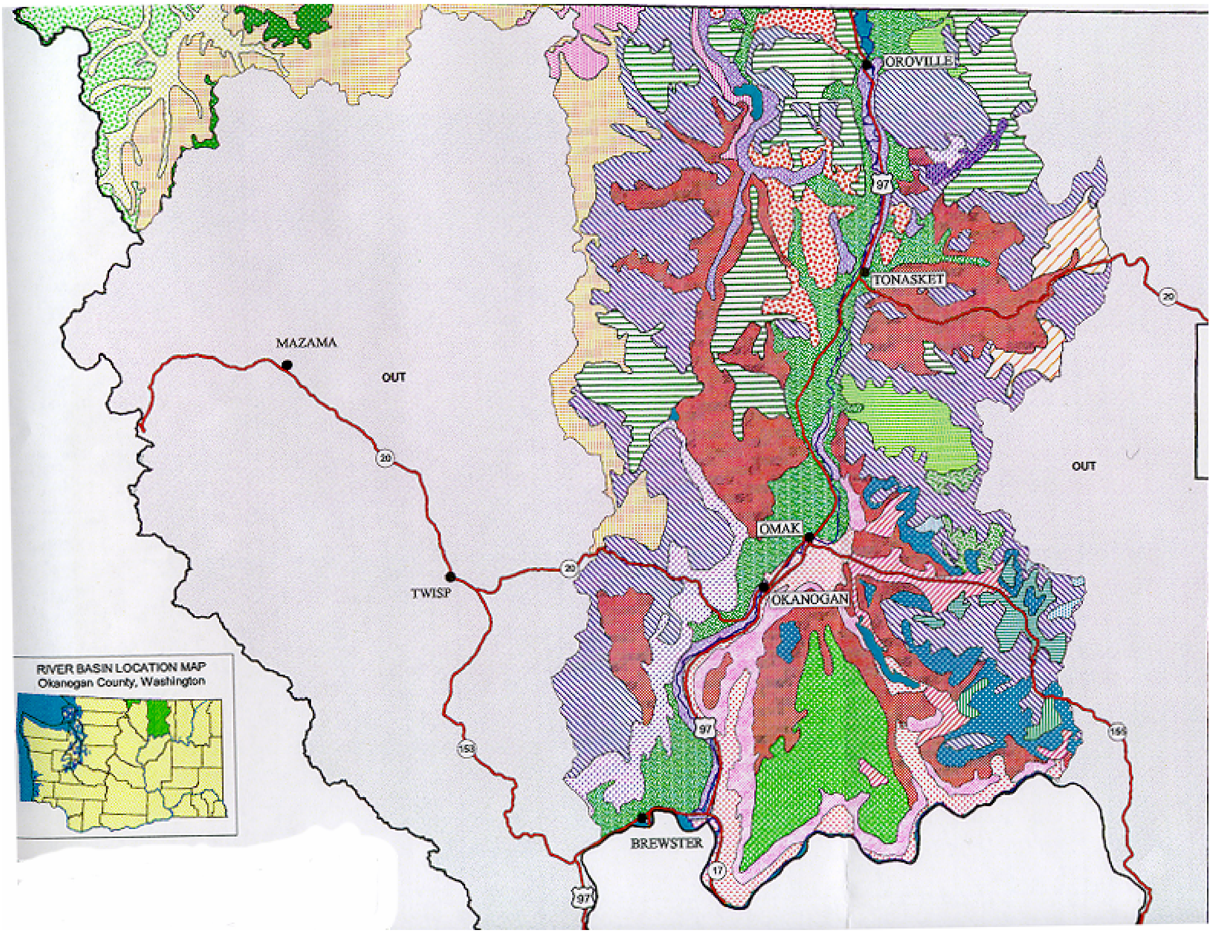
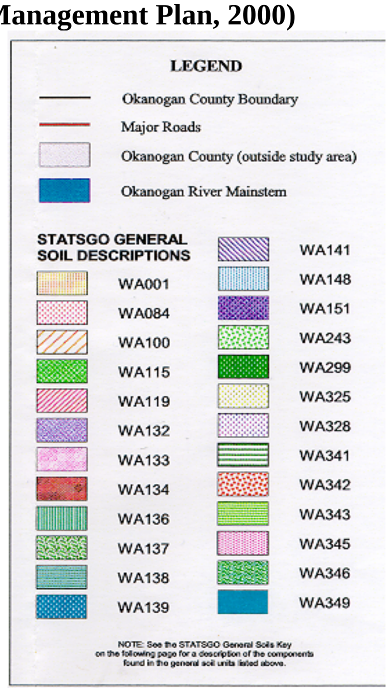


Figure 2-4. The soils found in the Okanogan River Basin. The soils are listed according to the USDA codes.

Source: Okanogan Water Quality Management Plan, 2000)



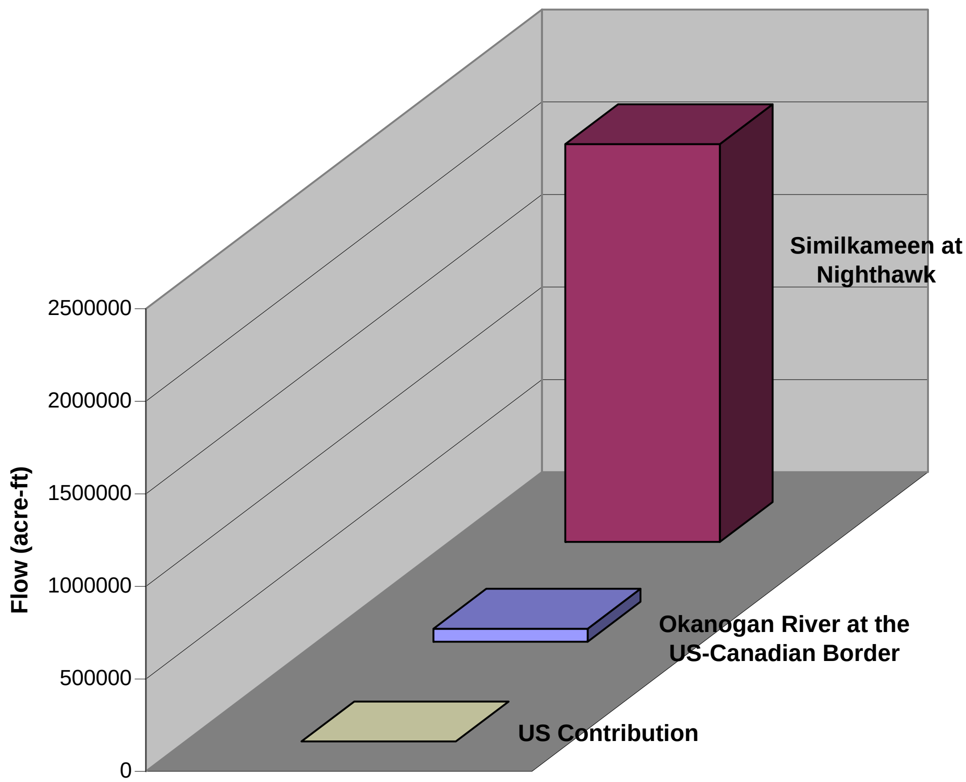


Figure 2-5. The USGS recording stations of annual flow for the Okanogan River. The contribution from each are calculated as the following:

Canada: **Flow measured near the US/Canada border at Oroville, Washington Gage Station + flow measured on the Similkameen at Nighthawk, Washington.**

US; **Flow measured at Malott, Washington – Candadian calculated contribution.**

3.0 FISH DISTRIBUTION AND STATUS

3.1 FISHERIES RESOURCES OF THE OKANOGAN RIVER WATERSHED

The Okanogan River represents the uppermost tributary of the Columbia River currently accessible to anadromous salmonids. The upper Columbia supports anadromous stocks of chinook and sockeye salmon, and steelhead trout (**Figure A-1, A-2, A-3**). Chinook salmon stocks of the Columbia River basin are classified by their adult migrational patterns as spring-run, summer-run, and fall-run. Stocks are further differentiated as ocean-type or stream-type fish, based on juvenile life history out-migration strategies. Ocean-type chinook juveniles migrate to sea as subyearlings, spend most of their ocean life in coastal waters and return to freshwater as adults a few months prior to spawning. Stream-type chinook migrate to sea as yearlings, exhibit extensive offshore migrations, and return to freshwater many months before spawning (Healey 1991). Within the Columbia River Basin, stream-type chinook tend to occur in upper tributaries and ocean-type chinook are produced in mainstem areas and lower tributaries (Waknitz et al. 1995). Sockeye salmon exhibit a summer-run migrational pattern only. Steelhead in the Columbia river are divided into winter-run and summer-run stocks, based primarily on their state of sexual maturity at the time they enter freshwater and the duration of their spawning migration. The Okanogan watershed of the Columbia system specifically supports anadromous fish runs of summer run chinook salmon, sockeye salmon (*O. nerka*), and a remnant run of summer steelhead. In addition, a variety of resident species occupy habitats upstream of anadromous barriers in the system.

Stock status information on Okanogan fisheries resources is detailed in **Table 3-1**, and further described below. Sub-basin information on species' use and distribution is provided in the sub-basin summaries in chapter 4.

Table 3-1. SASSI Stock Status and Escapement numbers for chinook, sockeye and steelhead (WDFW and WWTIT 1994).

Species and Subbasin	SASSI Stock Status	Stock Origin	ESA Status	Maximum Upriver Distribution	Mean Escapement
Okanogan					
Chinook	Depressed	Native	Endangered, 1999	RM 26-77	363-2,300 (1977-1991)
Sockeye	Healthy	Native		RM 90-106	65,000-64,700 (1977-1991)
Steelhead	Depressed	Mixed	Endangered, 1997		114-837 (1982-1991)

Source: Washington State Salmon and Steelhead Stock Inventory, 1992.

3.1.1 Chinook Salmon Stock Status and Distribution in the Okanogan Watershed

Chinook salmon currently using the Okanogan generally are considered a summer run stock. However, Utter (1993) was unable to ascertain a genetic distinction between summer and fall chinook populations above Wells Dam (includes all Methow and Okanogan chinook), and past spawning ground surveys have referenced the Okanogan chinook stock as a summer/fall run (Miller and Hillman 1996, 1997, 1998). Spring chinook are considered extirpated from the Okanogan River drainage, although historical records indicate that they occurred in at least three systems: (1) Salmon Creek, prior to construction of the irrigation diversion dam (Craig and Suomela 1941), (2) tributaries upstream of Lake Osoyoos (Chapman et al. 1995), and (3) possibly Omak Creek (Fulton 1968). The Similkameen River, the largest tributary to the Okanogan, also likely supported spring chinook. There were probably several life history strategies that historically existed in the Similkameen Watershed, prior to construction of Enloe Dam in 1920, although there is no clear evidence that chinook salmon passed the natural falls on the lower Similkameen River. Fall-run chinook are not known to have ever utilized the Okanogan watershed, likely owing to the long migration involved.

According to the most recent salmon and steelhead stock status inventory (SASSI) (WDFW & WWTIT 1994), the summer chinook in the Okanogan are considered “depressed” (**Table 3-1**), although they have not been formally listed under the Endangered Species Act by the National Marine Fisheries Service. Both hatchery origin and wild (naturally-derived) chinook spawn in the Okanogan and Similkameen drainages, but native stocks (i.e., completely lacking native genetics) are not known to persist in the system. No sub-basin characterization of summer-run Chinook stocks in the Okanogan watershed was considered in the original SASSI report, and long term monitoring of population trends is inadequate in most Okanogan tributaries to draw strong conclusions regarding the trends of sub-basin Chinook stocks in the watershed.

In general, the overall run strength of summer chinook salmon declined slightly in the mainstem Okanogan River, and increased slightly in the Similkameen River (its largest tributary) in the 1970s and 1980s (Chapman et al. 1994a). Summer chinook run sizes in the Okanogan averaged 532 fish in 1977 and 617 in 1985 (WDOE 1995). In 1998, the Colville Indian Nation harvested 759 chinook from a total population of 4,560 fish available to spawn in the Methow and Okanogan (inc. Similkameen) rivers (Murdoch and Miller 1999). Miller and Hilman (1998) estimated that between 14-72% of the chinook that pass Wells dam spawned in the Methow and Okanogan systems between 1980 and 1997. In 1998 Murdoch and Miller (1999) observed 88 and 276 redds in the Okanogan and Similkameen Rivers, respectively, representing an estimated escapement to these spawning grounds of 317 and 994 chinook, respectively (assumes 3.6 fish/redd). Thus, the most recent escapement estimates to the Okanogan system identified for this LFA indicates approximately 1,300 chinook are spawning in the system. Carcass retrievals, a subsample of the total spawning population, revealed that 33 and 52% of the spawners in the Okanogan mainstem and Similkameen, respectively, are of hatchery origin.

Adults enter the Okanogan River from July through late September, and spawn from late September through early November, peaking in mid-October (Peven and Duree 1992, Murdoch and Miller 1999). Current chinook spawning occurs in spatially discontinuous areas from the town of Malott upstream to Zosell Dam, approximately 103 km of the Okanogan River (Murdoch and Miller 1999). Usually 50% or more of spawning adults have a total age of 5 years, with the remainder predominantly 4 year old fish (Murdoch and Miller 1999). In the past, sporadic reports of chinook spawning above Lake Osoyoos have been recorded during sockeye salmon spawning ground surveys. Spawning ground data In the Similkameen River indicate that summer chinook spawn from Enloe Dam to Driscoll Island, a total distance of 14 km.

Emergence timing probably occurs from January through April, although specific data on emergence studies was not identified in reviews for this LFA. Juveniles generally emigrate to the ocean as subyearling fry, leaving the Okanogan River from one to four months after emergence. However, there is evidence that some fish undergo an extended residence period, with a protracted downstream migration. Many subyearlings rear in the mid-Columbia impoundments for various periods of time during their outmigration (Peven and Duree 1992).

3.1.2 Steelhead Stock Status and Distribution in the Okanogan Watershed

Only summer-run steelhead utilize the Okanogan watershed. Winter-run steelhead were not known to ever use this system, likely owing to the long migration involved. The summer run steelhead of the Okanogan are considered part of the upper Columbia summer steelhead ESU, and were listed as endangered on August 18, 1997. Upper Columbia steelhead in the Okanogan are considered depressed according to SASSI (WDFW & WWTIT 1994). Although the historical record for steelhead in the Okanogan Watershed is not complete, Mullan et al. (1992) asserts that few steelhead historically used the Okanogan River. Salmon Creek historically supported self-sustaining steelhead runs, but passage barriers currently restrict access in most years. Some evidence suggests that steelhead may also have historically used other tributaries in the Okanogan Basin (Chapman et al. 1994b). Current habitat conditions in the Okanogan basin are generally poor to support most life history requirements of steelhead.

Although steelhead were probably never abundant in the Okanogan River, due to natural habitat limitations, an estimated half of the steelhead production may have been lost as a result of fish access restrictions to Salmon Creek by irrigation water withdrawals (WDF and WDFW 1993). In 1955-56, the escapement estimate to the Okanogan was about 50 fish, from a total run size of about 97 fish. Assuming a 50 percent loss in production from Salmon Creek since 1916, the average run-size prior to the extensive hydroelectric development in the mid-Columbia River reach is believed to have been about 200 fish. The estimated total run-size of naturally produced summer steelhead to the Okanogan Subbasin declined to between 4 and 34 fish, from 1977 to 1988 (WDFW 1990). Current population estimates for steelhead in the Columbia range from 45-65 for summer steelhead and 29-62 for winter steelhead (ONRC et al. 1994).

Given that stock status on the sub-basin level has not been expressly established in the Okanogan, describing the relative importance of specific steelhead stocks throughout the Okanogan watershed has great uncertainty. Notwithstanding, 19 adult summer steelhead were trapped in Omak Creek in 2001 (C. Fisher, personal communication). When considered against a total escapement to the entire system of between 4 to 34 fish from 1977 to 1988 (WDFW 1990), such populations, although small, become disproportionately important. While the 2001 Omak steelhead may have originated from earlier smolt transplants from the Wells Hatchery into the system, Omak Creek may be especially important for the reestablishment of the summer-run steelhead ESU. Similarly, steelhead production from Salmon Creek was estimated to represent approximately 50% of the native production throughout the watershed prior to the erection of Conconuly Dam. Similarly, habitat in the upper Similkameen drainage, the largest tributary of the Okanogan basin, is restricted by Enloe Dam, four miles from its confluence with the Okanogan. Enhancements to each of these systems will also improve rearinng conditions for Chinook salmon.

3.1.3 Sockeye Stock Status and Distribution in the Okanogan Watershed

According to SASSI (1992), a "healthy" stock of sockeye salmon continues to use the Okanogan basin for spawning and rearing. The Okanogan sockeye are not currently listed under the ESA. Spawning population escapement estimates ranged from 20,202 to 34,679 fish in 1993, depending on the methodology used to calculate spawning population size (Hansen 1993).

Sockeye spawning in the Okanogan occurs in tributaries of Lake Osoyoos under high flow years, but predominantly in the mainstem of the Okanogan river, upstream of Lake Osoyoos. McIntyire Dam, 12.5 miles upstream of Lake Osoyoos, usually represents the upstream limit of spawning under typical flow years. Under high flow years sockeye may pass the dam and have been observed spawning up to Skaha Lake (Okanogan TAG). Spawning may occur as early as September 15, with timing tied tightly to water temperatures. Peak spawning activity in the Okanogan occurs at temperatures of approximately 11 degrees Celsius and lower (Hatch et al. 1993, as cited in Hansen 1993). In Hansen's study, approximately 58% of the spawning population was male and 42% female, 3,4 and 5 year old age classes represented. Four year old sockeye in the Okanogan spend either one or two years in freshwater residency before smoltification and sea-ward outmigration (Hansen 1993).

3.1.4 Resident Fish Species Stock Status and Distribution in the Okanogan Watershed

Important resident species include mountain whitefish (*Prosopium willamsoni*), rainbow trout (*O. mykiss*), westslope cutthroat trout (*O. clarki clarki*) and Pacific lamprey (*Entosphenus tridentatus*). Stock status and distribution of resident salmonids is not fully understood and was not a primary focus of this LFA, but a brief summary is provided here. Bull trout are not documented to have used the Okanogan basin, although the 'distinct population segment' (DPS) of the species incorporating the entire Columbia (i.e., upper and lower) was listed as endangered on June 20, 1999. An assessment of bull trout stock status on a watershed basis is currently under preparation, however, no such assessments are provided in SASSI (WDF &WWTIT 1994).

Resident rainbow trout, cutthroat trout and non-native brook trout occupy many of the waters above the anadromous zone in the Okanogan watershed. Stock status of these species is not known; however, it has been thought that the non-native brook trout occupy waters otherwise suitable for bull trout (Okanogan TAG). The extent to which such introductions may have displaced bull trout cannot be determined, as no historic documentation of bull trout in the Okanogan watershed has been discovered.

3.2 FISH PASSAGE

3.2.1 Dams

There are 21 dams in the U.S. portion of the basin: 9 state, 7 private, 3 federal, and 1 PUD (**Table 3-2**). There are 13 Vertical Drop Structures on the Canadian side (NMFS 2000). Zosel Dam (RM78) controls the levels of Osoyoos Lake. Reconstruction work in 1987 improved fish passage into thelake.

A diversion dam on the Okanogan River above Oliver, B.C. is the upper terminus to migratory fish. The Similkameen River is impassable at Enloe Dam, an abandoned power generation facility 8.8 miles above the mouth. It blocks access to more than 95% of the anadromous fish habitat in the Smilikameen River. Recently there has been interest in relicensing the Enloe Dam, and fish passage alternatives are being investigated.

Table 3-2. Summary of Water Rights in the Okanogan Basin (WDOE 1995)

Dam Name	Stream Name	Ownership	Year Completed	Dam Length	NID Height	Normal Storage	Max Storage
Fanchers Dam	Antoine Creek	Private	1926	450	68	500	600
Bonaparte Lake Dam	Bonaparte Creek	Private	1957	180	9	535	995
Stout Reservation Dam	Chiliwist Creek	Private	1958	250	25	18	24
Horse Spring Coulee Dam	Columbia River	Private	1924	650	67		7,000
Fish Lake Dam	Johnson Creek	State	1920	50	7	2,815	2,815
Schallow Lake Dam	Johnson Creek	State	1954	330	13	46	76
Osoyoos Lake Control Dam	Okanogan River	State	1986	321	40	1,700	55,000
Leader Lake Dam	Okanogan R & Tribs	Private	1910	300	53	5,900	6,750
Leader Lake Saddle Dam	Okanogan R & Tribs	Private	1910	650	11	1,000	1,850
Little Green Lake Dam	Okanogan R & Tribs	State	1959	88	11	400	730
Salmon Lake Dam	Okanogan R & Tribs	Federal	1921	1250	54	15,700	17,280
Sasse Reservoir Dam	Okanogan R & Tribs	State	1910	140	10	60	60
Spectacle Lake Dam	Okanogan R & Tribs	Federal	1969	1110	25	13,450	14,080
Whitestone Lake Dam	Okanogan R & Tribs	Private	1930	375	9	2,144	2,720
Conconully Dam	Salmon Creek	Federal	1910	1075	72	13,000	16,570
Enloe Dam	Similkameen River	PUD	1923	316	54	400	400
Blue Lake Dam	Similkameen R & Tribs	State	1923	1500	32	4,416	4,416
Sinlahekin Dam No. 1	Sinlahekin Creek	State	1949	180	14	175	333
Sinlahekin Dam No. 2	Sinlahekin Creek	State	1949	248	18	52	82
Sinlahekin Dam No. 3	Sinlahekin Creek	State	1950	285	9	304	593

4.0 METHODOLOGY FOR DEVELOPING HABITAT LIMITING FACTORS ASSESSMENTS BY SUBWATERSHED IN THE OKANOGAN WATERSHED

This chapter summarizes the methods used to characterize the habitat and its limitations for salmon production in each of the Okanogan subwatersheds south of the U.S.-Canada border. Results from these assessments are provided in chapter 5 of this document. Habitat conditions in the Canadian waters of the Okanogan, approximately 60% of the total watershed area, are summarized in Appendix A. The subwatersheds of WRIA 49 within the United States include: Chiliwist Creek, Dan Canyon, Felix Creek, Duley Lakes, Salmon Creek, Omak Creek, Wanacut Creek, Johnson Creek, Tunk Creek, Chewiliken Creek, Aeneas Creek, Whitestone Creek, Bonaparte Creek, Siwash Creek, Antoine Creek, Tonasket Creek, Osoyoos Lake and Ninemile Creek. The subwatershed boundaries delineated for this LFA for both the U.S. and Canadian sub-basins are generally consistent with the USFS Hydrologic Unit Code (HUC) 5th field boundaries and with most of the subwatershed boundaries used in the Okanogan Watershed Water Quality Management Plan (OCD 2000). Sub-basin maps, including fish distributions by species, are provided in Appendix B. At the end of each watershed section, a "Habitat Limiting Factors Assessment" is provided that describes how the current condition of the habitat affects salmonid performance within the watershed. The information presented in this chapter reflects field biologists' observations that may or may not have been published. The absence of information for a stream does not necessarily imply that the stream is in good "health" but may instead indicate a lack of available information. All references to River Miles (RM) are approximate, based upon map-wheel projections recorded from USGS topographic maps of the area (1:100,000). Uncertainties in the subbasin analyses, data gaps, and action item recommendations are summarized for each subwatershed in chapter 5.

4.1 HABITAT RATING CRITERIA ADOPTED FOR THE OKANOGAN WATERSHED

Identifying the extent to which a habitat factor may be limiting salmonid productivity requires a set of habitat rating criteria. These criteria can then be used to assess the functioning condition of selected habitat factors. In turn, this information can be used to promote an understanding of the relative significance of different habitat factors and allow for consistency in evaluating habitat conditions in each WRIA throughout the state.

Twelve habitat criteria most likely to affect salmonid productivity in WRIA 49 were selected by the Okanogan TAG as most applicable for rating habitat conditions on the basis of existing data. Habitat criteria represent those environmental conditions that best describe the relationship between biological performance and the environment (Mobrand Biometrics 1999). The National Marine Fisheries Service recognizes these criteria as "indicators" of habitat quality (NMFS 1996). The 12 habitat criteria selected by the TAG for evaluating habitat conditions in the Okanogan were: 1) dissolved oxygen, 2) temperature, 3) turbidity, 4) suspended sediment, 5) chemical contamination/nutrients, 6) fine sediment (substrate), 7) large woody debris, 8) percent pool, 9) fish passage, 10) change in peak or base flows, 11) riparian, and 12) streambank stability. These habitat attributes were grouped into five categories according to their relationship to the physical environment: 1) Water Quality; 2) In-Channel Habitat; 3) Habitat Access; 4) Flow; and 5) Channel Conditions. These categories are consistent with the "pathways" considered relevant to sustaining salmonid productivity by the NMFS (1996).

Numeric and/or narrative standards of several agencies have been developed for the habitat criteria selected by the Okanogan TAG, and these were reviewed for their applicability in rating salmonid habitat conditions in the Okanogan watershed (**Table 4-1**). It was decided to rate habitat conditions for each criterion as "good", "fair" or "poor" in accordance with numeric qualifiers for the 12 criteria (**Table 4-1**). For habitat criteria that had wide agreement on how to rate habitat condition, an accepted and appropriate standard for the ecoregion was adopted by the Okanogan TAG for the purpose of the assessment excercise. Where local conditions warranted deviation from rating standards developed elsewhere, alternate criteria were used. These ratings were not, and are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant habitat limiting factors in the WRIA. They provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state.

The following criteria in **Table 4-1** were selected by the Okanogan TAG as acceptable for rating habitat elements on a reach and/or sub-basin level in the Okanogan watershed (WRIA 49). These criteria are to be applied (based on) reviews of existing data sources, or, alternatively from the combined professional expertise of the TAG where data is unavailable or where analysis of data has not been conducted. It is assumed that both the interpretation of existing data sources and the application of professional knowledge to sub-basin ratings will require best professional judgement. When using these criteria in the assessment process, the user will clarify whether quantitative studies or published reports or qualitative, professional knowledge was used for rating the habitat factors.

Table 4-1. Salmonid Habitat Rating Criteria Adopted by the Okanogan TAG

Pathway	Habitat Factor (Indicator)	Source of Criteria	Parameter/Unit	Parameter Qualifiers	Channel Type	Poor	Fair	Good
Water Quality	Dissolved Oxygen (D.O.)	WAC173-201A	Measured as millgrams per liter in the water column.	Evaluate % saturation to re-flect altitude & temperature effects on dissolved oxygen levels. There are no class B waters in the watershed so these criteria are not presented.	Class AA waters Class A waters	D.O. < 8.0 mg/l, and/or < 85% saturation D.O. < 7.0 mg/l, and/or < 80% saturation	D.O. 8.0-9.5 mg/l, and/or between 85 and 95% saturation D.O. 7.0-8.0 mg/l, and/or between 80 and 90% saturation	D.O. > 9.5 mg/l, and/or > 95 % saturation D.O. > 8.0 mg/l, and/or > 95 % saturation
Water Quality	Temperature	WSP (= WAC 173-201A)	Degrees Farenheit, (Celsius in Parens.).	Assumes 7day average temperature, not instantaneous measure. No class B waters in watershed.	Class AA waters Class A waters	$^{o}F \geq 75$ (23.9 ^{o}C) $^{o}F \geq 75$ (23.9 ^{o}C)	61 $\leq ^{o}F <$ 75 (16.1 $\leq ^{o}C <$ 23.9) 64.4 $\leq ^{o}F <$ 75 (18 $\leq ^{o}C <$ 23.9)	^{o}F < 61 (<16.1 ^{o}C) < 64.4 ^{o}F (<18 ^{o}C)
Water Quality	Turbidity	See McArthur & Fisher review 1999	Measured in nephelometric units (NTUs)	Could be assessed visually if hard data do not exist.	All waters in watershed	Greater than 100 NTUs for extended durations	20 to 100 NTUs for extended durations.	Less than 20 NTUs for extended durations.
Water Quality	Suspended Sediment	See Newcomb and Jensen 1996 (N. American Journal of Fisheries Mngt.).	Suspended sediment measured in mg/L. Clays: < 2 um Silts: 2 to < 50 um Sand: 50 to 2000 um. (Most suspended particles are between 0.1 to ~ 200 um).	Use appropriate effects thres-hold for eval-uating suspen-ded sediment data. Or, model effect of conc. & exposure duration (Newcomb & Jensen 1996).	All waters in watershed	Suspended sediment concentrations exceed relevant risk thresholds often.	Suspended sedi-ment concen-trations exceed relevant risk thresholds occasionally.	Suspended sediment concentrations and durations do not exceed relevant risk thresholds.

Pathway	Habitat Factor (Indicator)	Source of Criteria	Parameter/Unit	Parameter Qualifiers	Channel Type	Poor	Fair	Good
Water Quality	Chemical Contamination/ Nutrient Loading	a) Ecology pub. 97-14 (impaired and threatened surface waters requiring additional pollution controls) b) WAC 173-204 (Sediment Mngt. Standards) c) Summary of guidelines for contaminated freshwater sediments (WDOE 1995).	Generally measured in mg/l (ppm) or ug/l (ppb) for water criteria. Sediment criteria measured in mg/kg (ppm), ug/kg (ppb). Some sediment criteria are normalized to percent organic carbon. SMS criteria are for marine sediments, therefore other freshwater criteria [c] may be more applicable.		a) All waters in watershed/ subbasin/ reach	a) High levels of chemical contamination from agricultural and other sources. Greater than one 303(d) listing in sub-basin (reach) b) Sediment quality does not meet SQC and currently exceeds other accepted freshwater effects thresholds (see c).	a) Moderate levels of chemical contamination from agricultural and other sources. One (1) 303(d) listing in sub-basin (reach) b) Sediment quality currently meets SQC but has record of not meeting SQC or other accepted freshwater effects thresholds (see c).	a) Low levels of chemical contamination from agricultural and other sources. No 303(d) listings in the sub-basin (reach) b)Sediment quality meets SQC and other freshwater effects thresholds (see c).
In-Channel Habitat	Fine Sediment (Substrate)	NMFS	Fines < 0.85 mm in spawning gravel (criteria to be applied to lower gradient reaches only, where spawning might naturally occur [1-3% gradient])	Measured preferentially by: (1) core sample, or (2) surficial embed-dedness eval-uation.	All waters in watershed	> 20%	12-20%	< 12%

Pathway	Habitat Factor (Indicator)	Source of Criteria	Parameter/Unit	Parameter Qualifiers	Channel Type	Poor	Fair	Good
In-Channel Habitat	Large Wood Debris (LWD)	NMFS (originally derived from PACFISH)	Pieces/mile >12” dia., and >35’ length	Overton et al. (1995) provide LWD loading stratified to channel type, width, and geology. TAG members are encouraged to consider these criteria when NMFS criteria appear inappropriate.	All waters in watershed	Less than 20 LWD pieces per mile, and ripar-ian reserves lack sufficient recruitment potential.	Greater than 20 LWD pieces per river mile, but ri-parian reserves lack sufficient recruitment potential	Greater than 20 LWD pieces per mile with sufficient recruit-ment potential from riparian stand for con-tinued func-tioning.
In-Channel Habitat	Percent Pool	WSP/WSA	% pool, by surface area	P1a = WSA pool definition	Waters of <2% gradient & <15m wide	< 40%	40-55%	> 55%
In-Channel Habitat	(con.)		% pool, by surface area	P1b = USFS pool definition	Waters of 2-5% gradient & <15m wide	< 30%	30-40%	> 40%
In-Channel Habitat	(con.)		% pool, by surface area	P1c = Colville tribe . P2 = prof. Judgement	Waters of greater than 5% gradient, with bankfull width less than 15m	< 20%	20-30%	> 30%
Habitat Access	Fish Passage	NMFS (WDFW SHEAR Program [WDFW 1997a,b] provides data on juvenile passage criteria)	Measure jump heights by inches, velocity in ft/sec-onds. Numeric criteria for passage through culverts from WDFW 1997b are found in the appendix to this document.	Passage restrictions will vary by species and between juvenile and adult stages.	All waters in watershed	Any artificial barriers present do not allow upstream and/or downstream passage at all flows	Any artificial barriers present do not allow upstream and/or downstream passage at low flows	Any artificial barriers present provide upstream and downstream passage at all flows

Pathway	Habitat Factor (Indicator)	Source of Criteria	Parameter/Unit	Parameter Qualifiers	Channel Type	Poor	Fair	Good
Flow	Resembles Natural Hydrograph	NMFS	Hydrograph change	Professional judgement required	All waters in watershed	Pronounced changes in peak flow, baseflow and/ or flow timing relative to an undisturbed reference watershed.	Some evidence of altered peak flow, baseflow and/or flow timing relative to an undisturbed reference watershed.	Watershed hydrograph indicates peak/ base flow and flow timing are comparable to an undisturbed reference watershed.
	Impervious Surface					Greater than 10% impervious surface.	From 3 to 10% impervious surface.	Less than 3% impervious surface.
Channel Condition	Riparian Vegetation	NMFS	A variety of metrics can be applied to address riparian condition. Interpretation should include aerial photograph and/or ground survey.			Riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (< 70% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/ composition <25%	There is a moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (~70-80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community composition is 25to50% or better.	The riparian provides adequate shade, LWD recruitment, and habitat protection and connectivity in all areas, and buffers include known refugia for sensitive aquatic species (>80% intact), and/or grazing impacts: percent similarity of riparian veg. to the pot. natural community/comp is > 50%

Pathway	Habitat Factor (Indicator)	Source of Criteria	Parameter/Unit	Parameter Qualifiers	Channel Type	Poor	Fair	Good
Channel Condition	Streambank Stability	NMFS	% of banks not actively eroding		All	<80% stable (>200 ft?)	80-90% stable	>90% stable
Channel Condition	Floodplain Connectivity	NMFS			All	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wet-land extent drastically reduced and riparian vegetation/ succession altered significantly	Reduced linkage of wetland, floodplains, and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate deg-radation of wet-land function, ri-parian vegetation/ succession	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession

NMFS = National Marine Fisheries Service, matrix of pathways and indicators, 1996

WSP = Wild Salmonid Policy (WDFW 1998)

WSA = Watershed Analysis (WDNR 1997)

WAC = Washington Administrative Code

4.2 OVERVIEW OF EFFECTS OF HABITAT PATHWAYS ON SALMONIDS

4.2.1 Water Quality.

Cool, well-oxygenated water is required by salmonids. As stream temperatures rise, their dissolved oxygen content is reduced. Water temperatures of approximately 23-25°C (73-77°F) are lethal to salmon and steelhead (Theurer et al. 1985) and genetic abnormalities or mortality of slamonid eggs occurs above 11°C (51.8°F).

Temperature increases and consequent reductions in available oxygen tend to have deleterious effects on fish and other organisms by: 1) inhibiting their growth and disrupting their metabolism; 2) amplifying the effects of toxic substance; 3) increasing susceptibility to diseases and pathogens; 4) encouraging an overgrowth of bacteria and algae which further consume available oxygen; and 5) creating thermal barrier to fish passage.

In addition to fine sediment levels and water temperatures, other water quality parameters such as dissolved oxygen (DO) levels, the presence of fecal coliform, and pH levels can affect salmonid habitat quality. Major potential stream pollutants include nutrients such as nitrates and phosphates, heavy metals from mining waste, and compounds such as insecticides, herbicides, and industrial chemicals.

Dissolved Oxygen

Dissolved oxygen is essential for fish survival. Requirements of salmonids vary by life stage, but are generally considered stressful to salmonids below a concentration of approximately 5 mg/L, with lethality occuring at levels around 2-3mg/L. Dissolved oxygen saturation decreases with increasing temperature, altitude, and salinity. The absolute requirement for oxygen in fish is driven by the partial pressure differences between fish blood and the dissolved oxygen concentration in the water (Fisher 2000). Thus, fish use of dissolved oxygen is maximal and independent of environmental oxygen concentrations when the partial pressure of oxygen is sufficiently high. For steelhead and related salmonids, a minimum partial pressure of 118 mmHg in water is required to prevent hypoxia (Forteath 1988).

Temperature.

Water temperature strongly influences the composition of aquatic communities with salmonids thriving or surviving only within a limited temperature range. Physiological functions are commonly influenced by temperature, some behaviors are linked to temperature, and temperature is closely associated with many life cycle changes. Temperature indirectly influences oxygen solubility, nutrient availability, and the decomposition of organic matter; all of which affect the structure and function of biotic communities. As water warms, oxygen and nutrient availability decrease, whereas many physiological and material decomposition rates increase. These temperature-moderated processes can influence the spatial and temporal distribution of fish species and aquatic organisms (Bain and Stevenson 1999).

Water temperature varies with time of day, season, and water depth. Although temperatures are particularly dependent on direct solar radiation, they are also influenced by water velocity, climate, elevation, location of stream in the watershed network, amount of streamside vegetation providing shade, water source, temperature and volume of groundwater input, the dimensions of the stream channel, and human impact. This attribute addresses high or low instream water temperatures that negatively affect salmonid migration or survival during any life history stage.

Turbidity/Suspended Sediment

This attribute addresses impacts to spawning habitat from fine sediment levels and potential direct and indirect effects from suspended solids on fish health, behavior and food supply. Streambed particles in the redd after eggs have been laid and covered, and particles that settle into the redd and surrounding substrate during incubation, affect the rate of water interchange between the stream and the redd, the amount of oxygen available to the embryos, the concentration of embryo wastes, and the movement of alevins (especially when they are ready to emerge form the redd). Condition for embryos within redds may change little or greatly during incubation depending on weather, streamflows, spawning by other fish in the same area at a later time, and fine sediments and organic materials transported in the stream. Redds that remain intact during incubation may become less suitable from embryos if fine sediments are deposited in the interstitial spaces between the larger particles. The fine inorganic particles impede the movement of water and alevins in the redd. Fine organic particles consumes oxygen during decomposition; if the oxygen is consumed faster than the reduced intragravel water flow can replace it, the embryos or alevins will asphyxiate (Bjornn and Reiser 1991).

Nutrient/Contaminant Loading

Nutrients can alter the trophic structure of aquatic systems by enriching aspects unfavorable to salmonids. High nitrate and phosphate loading can lead to eutrophication, choking fluvial systems with aquatic vegetationand subsequently affecting physical parameters of waters such as dissolved oxygen and temperature that have direct physiological implications on salmonid health. Chemical contaminants may lead to sub-lethal or lethal consequences in salmonids through a variety of direct and indirect mechansims (e.g., immunosuppression, behavioral alterations, reproductive disorders, etc.). Collectively and/or individually, these elements can limit or preclude the use of habitat otherwise suitable to salmonids for spawning or rearing.

4.2.2 In-Channel Habitat

This category includes components of the stream channel that contribute to habitat complexity. These elements in turn translate to an increased potential for density dependent salmonid productivity.

Fine Sediment (Substrate)

Substrate refers to the mineral and organic material forming the bottom of a waterway or waterbody. The composition of the substrate determines the roughness of stream channels, and roughness has a large influence on channel hydraulics (water depth, width, and current velocity) of stream habitat. Substrate provides the micro-conditions needed by salmonids for both spawning and rearing (Bjornn and Reiser 1991). Increased sediments reduce pool depth, alter substrate composition, reduce interstitial space, and result, through channel aggradation, in streambank instability. Rearing juvenile salmon and steelhead have been observed to use the spaces between boulders in the substrate (interstitial space) for cover from predators and during low instream temperatures (50° F/10° C; Don Chapman Consultants 1989). A high percent of fine sediment in a stream channel can fill the interstitial spaces, eliminating rearing habitat and contributing to a decreased survivability. This attribute includes substrate conditions as they relate to rearing habitat only, including but not limited to, the degree of substrate embeddedness and substrate mobility.

Large Woody Debris (LWD).

LWD provides important physical and biological functions in the wide variety of habitats used by all salmonids; such as cover in which to hide from predators or retreat from high velocities. The presence of

LWD in the floodplain creates the diversity of habitat conditions that support multiple life stages of salmonids. In small streams, LWD traps sediment, causes local bed and bank scour, and creates pools. Small channels are highly dependent on in-channel woody debris structure for stability. Nelson (1998) states that the abundance of LWD is often associated with the abundance of salmonids and is thought to be the most important structural component of salmon habitat. Large woody debris east of the Cascades is generally described as wood material (>12 in diameter and >35 ft long; USFS 1998) that mainly enters stream channels from stream bank undercutting, windthrow, and slope failures.

When considering channel conditions in fish-bearing streams, the potential contribution or recruitment of LWD from non-fish-bearing tributaries is an important factor. Size standards for LWD and number of pieces per area are highly variable between agencies. So are the threshold criteria established to differentiate between levels of habitat functionality as it relates to LWD. Some of this variation is the result of the variability among stream geomorphology, hydrology and the surrounding ecosystem. The anticipated location and size of LWD accumulations within a stream channel and its floodplain are a function of the stream's hydrology, its physical characteristics (geomorphology) and the surrounding physical/vegetative environment. For example, the White/Little Wenatchee watershed analysis (USFS 1998e) showed that the White and Little Wenatchee river channels may be comparable to the Chiwawa River, Nason, and Icicle creeks channels in terms of processes and range of natural condition. The mainstem Chiwawa River (95-160 LWD>12"/mile) and Indian Creek, Reach 2 (74 LWD>12"/mile) may represent the natural condition of LWD abundance in low gradient, gravel-dominated, pool-riffle channels in this landtype (USFS 1998aa).

LWD creates lateral channel migration and complexity. It sorts gravels, stores sediment and gravel, contributes to channel stabilization and energy dissipation and maintains floodplain connectivity. Large accumulations of LWD in the lower floodplain can direct flow into meander loops and result in formation of riverine ponds and other off-channel habitat features, providing for the recruitment of new LWD from these side channel areas. Large woody debris can also indirectly function as a formative factor in channel processes.

This attribute addresses impacts resulting from: the removal or the lack of LWD; and the decrease or the loss in LWD recruitment and/or recruitment potential.

Percent Pool

Pools are formed by the interaction of flow with solid and loose boundaries, such as LWD, boulders, bends, streambed and other flows (Nelson 1998). Pool formation primarily occurs during moderate to high flow events. The interaction of flow with these boundaries causes flow to converge and accelerate, increasing bed scour though increases in bed shear stress. Pools form around channel obstructions (i.e. boulders, bridge piers, culverts, LWD), at meander bends, and at tributary channel junctions (Nelson 1998). Sediment levels, LWD levels, and human-made channel obstructions can alter the pattern and frequency of pool development within the geologic and hydrologic confines of the channel. Pools function to provide adult holding habitat, juvenile overwinter rearing habitat and thermal refuge.

In a study of how sediment supply influences features like pools and habitat diversity in the presence of LWD, Nelson (1991) concluded that large woody debris had the most significant influence on pool frequency and amount of pool area present, with pool area is a function of LWD and channel slope. The location of LWD within the bankfull channel had a significant effect on the amount of pool area. Large woody debris in contact with the summer low flow stream channel was the most effective at forming pools. Large woody debris was also the primary pool-forming factor identified. No significant relationship was found between sediment supply and pool area although sediment supply did appear to have a weak positive relationship to pool frequency.

4.2.3 Habitat Access

In general, spring spawning species (rainbow/steelhead) take advantage of high spring flows, accessing smaller tributaries, headwater streams and spring snowmelt-fed streams not accessible later in the year. Reproduction of late summer and fall-spawning species (spring chinook, summer chinook, and fluvial bull trout) occurs most frequently in alluvial reaches of larger streams and rivers where groundwater recharge strongly buffers local interstitial and surface water conditions from decreasing flows and increasing or decreasing water temperatures. Incubation of salmonid eggs and fry occurs within the interstitial spaces of gravels in the beds of cool, clean streams and rivers. Once emergence from the gravel is complete, young salmon are mobile, which increases their flexibility to cope with environmental variation by seeking suitable habitat conditions. Mobility is limited however, particularly for fry, so that suitable habitat and food resources must be available in proximity to spawning areas for successful first-year survival. Ideal rearing habitat affords low-velocity cover, a steady supply of small food particles, and refuge from larger predatory fishes, birds and mammals (Williams et al. 1996).

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

Throughout Washington, barriers have been constructed that have restricted or prevented juvenile and adult fish from gaining access to formerly accessible spawning and rearing habitat. These barriers include dams and diversions with no passage facilities, culverts poorly installed or designed, and dikes that isolate floodplain off-channel habitat. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year. This category includes dams, dikes, culverts, and other artificial structures or conditions that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles. Included are barriers created by irrigation diversion dams and inadequate screens that allow access to unsuitable areas that result in mortality to salmonids. In the case of diversion dams, fish passage may be blocked or maintenance of the dam may require repeated manipulation of the streambed (i.e. “push-up” diversion dams).

4.2.4 Flow

Changes in flow conditions can have a variety of effects on salmonid habitat. Decreased flows can reduce the availability of summer rearing habitat and contribute to temperature and access problems, while increased peak flows can scour or fill spawning redds. Other alterations to seasonal hydrology can strand fish or limit the availability of habitat at various life stages. Extended periods of low flows can delay the movement of adults into streams, draining their limited energy reserves, affecting upstream distribution and spawning success. High winter flows can cause egg mortalities by scouring and/or sedimentation of the spawning beds. Low winter flows can contribute to anchor ice formation and result in the freezing of eggs or stranding of fry. The overwinter survival of juvenile fish can be negatively affected by the reduction in the quantity and quality of winter rearing habitat as a result of low flows.

Stream flow is moderated by riparian vegetation as well as vegetative cover in the uplands. The removal of upland and riparian vegetation through timber harvest, road development, and through the conversion of land for agriculture and residential/urban use alters surface water runoff patterns and ground water storage patterns. Riparian areas, in particular, assist in regulating stream flow by intercepting rainfall, contributing to water infiltration, and using water via evapotranspiration. Plant roots increase soil permeability, and vegetation helps to trap water flowing on the surface, thereby aiding infiltration. Water stored in the subsurface sediments is later released to streams through subsurface flows. Through these processes, riparian and upland vegetation aid in moderating storm-related flows and reduce the magnitude of peak flows and the frequency of flooding.

Stream flows are also be affected by the removal of instream flows for domestic, agricultural and municipal use, thereby reducing fish habitat quantity and quality. The impacts of reduced flows vary depending on a combination of fish use in the affected reach and the extent and duration of reduced flows.

Impervious Surface

Roads can affect streams directly by accelerating erosion and sediment loading, by altering channel morphology, and by changing the runoff characteristics of watersheds. These changes can later affect physical processes in streams, leading to changes in streamflow regimes, sediment transport and storage, channel bank and bed configurations, substrate composition and stability of slopes adjacent to streams (Furniss et al. 1991). Sediment entering stream is delivered chiefly by mass soil movements and surface erosion processes (Swanson 1991). Failure of stream crossings, diversion of streams by roads, washout of road fills, and accelerated scour at culvert outlets are also important sources of sedimentation in streams within roaded watersheds (Furniss et al. 1991). Construction of roads, dikes or other structures:

Resembles Natural Hydrograph

This habitat indicator addresses changes in peak or base flows and/or flow timing relative to what one would expect to see in an undisturbed watershed of similar size, geology and geography. The quantity of available water and the rate at which it reaches the stream channel and passes through the channel system are influenced by precipitation regimes, watershed size, vegetation cover, and certain topographic consideration (Swanston 1991) Altering the vegetative component of a watershed and diverting instream flows for out-of-stream uses can have a significant effect on the timing and magnitude of peak and low flows. Changes in percent cover, species composition, and/or stand age class can change interception, evapotranspiration and soil water retention rates. Timber harvest activities, conversion of land to agricultural and urban/residential use, and fire are all actions that have the potential to disturb the vegetative community of a drainage to the extent that there is a noticeable affect on the stream flow regime. High road densities, soil compaction associated with agricultural activities, timber harvest, and grazing all contribute to increased surface water runoff and decrease soil permeability and water retention. The diversion of instream flows have the potential to alter the magnitude and duration of low flows, affecting stream channel conditions and decreasing total wetted area.

4.2.5 Channel Condition

A stream channel represents the integration of physical processes occurring at the watershed level: hydrologic (i.e. precipitation, snow melt); erosional (i.e. debris flows); and tectonic processes (i.e. mass wasting events). The physical processes determine sediment, water, and LWD input to the channel. At the same time channel form or morphology is naturally constrained both laterally and vertically by valley form, riparian conditions and geology. The ability of the channel to transport and manage sediment, water and LWD is a function of the channel's morphology and roughness and the input of sediment and LWD (i.e . source, transport or response reaches; Montgomery and Buffington 1993). Channel form will change when any of these inputs are altered or when the channel is artificially confined or constrained.

Riprapping can reduce the river's ability to access its floodplain and migrate laterally, thereby dissipating high flow energy. Loss of floodplain access and opportunity for lateral channel migration can lead to channel downcutting that further reduces access to the floodplain (USFS Mainstem Wenatchee River Watershed Assessment 1999) and changes the sediment and LWD transport regimes of the river system.

Riprapping and stream downcutting can also lead to accelerated bank erosion by diverting flow energies to opposite banks and weakening the toes of banks causing slumping.

Human land use activities within a watershed (i.e. road development, vegetation removal, water diversion) can alter the outcome of physical processes on channel formation and alter the ability of the channel to develop both laterally and vertically. For example, the quality and quantity of salmonid rearing and spawning habitat in a stream channel is controlled by the interaction of sediment and LWD with water and the transport of all three components through the channel network. Altering LWD levels or increasing sediment input can result in a decrease in the number and quality of pools, a decrease in the ability of the channel to retain sediment and organic matter, and an increasing width to depth ratio in low gradient reaches. Confining or constricting the stream channel can affect the rate and manner of sediment, LWD, and water transport through the system. It is important to note that habitat conditions in fish-bearing streams are intimately influenced by contributions of sediment and LWD from non-fish-bearing streams within a watershed. In the Pacific Northwest, LWD has been found to have a significant influence on the formation of pools and channel form (Nelson 1998).

Agricultural practices and residential/urban development can also affect streams by accelerating erosion and sediment loading to streams and by changing the runoff characteristics of watersheds. Farmed fields left fallow (i.e. barren of vegetative cover) cause much surface erosion and sediment movement to streams as winter snow melts and runs off carrying soil into stream channels (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids et al. 1996). This is particularly a problem where riparian vegetation has been removed and the land is farmed up to the bank's edge. The conversion of riparian habitat to landscaped lawns has the same effect, removing bank stabilizing root mass thereby contributing to accelerated streambank erosion. Riparian vegetation naturally functions as a filter, capturing sediments and buffering the flow of surface runoff into stream channels.

Riparian Vegetation

The riparian ecosystem is a bridge between upland habitats and the aquatic environment and includes the land adjacent to streams that interacts with the aquatic environment. Riparian forest characteristics in ecologically healthy watersheds are strongly influenced by climate, channel geomorphology, and location of the channel in the drainage network. For example, fires, severe windstorms, and debris flows can dramatically alter riparian characteristics. The width of the riparian zone and the extent of the riparian zone's influence on the stream are strongly related to stream size and drainage basin morphology. In a basin unimpacted by humans, the riparian zone would exist as a mosaic of tree stands of different acreage, ages (e.g. sizes), and species.

Riparian habitats include side channels which offer refuge from adverse winter conditions such as rain-on-snow events/flooding and icing, and often influence the water quality of adjacent aquatic systems. Riparian vegetation provides shade which shields the water from direct solar radiation thereby moderating extreme temperature fluctuations during summer and keeping streams from freezing during winter. Riparian vegetation helps stabilize banks by maintaining masses of living roots which reduce surface erosion, mass wasting of stream banks and consequently reducing sediment delivered to the stream channel (Platts 1991). Riparian vegetation also contributes to the recruitment of large woody debris (LWD). Large woody debris contributes to channel complexity, including pool development, and sediment storage. Riparian ecosystems act as reservoirs, storing run-off in soil spaces and wetland areas and diminishing erosive forces caused by high flow events. The presence of stream-side vegetation also reduces pollutants, such as phosphorous and nitrates through filtration and binding them to the soil. Riparian vegetation contributes nutrients to the stream channel from leaf litter and terrestrial insects which fall into the water.

Riparian zones are impacted by all types of land use practices. Riparian forests can be completely removed, broken longitudinally by roads, and their widths can be reduced by land use practices. Further, species composition can be dramatically altered when native, old-growth, coniferous trees are harvested, allowing for the establishment of a younger seral stage of hardwood, deciduous tree species and young, smaller diameter conifers. Deciduous trees are typically of smaller diameter and shorter lived than coniferous species. They decompose faster than conifers so they do not persist as long in streams and are vulnerable to washing out from lower magnitude floods. Once impacted, the recovery of a riparian zone can take many decades as the forest cover reestablishes and matures and coniferous species colonize. In the more arid, narrower riparian zones common in the steep canyons of the lower Wenatchee basin watersheds, reestablishing conditions that support the regrowth of native riparian vegetation can be an even more difficult once the soil is disturbed.

Salmonids habitat requirements are met in part by healthy, functioning riparian habitat. For example: adequate stream flows must be present in order for fish to access and use pools and hiding cover provided by root wads and LWD positioned at the periphery of the stream channel. Microclimate, soil hydration, and groundwater influence stream flow; these factors are in turn influenced by riparian and upland vegetation. Vegetation and the humus layer intercept rainfall and surface flows. This moisture is later released in the form of humidity and gradual, metered outflow through groundwater where the geology supports the groundwater/surface water interaction. Through this process, stream flows may be maintained through periods of drought (Knutson and Naef 1997).

This category addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and a source for LWD. Human impacts to riparian function include timber harvest, clearing for agriculture or development, and direct access of livestock to stream channels.

Streambank Stability

Natural stream channel stability is achieved by allowing the river to develop a stable dimension, pattern, and profile such that over time, channel features are maintained and the stream system neither aggrades or degrades (Rosgen 1996; Leopold et al. 1992, Fluvial Processes in Geomorphology). For a stream to be stable it must be able to consistently transport its sediment load, both size and type (Rosgen 1996; Leopold et al. 1992). When the stream laterally migrates, but maintains its bankfull width and width/depth ratio, stability is achieved even though the river is considered to be an "active" and "dynamic" system (Rosgen 1996). Changes in discharge and sediment supply result in a limited number of possible channel adjustments, which vary with channel form and position within the stream network (Montgomery and Buffington 1993). Potential adjustments include changes in width, depth, velocity, slope, roughness and sediment size (Leopold et al. 1992). Channel instability occurs when, over a period of years, the scouring process leads to degradation (downcutting), or excessive sediment deposition results in aggradation. This attribute includes known areas of destabilized streambanks, actively eroding or stabilized by some channel stabilization technique.

Floodplain Connectivity.

Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. In a natural state, they allow for the development of productive aquatic habitats through lateral movement of the main channel. Floodplains also provide storage for floodwaters, sediment, and large woody debris. Floodplains generally contain numerous sloughs, side channels, and other features that provide important spawning habitat, rearing habitat, and refugia during high flows.

The alluvial fans area of the floodplain is an important feature of the floodplain, dissipating flow energy and maintaining and creating suitable rearing and spawning habitat over a wide range of flows. Large woody debris in an active channel or floodplain creates conditions necessary for plant colonization within an alluvial plain. Large woody debris is a primary determinant of channel morphology, forming pools, creating low velocity zones, regulating the transport of sediment, gravel, organic matter and nutrients and providing habitat and cover for fish (Bisson et al. 1987).

There are two major types of human impacts to floodplain functions. First, channels are disconnected from their floodplain laterally as a result of the construction of dikes and levees, which often occur simultaneously with the construction of roads, and longitudinally as a result of the construction of road crossings. Riparian forests are typically reduced or eliminated as levees and dikes are constructed. Channels can also become disconnected from their floodplains as a result of downcutting and incision (degrading) of the channel from losses of LWD, decreased sediment supplies, and increased high flow events. Reduced overbank flooding resulting from increased entrenchment can reduce groundwater recharge and alter the flow regime (Naiman et al. 1992 cited in USFS Mainstem Wenatchee River Watershed Assessment 1999).

The second major type of impact is loss of natural riparian and upland vegetation. Conversion of mature vegetated cover to impervious surfaces, early-mid seral deciduous riparian stands, pasture, and farmed fields has occurred as floodplains have been converted to urban/residential and agricultural uses. This has: 1) eliminated off-channel habitats such as sloughs and side channels, 2) increased flow velocity during flood events due to the constriction of the channel, 3) reduced subsurface flows, and 4) simplified channels since LWD is lost and channels are often straightened when levees are constructed.

Elimination of off-channel habitats can result in the loss of important rearing habitats for juvenile salmonids such as sloughs and backwaters that function as overwintering habitat for spring chinook, steelhead and bull trout. The loss of LWD from channels reduces the amount of rearing habitat available for juveniles. Disconnection of the stream channels from their floodplain due to levee and dike construction increases water velocities, which in turn increases scour of the streambed. Salmon that spawn in these areas may have reduced egg to fry survival due to the scour. Removal of riparian zones can increase stream temperatures in channels, which can stress both adult and juvenile salmon. Sufficiently high temperatures can increase mortality.

This attribute includes direct loss of aquatic habitat from human activities in floodplains (such as filling) and disconnection of main channels from floodplains with dikes, levees, and revetments. Disconnection can also result from channel degradation (downcutting) caused by changes in hydrology or sediment inputs.

5.0 FISHERIES RESOURCES AND HABITAT LIMITING FACTORS RATINGS BY SUBWATERSHED

The following subbasin assessments evaluate subwatersheds where salmon or steelhead are known to occur, or where habitat conditions in the stream(s) have the potential to degrade habitat downstream, in salmonid-bearing waters. Ratings of "Good", "Fair" or "Poor" were assigned during the assessment using the Okanogan Watershed Habitat Rating Criteria outlined in chapter 4, (**Table 5-1**). The information upon which the assessments were based was derived from published sources and the combined professional knowledge of the TAG participants. Therefore, each rating incorporates how biologist(s) judged the quality of habitat for the various stream reaches from available information. The number "1" assigned to the rating indicates quantitative studies or published reports exist to support the rating. The number "2" assigned to the rating indicates the professional knowledge of the TAG was used to rate the condition and data analysis, data, or published reports were not available. Where "**DG**" (Data Gap) appears in the table, there was so little information available on the habitat condition (published or professional knowledge) that the TAG members did not feel confident making even a qualitative determination of condition for the habitat criteria. The absence of a stream on the list does not necessarily indicate salmon or steelhead do not occur in the stream or imply that the stream is in good (or poor) condition. Summaries of some subwatershed are highly truncated because they have not been documented to support salmon or steelhead, or they have not been surveyed. Where possible, reach breakdowns were incorporated into the rating schema, reflecting geomorphic contstraints or other logical boundaries for evaluating habitat conditions within a subwatershed.

Table 5-1. Sub-Basin Total River Stream Miles, Stream Order and Impervious Surface Area for Washington Sub-Basins.

Sub-basin	Mainstem and Tributary Stream Miles	Other Related Stream Miles in Sub-Basin	Total Impervious Surface Area	Order
Chiliwist	19.26	15.20	58.91	2
Dan Canyon	21.60	8.51	45.54	3
Felix Creek	6.02	56.39	35.00	2
Duley Lakes	0.00	0.00	40.00	0
Loup-Loup	61.97	31.91	117.40	4
Salmon	137.12	19.17	184.16	4
Omak	155.42	118.35	164.93	4
Wanacut	27.60	26.02	1.92	3
Tunk	67.54	8.94	49.86	3
Johnson	17.85	44.89	141.95	2
Chewiliken	84.69	167.59	38.70	2
Bonaparte	117.55	8.52	165.36	4
Aeneas	23.79	3.06	19.89	2
Whitestone	25.88	57.50	89.31	2
Siwash	38.12	4.42	50.21	3
Antoine	53.97	1.08	57.89	3
Tonasket	41.04	33.72	109.57	3
Ninemile	11.44	2.40	12.27	2
Osoyoos Lake	0.00	3.78	27.39	0

This chapter provides assessments of the habitat conditions and fisheries resources in the US sub-basins of the Okanogan watershed. Rankings of habitat indicators utilize the methodology and numeric and/or narrative standards outlined in Chapter 4. Reaches are delineated where possible. Drainage area, stream order classifications, river miles, and impervious surface area estimates for each of the Okanogan River sub-basins south of the U.S.-Canada border examined in this LFA are provided in **Tables 5-2** and **5-3**. Photographic representation of habitat conditions around the mouths of most of these sub-basins is provided in Appendix C.

Table 5-2 Area and tributary status of Okanogan River sub-basins

	Area (acres)	Tributary to:
Okanogan River – Interfluve	204,398	Columbia River
Nine Mile Creek	13,516	Okanogan River Interfluve
Tonasket Creek	37,874	Okanogan River Interfluve
Mosquito Creek[1]	6,093	Okanogan River Interfluve
Antoine Creek	46,690	Okanogan River Interfluve
Siwash Creek	31,032	Okanogan River Interfluve
Bonaparte Creek	97,877	Okanogan River Interfluve
Chewilken Creek	17,125	Okanogan River Interfluve
Tunk Creek	45,586	Okanogan River Interfluve
Wanacut Creek	12,595	Okanogan River Interfluve
Omak Creek	90,691	Okanogan River Interfluve
Chiliwist Creek	27,842	Okanogan River Interfluve
Loup Loup Creek	40,868	Okanogan River Interfluve
Tallant Creek[1]	9,832	Okanogan River Interfluve
Salmon Creek	98,625	Okanogan River Interfluve
Johnson Creek	28,694	Okanogan River Interfluve
Fish Lake Basin Area[1]	23,124	Self Contained Basin
North Fork Pine Creek[1]	23,841	Self Contained Basin
Aeneas Creek	6,890	Okanogan River Interfluve
Aeneas Lake[1]	21,246	Self Contained Basin
Whitestone Creek (Spectacle Lake)	27,333	Okanogan River Interfluve
Similkameen River	228,536	Okanogan River Interfluve
Sinlahekin Creek[1]	189,521	Similkameen River
Wanacut Lake[1]	13,853	Self Contained Basin
Omak Lake	68,685	Self Contained Basin
Duley Lakes/Joseph Flats Area	51,319	Self Contained Basin
Swamp Creek	64,158	Columbia River
Columbia River Interfluve - East	139,955	Columbia River
Total	**1,667,798**	

1: included within spatial boundaries of sub-basin listed above it for the LFA. To calculate total area of LFA sub-basin the totals must be added (e.g., total Loup Loup area, with Tallant Creek drainage area is 40,868 + 9,832 acres = 50,700 acres).

Table 5-3 Stream order, river and road miles, and estimate of impervious surface area of Okanogan watershed sub-basins.

Sub-basin	Stream Order	Mainstem River Miles	Mainstem w/Tributary River Miles	Total Sub-basin River Miles	Total Road Miles	Total Impervious Surface (acres)	Percent Imper-vious Surface
Chiliwist	2	3.7	19.3	15.2	108.4	420.6	1.5
Dan Canyon	3	5.5	21.6	8.5	33.9	131.6	
Felix Creek	2	2.6	6.0	56.4	56.8	220.1	6.5
Duley Lakes	0	0.0	0.0	0.0	70.5	273.5	0.5
Loup-Loup	4	16.8	62.0	31.9	141.3	548.0	1.1
Tallant Creek[1]	2	5.9	8.8				
Salmon	4	38.1	137.1	19.2	295.6	1146.7	1.2
Omak	4	22.4	155.4	118.4	264.6	1026.4	0.6
Wanacut	3	7.6	27.6	26.0	3.8	14.9	0.1
Tunk	3	3.7	67.5	8.9	96.5	374.2	0.8
Johnson	2	7.9	17.9	44.9	207.3	803.9	1.1
N/S Fork Pine Creek[1]	2	13.3	13.3				
Chewiliken	2	10.9	84.7	167.6	57.8	224.2	1.3
Bonaparte	4	24.1	117.6	8.5	202.5	785.5	0.8
Aeneas	2	8.0	23.8	3.1	39.8	154.3	0.5
Whitestone	2	2.8	25.9	57.5	162.5	630.3	2.3
Siwash	3	20.8	38.1	4.4	76.7	297.6	1.0
Antoine	3	16.6	54.0	1.1	94.5	366.5	0.8
Tonasket	3	7.3	41.0	33.7	130.9	507.6	1.2
Ninemile	2	6.8	11.4	2.4	21.1	81.9	0.6
Osoyoos Lake	0	0.0	0.0	3.8	25.9	100.4	
Similkameen River		20.56					
Sinlahekin River		23.47					

1: Considered within sub-basin boundary of adjacent watershed listed in Table above.

5.1 CHILIWIST CREEK WATERSHED

5.1.1 Sub-basin Overview.

The Chiliwist Creek sub-basin comprises approximately 27,842 acres, representing approximately 1.7% of the Okanogan watershed (OCD 2000). It is located in the southwestern corner of the Okanogan watershed, and is the lowest Okanogan sub-basin upstream of the Okanogan River's confluence with the Columbia River (Figure B-1). Chiliwist Creek enters the Okanogan River on its western side at approximately RM 15.1 (WDNR 1982). The sub-basin includes all the habitat along the southeast border of the sub-basin (i.e., the western shore of the mainstem Okanogan) for approximately 27 km (before entering the Columbia. The principal tributary within this sub-basin is Chiliwist Creek, however, the sub-basin also includes Sulivan Creek, Smith Lake, and Starzman Lake. None of these other waters within the sub-basin regularly convey surface waters to the Okanogan. Over half of the sub-basin is within the Okanogan National Forest, found in the northwestern and part of the northeastern portions of the sub-basin watershed.

Land Use and Ownership.

Forestry, livestock grazing, and irrigated agriculture are the primary uses of the Chiliwist sub-basin (WDFW 1990). Forests account for roughly 61.6 percent of the basin (17,142 acres), rangeland comprises approximately 36.1 percent (10,053 acres), and the remaining 2.3 percent is cropland (514 acres) (OCD 2000). Apples are the main crop cultivated in the Chiliwist valley and lower Chiliwist Creek sub-basin. The upper portion of the Chiliwist sub-basin is part of the National Forest Service and offers a host of recreational activities, in addition to timber resources.

Topography, Geology & Soils.

Glacial activity created the Chiliwist sub-basin. The central portion of the sub-basin forms a valley at approximately 500 ft that rises to 1000 ft around the western border of the sub-basin. The Okanogan National Forest portion of the Chiliwist sub-basin lies is part of the eastern slopes of the Cascade Range (LMEA 1997). Four mountains demarcate the sub-basin's western and northern borders: Cook Mountain (1189 ft), Woody Mountain (1398 ft), Thrapp Mountain (1300 ft) and Dent Mountain (956 ft).

The lower Chiliwist sub-basin is principally a quaternary alluvium with terrace deposits (USGS 1954). This strata is characterized by unconsolidated gravels, sand, silt and clay deposited by modern streams and by glacial melt. The central Chiliwist valley is principally composed of glacial till (granite, volcanic and sedimentary parent material) and bare bedrock. Within the Chiliwist Creek valley the bedrock surface is irregular and often exposed; however, unconsolidated glacial deposits overlying the bedrock may be up to 200 ft thick. In the upper portion of the basin above the Chiliwist valley the geology has been characterized as undifferentiated igneous and metamorphic rock which is generally non water bearing (USGS 1954).

Fluvial Geomorphology & In-Channel Habitat.

No formal studies were identified that quantified or otherwise characterized fluvial geomorphology or in-channel habitat conditions in the Chiliwist sub-basin. The lower Chiliwist sub-basin represents a small portion of the U-shaped unconfined alluvial valley through which the Okanogan River flows. The lower portion of the Okanogan River flows through sinuous, broad, low gradient channels depositing large accumulations of sediment into the alluvial fans of lower tributaries such as Chiliwist Creek (WDFW 1990).

Vegetation and Riparian Condition.

No formal studies were identified that quantified or otherwise characterized riparian condition in the Chiliwist sub-basin. In the lower Chiliwist sub-basin, along the Okanogan River, shrub/grass land dominate the plant community. Further upstream, in the Chiliwist valley, the soils and dry valley climate generate little vegetation and organic matter (WDFW 1990). Yellow pine and mountain alder dominates Okanogan National Forest lands in the upper basin.

Water Quantity/Hydrology

Surface Water

No gauges operating on Chiliwist Creek or Sullivan Creeks were identified in the review process for this LFA. During much of the growing season all surficial flows from lower Chiliwist Creek are diverted for irrigation (Walters 1974). Flows in the basin, especially the lower portions, travel over permeable materials that result in subterranean flows over many portions of the year such that flows rarely exceed 1 cfs. Within and downstream of the Chiliwist valley the flow in Chiliwist Creek becomes erratic and often subterranean. Surface flows measured sporadically in Chiliwist Creek between 1968 and 1970 ranged from 0.55 to 0.59 cfs in the upper basin above the Chiliwist valley (near center sec. 14, T. 32 N., R. 24 E; n = 5), 0.6 to 1.16 in the mid-basin (NE ¼ SW ¼ sec.13, T. 32 N., R. 24 E.; n = 6) and 0.75 to 3.30 cfs (SE ¼ SE ¼ sec. 18, T. 32 N., R. 25 E., n = 4) under highway 97 approximately 0.5 km from the mouth (Walters 1974). Recent monthly measurements conducted by the Okanogan Conservation District between May and December of 2000 recorded a range of 0.037 to 0.987 cfs in the upper Chiliwist basin, and a range of 1.27 to 8.488 in the lower basin (C. Nelson, OCD, personal communication).

Much of Chiliwist creek downstream of the valley has been channelized, and flows have been directed through at least a dozen culverts (Figure B-1). According to Streamnet, there are at least five irrigation diversion dams in lower Chiliwist, downstream of the valley.

No information on surface flows in Sullivan creek was reviewed for this LFA. This creek flows into the Chiliwist valley and then becomes subterranean. The contributions of this creek to recharging the valley aquifer and supplementing flows in lower Chiliwist Creek are not known.

Groundwater

Pumping records from 1969 recorded 80 million gallons (250 acre-feet) of groundwater withdrawn for irrigation (Walters 1974). Deep unconsolidated deposits within the Chiliwist valley may yield up to 300 gallons per minute of flow and the combined Chiliwist-Loup-Loup sub-basins were estimated to store approximately 35,000 acre-feet of water (Walters 1974). Current pumping records were not reviewed for this LFA. The relationship between surface flows and groundwater recharge has not been formally investigated in Chiliwist creek.

Water Quality.

Historic data on conventional water quality or chemical pollutants in the Chiliwist sub-basin were not identified. The Okanogan Conservation District (C. Nelson, OCD, personal communication) has conducted recent conventional water quality monitoring in upper and lower Chiliwist Creek.

In monthly monitoring between mid-May and early July of 2000 in the upper Chiliwist, dissolved oxygen concentrations appear to be at or near saturation, ranging from 9.35 to 10.71 mg/L. The pH of the upper basin's surface waters in this period were alkaline, ranging from 8.34 to 9. Turbidity was low, ranging from 1.2 to 9.32 NTUs. Temperatures ranged from 14.2 to 15.5 degrees Celsius. Subsequent monitoring in the upper basin through the duration of the year could not be performed due to lack of flow.

In the lower Chiliwist basin, where flows permitted monthly monitoring through hydrologic year 2000, the OCD measured dissolved oxygen values between 9.86 and 14.53 mg/L, pH values of 8.35 to 8.92, turbidity ranging from 2.37 to 5.1 NTUs, temperatures of 1.4 to 14.5, and conductivity of 54 to 411 uS/cm. As expected, temperatures were highest and dissolved oxygen was lowest in August. These values are all within a range acceptable by salmonids for rearing and other life stage functions.

Data on nutrients and/or contaminants in the Chiliwist surface or groundwaters were not identified in review efforts for this LFA.

5.1.2 Fisheries Resources in Chiliwist Creek Sub-basin

Only about the lower ½ mile of Chiliwist Creek is accessible to anadromous salmonids (**Figure B-1**), because a natural gradient barrier likely prevents further access upstream (Okanogan TAG). The use of this area for juvenile rearing or refuge by chinook, steelhead and sockeye has not been formally determined. However, water quality in the lower basin would not preclude its use by any of the salmonid species in the basin for these functions. The cooler waters found within this tributary relative to the mainstem Okanogan suggest that it may be important in providing thermal staging during summer migrations of adult chinook, steelhead and sockeye, with permissible flows.

Sockeye salmon do not use the Chiliwist sub-basin for spawning. No data are available on the use of Chiliwist Creek for spawning by steelhead, but it is very unlikely given the low run size in the Okanogan River, and the limited use of more suitable habitat elsewhere in the Okanogan watershed. Summer chinook do not spawn in the Chiliwist sub-basin; the current chinook run spawn upstream of Mallott (Okanogan RM 16.9) to Zosel Dam (RM 78), with the majority near the confluence of Omak creek, and in the Similkameen region by the town of Oroville. Thus, no chinook redds were found in the Chiliwist sub-basin, or mainstem portions of the Okanogan river downstream from the Chiliwist confluence in 1998 ground and aerial surveys (Murdoch and Miller 1999). The mainstem Okanogan River downstream of the Chiliwist Creek confluence is inundated with backwater from the Wells Dam hydroelectric project and therefore offers unsuitable habitat for mainstem spawning of all salmonid species.

5.1.3 Rankings of Habitat Limiting Factors in the Chiliwist Sub-basin

Habitat condition ratings of the Chiliwist sub-basin are provided in **Table 5-4**. The numeric standards used to evaluate existing habitat literature and/or professional judgment from the Chiliwist subbasin are provided in **Table 5-4**. Two reaches were considered for habitat ranking, an upper Chiliwist reach above the anadromous zone, and a lower Chiliwist reach, including all waters downstream of the first anadromous barrier in the system at approximately RM 0.5 from the Okanogan confluence.

Table 5-4: Chiliwist Creek Limiting Factors Assessment

Habitat Pathway and Indicator	Habitat Indicator Rating Reach 1—Lower Chiliwist (0-0.5)	Habitat Indicator Rating Reach 2—Upper Chiliwist
Water Quality		
Dissolved Oxygen	G1	G1
Stream Temperature	G1	G1
Turbidity/Suspended Sediment	G1	G1
Chemical Contamination/ Nutrient Loading	DG	DG
In Channel Habitat		
Fine Sediment (substrate)	DG	DG
Large Woody Debris	DG	DG
Percent Pool by Area	DG	DG
< 2%		
2-5%		
>5%		
Habitat Access		
Fish Passage	F2	DG
Stream Flow		
Resembles Natural Hydrograph	F1,2	P1,2
Impervious Surface	F1	F1
Stream Corridor		
Riparian Vegetation	DG	DG
Stream Bank Stability	DG	DG
Floodplain Connectivity	F2	P1,2

Support for Limiting Habitat Factor Rankings in Chiliwist Creek Sub-basin

Water Quality

With the exception of information on chemical contamination and nutrients, current information on the convential water quality parameters known to affect fish health and distribution is favorable for salmonids. For this reason, the indicators of dissolved oxygen, turbidity and temperature were rated as “good” in both the upper and lower reaches of Chiliwist Creek. Chemical contamination and nutrient impacts in the sub-basin are not known are therefore indicated as data gaps for both reaches.

In-Channel Habitat

Because no formal habitat studies have been conducted in the Chiliwist basin, in-channel habitat conditions could not be rated, and the indicators of habitat pathways considered for this LFA were listed as ‘data gaps’.

Habitat Access

Below the barrier at RM 0.5 there are no passage barriers recognized, hence, the lower Chiliwist reach received a rating of good. The passage barrier at river mile 0.5 remains to be officially investigated and it is not known whether some flow conditions in the creek might pass anadromous fish. Data from Streamnet reveal numerous culverts and diversions in the upper

Chiliwist sub-basin. These water manipulations have not been formally evaluated, to our knowledge, for their ability to pass fish. For this reason, it was conservatively assumed that fish migrations within the upper basin may be compromised, as historic culvert placements did not regard juvenile fish passage critieria. Since data have not been fully evaluated, however, a ranking of F was supported. A qualifier of ½ indicates both data and professional judgement were considered in the ranking.

Stream Flow

Upstream water withdrawals allocate all surface flows from this drainage, thereby affecting potential rearing of all fish species over the entire basin area downstream of the withdrawals. While natural conditions also contribute to dewatering, current data support the rankings of poor for streamflow indicators (normal hydrograph) in both the upper and lower reach.

Esimates of impervious surface area (Table 5.1) indicate a 'fair' rating based upon numeric qualifiers provided in Table 4.1.

Floodplain Connectivity

No data are available with which to evaluate the functionality of floodplain indicators relative to the numeric and narrative qualifiers of Table 4.1. For this reason, the indicators of floodplain connectivity in both the upper and lower reaches of Chiliwist Creek were listed as 'data gaps'

5.2 DAN CANYON WATERSHED DESCRIPTION

5.2.1 Sub-basin Overview

Dan canyon is an intermittent tributary to the Okanogan River located entirely on the southwest plateau of the Colville Indian Reservation (Figure B-2). The watershed covers 9,081 acres and drains to the west. Dan Canyon enters the eastern side of the Okanogan River at approximately RM 5, although surface flows from Dan Canyon rarely (if ever) reach the Okanogan River. The watershed is a dense network of small, Type 4 and 5 intermittent streams, with a total stream length of 40.4 miles.

Land Use and Ownership

Rangeland, and crop production are the primary land uses in Dan Canyon (CCT 2001). No data were reviewed to provide a more refined percentage breakdown of land use activities. Dan Canyon drains lands owned entirely by the Confederated Tribes of the Colville Reservation.

Topography, Geology and Soils

Dan Canyon is part of the southwest plateau portion of the Colville Reservation that also includes the Felix Creek and Duley Lakes sub-basins. The sub-basin's elevation ranges from 820 feet at the Okanogan River confluence to 2,620 feet (USGS 1954, CCT 2001). From the river, slopes rise moderately until leveling out at the top of the southwestern plateau. The plateau is an area of mid-elevation rangeland located in the southern portion of the Colville Reservation.

The upper portion of the sub-basin is composed of undifferentiated igneous and metamorphic rocks with low water bearing potential (USGS 1954), and the lower portion of the basin adjacent to the river is comprised principally of a quaternary alluvium with terrace deposits. The plateau area is composed chiefly of range soils formed in basaltic glacial till and material weathered from basalt, with a mantle or component of loess. Most soils in the northwest part of the plateau escarpment derive from glacial till, weathered granite, and loess. Soils were principally formed in glacial outwash and eolian sand with a component of loess ocurr at lower elevations on terraces, terrace escarpments, and dunes, along the Columbia and Okanogan Rivers. Most of the area was glaciated over a layer of basalt, which probably accounts for the many isolated lakes (CCT 1997). Soil erosion potential is low.

Fluvial Geomorphology & In-Channel Habitat

No quantitative or qualitative studies on channel morphology and habitat were found in reviews conducted for this LFA. Moderate to low channel gradients (0-10%) prevail in the lower basin. Channel complexity is likely low due to the sparse tree layer naturally available to recruit wood (large or small) into the stream network. Intensive grazing pressure in the sub-basin may have exacerbated this situation. The potential may exist for off-channel habitat at the confluence of Dan Canyon, although this has not been confirmed.

Vegetation and Riparian Habitat

No quantitative or qualitative studies have been conducted on the vegetative communities in the Dan Canyon sub-basin. Sagebrush-steppe probably dominated the area historically. Riparian areas were historically dominated by deciduous vegetation (cottonwood and willow), with a very minor conifer component at the uppermost elevations. Presently, the area is heavily grazed (CCT 1997).

Water Quantity/Hydrology

A series of potholes dotting the landscape along the upper (eastern) margin of the Dan Canyon sub-basin are the principal water sources in the sub-basin. No formal studies have been conducted to determine the storage capacity of these waters, or to ascertain the link between groundwater and surface water flows. These potholes are fed by intermittent streams and groundwater, and hold water seasonally or year-round. The potholes may recharge groundwater that is ultimately conveyed towards the Okanogan River as Dan Canyon surface water, however, this scenario has not been confirmed with field study. Most of the plateau does not have surface flows to the Okanogan River.

Water Quality

No studies identified for this LFA that formally documented water quality in Dan Canyon's lentic or lotic waters. They are generally known to be highly alkaline, with high summer temperatures outside of the range acceptable to salmonids (CCT 2001).

5.2.2 Fisheries Resources in Dan Canyon Sub-basin

Fish presence in this area is minimal, as most streams are intermittent, and most lakes are highly alkaline or saline. Productivity in the pothole lakes is limited currently and historically by the alkaline waters condition, high water temperatures, and the fact that most of the lakes have no outlet, so no flushing can occur (CCT 2001). There are no anadromous species in the streams of the southwest plateau, including Dan Canyon (**Figure B-2**). There is no historical information on fish presence, but anecdotal reports suggest that the creek may never have supported fish (CCT 2001).

The Colville Tribe used the Unified Watershed Assessment Categories (UWAC), a part of the EPA Clean Water Action Plan Criteria (EPA 1998) to characterize the condition of the watersheds on the reservation. Dan Canyon received a Category I rating, indicating that the sub-basin does not meet clean water and other natural resource goals, and needs restoration. This rating was based on general knowledge of the area, and should be field checked (CCT 2001).

5.2.3 Habitat Limiting Factors Assessment of the Dan Canyon Sub-basin

No assessment was done, as there are no anadromous fish presently or historically in Dan Canyon. Dan Canyon rarely if ever has an impact on the Okanogan River, because its flow does not reach the river. The primary habitat concern in Dan Canyon is flow alteration caused by natural conditions, agricultural practices and the road construction.

5.3 LOUP-LOUP WATERSHED DESCRIPTION

5.3.1 Sub-basin Overview

Loup Loup Creek is a tributary of the Okanogan River and enters the river at RM 16.9, in the small community of Malott, WA (**Figure B-3**). Nearly the entire watershed (40,868 acres) is categorized as forested (86.5%). Peak elevation is approximately 1,700 feet. Land ownership includes the Bureau of Land Management (BLM), Washington Department of Natural Resources (WDNR), United States Forest Service (USFS) and private owners, with WDNR responsible for managing 31,506 acres.

Approximately 3,500 acre-feet of Loup Loup Creek is annually diverted into Leader Lake, a storage reservoir used for irrigation. Another irrigation diversion is located at ~ RM 2.0. Typically, due to water withdrawals, the lower reach of Loup Loup Creek is dry by mid-summer.

Land Use and Ownership

The Loup Loup Creek watershed (40,868 acres) contains a variety of land use including forest, range, non-irrigated pasture, irrigated orchard, urban and open water. However, the majority of the land use is forest (86.5%). Land ownership is primarily privately owned and managed by the Washington Department of Natural Resources (31,506 acres (C. Dibble personal communication). However, there are smaller parcels of public land managed by the Bureau of Land Management (BLM) and United States Forest Service (USFS).

Included in this watershed is the unincorporated community of Malott, Washington located adjacent to the confluence of Loup Loup Creek and the Okanogan River. According to the 2000 census the population of the voting precinct is 712 and approximately 83 within the city limits (T. Murray personal communication). The lowermost area of the watershed is primarily urban development and orchards. The mid-range area of the watershed consists of range land-type and the uppermost is forested. Two lakes, Leader and Buzzard, are destination points in the watershed with the former noted for trout fishing.

5.3.2 Fisheries Resources in Loup Loup Creek Sub-basin

Historically, cutthroat trout likely existed in the upper reaches of Loup Loup Creek, and perhaps bull trout, although no formal documentation of bull trout in the basin exist. Anadromous and resident forms of rainbow trout existed in Loup Loup Creek. The anadromous forms of rainbow trout (i.e. steelhead) migrated as far as the falls (approximately RM 2.5) (**Figure B-3**). Currently fish species in Loup Loup Creek include rainbow trout and brook trout. The rainbow trout are likely remnants of a historical anadromous form. Eastern brook trout were planted by the Washington Department of Fish & Wildlife and have either hybridized or out-competed the native bull trout. Today, the range of anadromous fish in Loup Loup Creek is limited by man-made fish passage barriers and discontinuous flows. The lowermost barrier is a perched culvert at approximately RM .1. At ~ RM 2.0 water is diverted for irrigation. Typically the lower reach becomes dry during early summer (June/July), thus voiding all possible natural reproduction.

Leader Lake in the Loup Loup sub-basin is a popular recreational sport fishery. Washington Department of Fish and Wildlife (WDFW) stock the Lake annually with 25,000 rainbow trout fry. During 1998 the WDFW rehabilitated Leader Lake to remove largemouth bass introduced by an unauthorized planting. Species known to exist in the upper reaches of the basin include rainbow and brook trout. There have been accounts of large fish utilizing the lower reaches of Loup Loup Creek and are presumed to be steelhead.

5.3.3 Habitat Limiting Factors Assessment for Loup Loup Sub-basin

For this analysis two reaches were evaluated in Loup Loup Creek (**Table 5-5**). The lower reach extends from the confluence to the base of a pair of falls approximately 12 feet high at ~ RM 2.5. These falls were likely the extent of the historical range of steelhead in Loup Loup Creek. The upper reach extends from the falls to the headwaters of Loup Loup Creek. The source of habitat and water quality information provided for this analysis of Loup Loup Creek was from reconnaissance-level surveys by the Colville Confederated Tribes Fish and Wildlife staff, data collection by Okanogan Conservation District or personal communication with Ken Williams, formerly regional fish biologist for Washington Department of Fish and Wildlife.

Table 5-5: Loup-Loup Creek Habitat Limiting Factors Assessment Rating

Habitat Pathway and Indicator	Assessment of Habitat Indicator Function Reach 1 RM 0 to 2.5	Assessment of Habitat Indicator Function Reach 2 RM 2.5 to 19.8
Water Quality		
Dissolved Oxygen	P1	G1
Stream Temperature	P1	G1
Turbidity/Suspended Sediment	P1	G1
Nutrient Loading	F1	G1
In Channel Habitat		
Fine Sediment (substrate)	DG	P2
Large Woody Debris	P2	DG
Percent Pool	DG	DG
Habitat Access		
Fish Passage	P1	DG
Stream Flow		
Resembles Natural Hydrograph	P1	P1
Summer Flow Level	P1	G2
Winter Base Flow	P1	F1
Impervious Surface	F1	F1
Stream Corridor		
Riparian Vegetation	F2	F2
Stream Bank Stability	F2	F2
Floodplain Connectivity	F2	G2

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

Water Quality

Reach 1

Water quality data was provided by the Okanogan Conservation District. The data was collected from May 17 through July 5, 2000 and from January 17 to May 16, 2001. From August 9 through December 20, 2000 the lower reach of Loup Loup Creek was dry. When flows did exist dissolved oxygen was good ranging from 9.79 to 13.79 mg/l. Water temperature was never recorded above 58.1^{o} F. However, flows were discontinued in this reach by August 9, 2000, when elevated water temperatures were likely to occur. Turbidity was evaluated 8 times during the period from May 17, 2000 to May 16, 2001. NTUs's varied from 0.3 to 5.69. Approximately 3,000 acre-feet is diverted from Loup Loup Creek and stored in Leader Lake. This water is diverted to Leader Lake at approximately RM 11.6, from October 1st to May 1st during the calendar year. By reducing the flow during typical peak spring runoff may be the reason for reduced turbidity found in the lower reaches of this stream. Total suspended solids have exceeded 144 for 4 of 7 measurements. These higher recordings were measured when flows continued after a 5-month absence. Thus the higher total dissolved solid measurements could be attributed to increased levels of calcium carbonate due to the discontinuation of flow during the previous 5 months (T. Neslen personal communication). When water exists, water quality in lower Loup Loup Creek overall rates "good", however the lack of flow, due to irrigation withdrawals limit the ability for this creek to support anadromous or resident salmonids throughout the year.

Reach 2

Water quality measurements, in the upper reach were taken upstream of the diversion to Leader Lake (~ RM 11.6). Dissolved oxygen has not been measured at levels that would be detrimental to salmonid populations. From May 17, 2000 to May 16, 2001 dissolved oxygen was measured 13 times ranging from 9.28 to 13.49 mg/l (T. Neslen, OCD, unpublished data). Based upon grab samples, water temperatures in Loup Loup Creek are conducive to salmonids. Water temperatures ranged from 32.5^{o} F to 54.0^{o} F (T. Neslen, personal communication). Turbidity samples were very low, ranging from 0.4 to 2.3 NTUs (T. Neslen, Okanogan Conservation District). Suspended sediment measured 8 times from June 7, 2000 to May 16, 2001, ranged from 20 to 119 ppm (T. Neslen, personal communication). These low levels of turbidity and total dissolved solids indicate that erosion is not excessive in the upper watershed. However, there is evidence, based upon habitat surveys, that the streambed contains a disproportionate amount of fine sediment (> 50%).

Tallant Creek—During 1995 the Washington Department of Ecology conducted a study to assess DDT in tributaries in the Okanogan River (Johnson et al., 1997). Concentrations substantially exceeded the state's chronic surface water quality standard of 0.001 ug/L (parts per billion) in Tallant Creek (0.19 – 0.50). These levels exceed concentrations found in other drainages where DDT was historically applied. Currently the Washington Department of Ecology is sampling for DDT and PCBs throughout the Okanogan River watershed to better identify sources.

In-Channel Habitat

Reach 1

Information regarding in-channel habitat in Loup Loup Creek is limited to reconnaissance-level surveys. This lower reach of Loup Loup Creek lies amongst orchards and the rural community of Malott, Washington. Where adjacent to orchards the stream appears to be channelized. Streambanks are typically grass covered and no actively eroding banks were observed. Fine sediment is less than expected possibly due to altered hydrology (flow discontinued or reduced throughout most of the year). During surveys, no large wood was observed in the lower reach. Due to development and bordering orchards, large wood is likely in lower amounts than was historically. Although not measured, pool frequency is expected to be substantially less than historical conditions due to channelization and the lack of pool forming material (i.e. large woody debris).

Reach 2

Environmental education workshops have been conducted on Rock Creek, a tributary of Loup Loup Creek, since 1997. Pebble counts on Rock Creek have indicated that fine sediment was found in frequencies greater than 50%. Possible sources of sediment could be roads into area lakes (Rock, Buzzard), logging roads and private drives. Also, there are areas that indicate concentrated cattle use along the stream and tributaries. It is not known if large wood debris surveys have been conducted along Loup Loup Creek or connected tributaries. It is suspected that large wood recruitment is lacking along certain reaches because of rural and recreational development. The amount of pool habitat in Loup Loup Creek is unknown. Based upon extremely limited information collected along Rock Creek indicates pool habitat is adequate.

Habitat Access

Reach 1

Currently, three barriers to anadromous fish passage exist on the mainstem of Loup Loup Creek. The lowermost two barriers are culverts and the uppermost barrier (~ RM 2.5) is a set of falls. The first culvert is located within the city limits of Malott, Washington and is approximately 1/8th mile upstream from the confluence. This culvert is perched approximately 30" above the water surface and would impede adult steelhead from accessing habitat upstream. The second culvert is located approximately ¼ mile upstream from the confluence. This culvert routes Loup Loup Creek under Old Highway 97. This culvert is approximately 100 feet in length and has an estimated gradient of 1 to 2%, and is likely limits passage by adult steelhead due to increased velocities. Finally, a pair of falls, approximately each 12 feet high, exist at ~ RM 2.5. These falls are the historical extent of anadromous fish in Loup Loup Creek.

Reach 2

From approximately RM 2.5 (natural falls) to the headwaters there are no known barriers to fish passage. However, there are no known surveys conducted to assess fish passage upstream of RM 2.5.

Stream Flow

Reach 1

The natural hydrology in Loup Loup Creek has been severely altered since the early 1900's. Flows are reduced from a diversion located at approximately ~ RM 11.6. This diversion routes approximately 3,472 acre-feet of water from Loup Loup Creek to Leader Lake from October 1st to May 1st each year. This water is used for irrigation during the following year. The water right connected to this diversion has been in existence since 1913 (Water Claim Right No. 33138). In addition another diversion exists at ~ RM 2.0, and is also for the purpose of irrigation. Typically flows are non-existent downstream of RM 2.0 by mid-July. Currently, the altered hydrology of Loup Loup Creek impedes access by adult steelhead and this system offers no effective advantage to perpetuate or enhancing the species in the Okanogan watershed.

Reach 2

As stated earlier, water is diverted at ~ RM 11.6. Approximately 3,500 acre-feet is diverted to Leader Lake between October 1st to May 1st each calendar year. These reduced wintertime flows may limit juvenile salmonid survival by reducing habitat increasing the likelihood of anchor ice to form. Furthermore, road densities may have an effect on changes in peak run off and base flows. Road densities, as of 1997, within WDNR managed lands in the basin were 1.9 miles/sq. mile and 2.7 miles/sq. mile on privately-owned lands (C. Dibble, personal communication). Higher road density on a limited amount of private land, suggests there is a higher percentage of impervious surface in this area (southeast) of the watershed.

Channel Condition

Reach 1

Riparian vegetation along the lower 2.5 miles of Loup Loup Creek is altered and fragmented. Canopy closure is reduced, because riparian vegetation was noticeably removed where orchards are adjacent to the stream channel. Because of discontinuous flows, the current riparian vegetation is surely lessened when compared to historical conditions.

Bank stability has not been evaluated in Loup Loup Creek. However, based upon reconnaissance-level surveys actively eroding banks were not observed along Loup Loup Creek. Grasses cover much of the streambanks and interrupted flows eliminate much of the erosive nature from spring run-off events.

Floodplain connectivity is limited in the lower 2.5.miles of Loup Loup Creek. Due to the apparent channelization of the lower reach of Loup Loup Creek the floodplain connectivity is absent. However, based upon the nearby landform it appears that Loup Loup Creek was naturally a relatively high-gradient stream. Therefore, although the floodplain connectivity is currently non-existent, it is likely that because of the high gradient the floodplain was never extensive.

Reach 2

As in the lower reach, there are areas in the upper reach that are obviously absent of riparian vegetation. Exploratory surveys point towards rural development and concentrated livestock use as the cause of reduced canopy closure. As in the lower reach, Loup Loup Creek is a high gradient stream with little floodplain development. The reduction in floodplain connectivity exists, primarily from loss of riparian vegetation. The incision or bedload movement is reduced due to attenuated peak flows by water being diverted for irrigation.

5.4 DULEY LAKE/JOSEPH FLATS WATERSHED DESCRIPTION

5.4.1 Sub-Basin Overview

The Duley Lakes/Joseph Flats sub-basin covers 51,000 acres, and is located in the southwest plateau of the Colville Indian Reservation, in the southeastern corner of the Okanogan River watershed (Figure B-4). This area covers about 51,000 acres. Pothole lakes and ponds make up over 1300 acres of open water and there are no surface water connections to the Okanogan River from this sub-basin.

Land Use and Ownership

Most of the basin is low-elevation mixed rangeland and shrub rangeland. Livestock grazing occurs on 90% of the land in the basin. About 6% of the land area is in non-irrigated small grain production. There are less than 300 acres of forest in the basin, and some timber harvest occurs. There is no rural development in the basin. Dirt roads parallel many of the lakes and ponds (OCD 2000).

Topography, Geology and Soils

The entire portion of the Duley Lakes/Joseph Flats sub-basin rests atop the southwestern plateau of the Colville Indian Reservation, in the southeastern edge of the Okanogan watershed. Atop the plateau, there is minimal variation in topography relative to many of the other Okanogan sub-basins, with elevations ranging from about 2,000 ft to 2,600 ft. Much of the sub-basin is composed of tertiary volcanic rocks which range from a dark-gray to a reddish-brown basalt. Pockets of quaternary alluvium and terrace deposits left over from glacial activity can also be found in this sub-basin. Soils are generally alkaline, rocky, and limited to grazing.

Vegetation and Riparian Condition

Vegetation is similar to the shrub-steppe and mixed rangeland found in Dan Canyon, although there is a slight increase in conifers, owing to the generally higher elevations found there. Cattle have access to the banks of the lakes, resulting in siltation and sedimentation, nutrient loading, and loss of riparian habitat. Formal studies of the degree of riparian damage were not identified in the review for this LFA.

Water Quantity/Hydrology

The potholes that dot the landscape in this sub-basin are fed by intermittent streams and groundwater, and hold water seasonally or year round. They are more abundant in this sub-basin than found in the adjacent Dan Canyon or Felix Creek sub-basins. No surface flows from the sub-basin convey waters to the Okanogan River. Based upon map-wheel projections

Water Quality

Waters in the sub-basin are known to be highly alkaline (CCT 1997). The high alkalinity of the lakes in the sub-basin likely limits their productivity, along with extreme summer and winter temperatures, nutrient loading, and lack of flushing most of the lakes have no outlet, so no flushing can ocurr (CCT 1997). For example, Duley Lake is eutrophic, probably due to both natural causes and nutrient loading (OCD 2000). The Colville Tribe used the Unified Watershed Assessment Categories (UWAC), a part of the EPA Clean Water Action Plan Criteria (EPA

1998), to characterize the condition of the watersheds on the reservation. Duley Lake received a Category I rating, indicating that the watershed does not meet clean water and other natural resource goals, and needs restoration.

5.4.2 Fisheries Resources in the Duley Lake Sub-basin

There are no anadromous species in the streams of the plateau (**Figure B-4**). Resident fish presence in this sub-basin is minimal as most lakes are highly alkaline or saline. Carp are likely the only fish species in Duley Lake. Rainbow trout and largemouth bass have been planted in the past, but are no longer present. The lake is alkaline and does not support most species of fish. This is true of most of the lakes in the area. Little Goose Lake, north of Duley Lake, is relatively deep, and does support a population of stocked rainbow trout (J. Marko, personal communication, 2001).

5.4.3 Habitat Limiting Factors Assessment in the Duley Lake/Joseph Flats Sub-basin

No limiting factors assessment was done for Duley Lake and the Joseph Flats sub-basin because there is no anadromous use, and the basin is self-contained. The sub-basin's water quality is heavily impacted by livestock grazing. The Duley Lake sub-basin's numerous pothole lakes may affect overall basin hydrology by providing a source of groundwater feeding perrenial and/or ephemeral streams outside of the sub-basin's boundaries.

5.5 FELIX CREEK WATERSHED DESCRIPTION

5.5.1 Sub-basin Overview

The Felix Creek sub-basin comprises a variety of intermittent tributaries to the Okanogan River that drain the southwestern plateau of the Colville Indian Reservation on the eastern side of the Okanogan River. The sub-basin is adjacent and north of the Dan Canyon sub-basin (**Figure B-5**). Felix Creek, for which the sub-basin has been named, is the largest of the tributaries within the sub-basin and no others have been named. It enters the Okanogan River along the eastern side at approximately RM 24.

Surface flows from Felix Creek rarely reach the Okanogan River. The mainstem of Felix Creek is 2.9 miles long, and, based on USGS map-wheel projects, there are approximately 6 miles of stream channel in Felix Creek when its tributaries are included. Within the sub-basin as a whole, a total of 56 miles of stream channel have been identified from the USGS, although most of these channels are generally dry or ephemeral.

The Felix Creek sub-basin area is 3,405 acres, and elevation ranges from 820 feet at the mouth, to 3,120 feet. (CCT 2001). A series of potholes dot the landscape in the Felix Creek sub-basin, the largest of which is Soap Lake. The potholes in the basin are fed by intermittent streams and groundwater, and hold water seasonally or year round. Fish presence in this area is presumed minimal to non-existent, as most streams are intermittent, and most lakes are highly alkaline or saline

Land Use and Ownership

Land cover includes deciduous forest along the Okanogan River, crop, pasture and range lands at low to mid elevations, and mixed forests at upper elevations. Agriculture is the dominant land use in the watershed. Crop production and pastureland dominate the lower part of the watershed. The mid to high elevations are used for livestock grazing, and limited timber harvest occurs in the forested area at the upper elevations as well (OCD 2000). All lands within the Felix Creek sub-basin lie within the Colville Indian Reservation.

Topography, Geology and Soils

The southwestern plateau portion of the of the Colville Reservation that includes the Felix Creek sub-basin is mostly mid-elevation rangeland located in the southern portion of the Okanogan watershed. The geology is dominated by undifferentiated igneous and metamorphic rocks (USGS 1954). The plateau is composed chiefly of range soils formed in basaltic glacial till and material weathered from basalt, with a mantle or component of loess. Most soils in the northwest part of the plateau escarpment derive from glacial till, weathered granite, and loess. Soils formed in glacial outwash and eolian sand with a component of loess occur at lower elevations on terraces, terrace escarpments, and dunes, along the Columbia and Okanogan Rivers. Most of the area was glaciated over a layer of basalt, which probably accounts for the many isolated lakes (CCT 1997).

Fluvial Geomorphology & In-Channel Habitat

No quantitative or qualitative studies have been conducted on the drainages in the Felix Creek sub-basin that characterized stream channel geomorphology or in-channel habitat.

Vegetation and Riparian Conditions

No quantitative or qualitative studies were reviewed for this LFA that characterized vegetation communities or riparian conditions in the Felix Creek sub-basin. Sagebrush-steppe probably dominated the area historically. Riparian areas were historically dominated by deciduous vegetation, with a very minor conifer component at upper elevations. Presently, the area is heavily grazed (CCT 2001).

Water Quantity/Hydrology

Felix Creek is an intermittent tributary that does not flow into the Okanogan River for most of the year. Stream flow measurements taken from March through September, 1998, were less than 1 cfs throughout the season (CCT 2000). The hydrology of the basin has been altered by timber harvest and livestock grazing practices, and by road construction, and the historic flow regime is not known. There are no water rights on Felix Creek, but there is one instance of illegal withdrawal currently under investigation. In the past, all flow was diverted from the channel for agricultural use (Trevino, personal communication, 2001).

Water Quality

Felix Creek has water quality impairments due to agricultural and grazing practices (CCT 2001). The Colville Tribe used the Unified Watershed Assessment Categories (UWAC), a part of the EPA Clean Water Action Plan Criteria (EPA 1998) to characterize the condition of the watersheds on the reservation. Felix Canyon received a Category I rating, indicating that the watershed does not meet clean water and other natural resource goals, and needs restoration. This rating was based on general knowledge of the area, and should be field checked (CCT 2001). Grazing pressures likely contribute fecal coliform and nutrients into the tributaries of the sub-basin.

5.5.2 Fisheries Resources in the Felix Creek Sub-basin

No anadromous species are known to utilize any of the streams in the Felix Creek sub-basin (**Figure B-6**). However, presence/absence has not been recently confirmed in formal studies, and there is no historical information on fish presence (CCT, 2001). Access would appear to be prevented by naturally inadequate flows under most conditions.

Productivity in the lakes of the Felix Creek subbasin are limited presently and historically by the alkaline condition, high water temperatures, and the fact that most of the lakes have no outlet, preventing flushing from occurring (OCD 2000).

5.5.3 Habitat Limiting Factors Assessment in the Felix Creek Sub-basin

This limiting factors assessment is based on observations by tribal personnel and water quality data collected since 1995 by the Colville Tribe at approximately river mile 1.5 (CCT 2001) (**Table 5-6**). Felix Creek has minimal impact on the Okanogan River because the stream rarely flows to the river during most of the year. Thus, only one reach was evaluated, the lowermost 1.5 miles.

Table 5-6: Felix Creek Limiting Factors Assessment

Habitat Pathway and Indicator	Assessment of Habitat Indicator Function (RM 0-1.3)
Water Quality	
Dissolved Oxygen	F1
Stream Temperature	F1
Turbidity/Suspended Sediment	G1/F2
Nutrient Loading	DG
In Channel Habitat	
Fine Sediment (substrate)	DG
Large Woody Debris	DG
Percent Pool	DG
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	P2
Stream Flow	
Resembles Natural Hydrograph	P2
Impervious Surface	DG
Stream Corridor	
Riparian Vegetation	DG
Stream Bank Stability	DG
Floodplain Connectivity	DG

Support for Limiting Habitat Factor Rankings in the Felix Creek Sub-basin

Water Quality

Dissolved Oxygen—Three dissolved oxygen (DO) values were collected by the CCT in 1998 monitoring. Dissolved oxygen recorded in March, May, and August of 1998 measured 11.6. 10.4 and 7.8 mg/L, respectively. These data suggest that saturation during the summer months may be low. Felix Creek was given a 'fair' rating for DO.

Temperature—Stream temperatures ranged from 4.5 to 20.9 degrees C. Summer water temperatures were generally over 15 degrees, and the stream was given a rating of 'fair'.

Turbidity—Turbidity levels ranged from 1 to 77 NTUs, and were generally below 10 NTUs. On this basis, turbidity in Felix Creek was rated as 'good'. Specific information on suspended sediment loads was not available.

Nutrient Loading - There is a data gap in regards to nutrient loading. Agriculture and range activity in the basin probably contributes nutrients to the stream. Felix Creek is not on the Washington State 303(d) list (Hunner, Personal Communication, 2001).

In-Channel Habitat

There are no data on fine sediment, large woody debris, or percent pool area from the streams in the sub-basin, thus, these habitat indicators were listed as 'data gaps' (DG).

Habitat Access

The existing habitat is limited by dewatering in the lower end of the stream during summer months as previously described. Fish passage was therefore rated as ‘poor’.

Streamflow

Stream flows measured 0.54 to .70 cfs in monitoring conducted by the CCT from when to when ?? (CCT 2001). The natural hydrograph is assumed to have been affected by water withdrawal as well as land use practices. Felix Creek was therefore rated as ‘poor’ for this habitat indicator. There are roads adjacent to stream channels in the Felix Creek drainage, but there are no quantitative data available. The road network occupies 6.5% of the watershed, and therefore the impervious surface area rating was listed as ‘fair’.

Stream Corridor

There is a data gap in regards to the habitat indicators of stream corridor condition evaluated in this LFA for this sub-basin.

5.6 OMAK CREEK WATERSHED DESCRIPTION

5.6.1 Sub-Basin Overview

Omak Creek is a fourth order tributary of the Okanogan River that flows into the mainstem at RM 31. Of the 90,683 acres in this watershed, 73,029 acres are owned and managed by the Colville Confederated Tribes (CCT) (NRCS 1995). Elevations within the sub-basin range from 860 feet above sea level at the Omak confluence with the Okanogan River, to 6,774 feet at Moses Mountain.

The climate of the sub-basin varies from arid to montaine, with an average annual precipitation of 12 inches in the lower elevations to over 45 inches at Moses Mountain. Average daily temperatures range from 23^{o} F in winter to 70^{o} F in the summer. The average growing-season in the watershed lasts 120 days.

Land Use and Ownership

The Omak Creek watershed has 63,565 acres of commercial forest managed by the CCT (NRCS 1995). Past logging practices and fire suppression have changed the forest species composition, structure and density. These practices have led to over-stocked forest stands throughout the watershed that are susceptible to disease, insects and fire. Current logging practices include prescribed burning, pre-commercial thinning, and harvest of disease-stricken trees. Livestock producers utilize most of the forest and range areas in the watershed. Sixty percent of the rangeland in the watershed is in heavy concentration of livestock in certain areas causing excessive utilization of vegetation often in riparian areas animals poor ecological condition due to lack of proper management and water distribution (NRCS 1995). Water distribution in the uplands can thus be considered inadequate to meet agricultural and rangeland needs. Fifteen percent of the rangeland is in fair condition and 25 percent is in either good or excellent condition (NRCS 1995).

Topography, Geology and Soils

Fluvial Geomorphology & In-Channel Habitat

Physical habitat conditions within the Omak Creek watershed are being addressed recently through restoration practices implemented by the Colville Confederated Tribes and Natural Resource Conservation Service. Improvements have included a reduction in road density, removing two fish passage barriers, installing instream structures, planting riparian vegetation and implementing livestock management practices.

Vegetation and Riparian Condition

Riparian area vegetation in the watershed is estimated to be 54% deciduous and 46% coniferous. Riparian vegetation along the lower 5.1 miles of Omak Creek is fragmented. Lack of spring developments and inadequate fencing allows livestock access to stream corridors. This results in severe over-use of riparian vegetation and streambank failure (NRCS 1995). Reconnaissance-level and quantitative surveys have been conducted within the lower reaches of Omak Creek, identifying several lengths of eroding stream bank. Often the cause of the eroding banks was loss of riparian vegetation due to over-grazing by livestock.

Water Quantity/Hydrology

A crest gauge maintained on a tributary to Omak Creek at Disautel recorded annual peak flows of 1 to 13 cfs between 1956 and 1965 (Walters 1974). Continuous flow monitoring was conducted in Omak Creek by the USGS from July 1972 to March 1973, and again from July 1976 to November 1978 (as cited in CCT 1996—need numbers, none provided in this reference!). Relative to historic conditions, flooding beyond bankfull widths has increased in recent years in the Omak Creek sub-basin.

An extensive road transportation system exists throughout the forest as identified in the geographical information system file (whose file?). Roads have been identified as a significant source of sediment (NRCS 1995) and are likely to contribute to the streams "flashy" discharge via the impervious surfaces they have created. It has been estimated that there are more than 900 miles of roads within the watershed, although only approximately 265 miles of these roads in the sub-basin are paved (Table 5-2). The Omak Creek sub-basin inherent sensitivity has been ranked as low, and the current sensitivity rating is moderate (CCT 1996); these ratings reflect surface erosion potential. The current increase in sensitivity is considered the result of adverse road-related impacts (CCT 1996).

Water Quality

Water quality has been regularly evaluated by CCT-Environmental Trust in Omak Creek for several years (W. Hunter, personal communication, 2001). This monitoring has indicated dissolved oxygen levels appropriate for salmonid species (see Table 4.1).

Recorded temperatures can be stressful in the lower Omak Creek basin during the warmer months, exceeding both values suitable for optimal growth (Fisher 2000) and even survival (Brett 1952). All locations examined in Omak Creek and its tributaries received habitat quality index ratings of moderate to poor for temperature in previous studies (CCT 1996). Temperature information continues to be collected and tribal restoration efforts are directed towards reaches that contribute to warm water conditions.

Accelerated sediment yields from uplands and streambanks was identified as one of the main factors affecting water quality in Omak Creek (NRCS 1995).

5.6.2 Fisheries Resources in Omak Creek

Historically fish species included steelhead and chinook salmon which both were culturally important to the members of the Colville Confederated Tribes. It is presumed that steelhead utilized most of the perennial stream channels within the watershed. Mission Falls was likely an effective barrier to Chinook salmon and limited this population to the lower 8 miles of Omak Creek. During 1997 steelhead were listed as "endangered" under the Endangered Species Act. Spring Chinook salmon were considered extirpated by the National Marine Fisheries Service.

The CCT and the Natural Resources Conservation Service are actively implementing restoration practices to improve the condition of Omak Creek and reestablish anadromous fish populations, a goal of the Omak Creek Watershed Plan/Environmental Assessment (1995). Steelhead smolts have been collected from the Wells Hatchery for stocking since 1980. Recently, smolts have been planted upstream of the Mission Falls since it was known (**Figure B-6**).

5.6.3 Habitat Limiting Factors Assessment of the Omak Sub-basin

For this analysis two reaches were evaluated in Omak Creek (**Table 5-7**). The lower reach extends from the confluence to the base of Mission Falls (~ RM 5.1). Mission Falls was likely the extent of the historical range of Chinook salmon in Omak Creek. The upper reach extends from Mission Falls to the upper end of Omak Creek. The source of habitat and water quality information provided for this analysis of Omak Creek and associated tributaries was from surveys conducted by the Colville Confederated Tribes Fish and Wildlife staff or Environmental Trust and the Natural Resources Conservation Service.

Table 5-7: Omak Creek Limiting Factors Assessment

Habitat Pathway and Indicator	0.0 to 5.1 Reach1	5.1 to 25.0 Reach 2
Water Quality		
Dissolved Oxygen	F1	F1
Stream Temperature	P1	G1
Turbidity/Suspended Sediment	P1	P1
Nutrient Loading	F1	F1
In Channel Habitat		
Fine Sediment (substrate)	P1	F2
Large Woody Debris	G1	DG
Percent Pool	G1	DG
Habitat Access		
Fish Passage	G1	F1
Streamflow		
Resembles Natural Hydrograph	P2	P2
Summer Flow Level	F2	F2
Winter Base Flow	F2	F2
Impervious Surface	F1	P1
Stream Corridor		
Riparian Vegetation	P1	F2
Streambank Stability	P1	F2
Floodplain Connectivity	P2	F2

Additional Support for Limiting Factors Assessment Ratings in the Omak Creek Sub-basin

Water quality

Reach 1

Dissolved oxygen has not been identified as problematic in the lower reach, but was rated as 'fair' because of high temperatures in the lower basin that reduce oxygen saturation.

Water temperature has exceeded lethal levels for steelhead (75^o F; Bell 1986) and is marginal for chinook salmon (79^o F; Brett 1952) in the lower reaches of Omak Creek in the summer months (78^o F, 1997; 79.9^o F, 1998; 78^o F, 1999; 75.5^o F, 2000, CCT, unpublished data). For this reason, temperature was listed as 'poor' in reach 1.

Turbidity was evaluated twice during an 8-day period in 1990. NTUs's varied from 24.0 to 39.0 NTUs. Most of the year (10 months) value is less than 20 NTUs, but some samples (13) have exceeded 100 NTUs and several have been between 20 and 100 NTUs but only during the months of April and May (W. Hunter, CCT – Environmental Trust, unpublished data). It is suspected that the major source of turbidity originates in the watershed from upstream of Mission Falls. Total suspended solids have exceeded 130 mg/l during April and May, corresponding with peak spawning times for steelhead (W. Hunter, CCT – Environmental Trust, unpublished data).

Besides thermal and turbidity impairments, fecal coliform was detected in high concentrations and found to be the cause of water quality standard non-compliance (NRCS 1995). Fecal coliform, nutrients (nitrate, phosphate) and ammonia have been recorded in lower and upper reaches of Omak Creek, primarily from livestock and also septic tanks (W. Hunter, CCT – Environmental Trust, unpublished data). For this reason, the nutrients/contaminants habitat indicator was rated as 'fair', recognizing that the system is at risk from elevated nutrients, and that a more complete data set is needed to establish potential effects on habitat function for salmonids.

Reach 2

Dissolved oxygen - has not been measured at levels that would be detrimental to salmonid performance (See reach 1).

Water temperature - data has been collected at four locations (Disautel, Haley Creek confluence, Stapaloop Creek, Trail Creek) within this reach since 1999. Water temperatures exceeding 70^{o} F during the 2-year time period were recorded in Stapaloop Creek during 1999 and at the Haley Creek confluence during both years.

Turbidity - samples were collected on May 14, 1990 ranged from 18 (Hwy 155 bridge near Trail Creek) to 42 (Disautel). On May 23, 1990 turbidity samples ranged from 4 NTUs in Stapaloop Creek to 21 NTUs at Haley Creek. During April 23, 1990 turbidity was sampled and ranged from 50 NTUs at Hwy 155 to 29 NTUs at Haley Creek (See reach 1). Sampling the volume of sediment in pools (V*) was conducted during August 2000. Although the collected data has not been analyzed, depths within an upstream reach often exceeded 2 feet, indicating a high amount sediment delivered to Omak Creek.

Based upon an observation of approximately 6" of sediment deposited there is evidence that suspended sediment is well beyond levels appropriate to maintain good salmonid habitat.

In-Channel Habitat

Reach 1

A fish spawning substrate evaluation was conducted by CCT - Fish and Wildlife staff during 1989. The results of this study found fine sediment tightly packed around the larger materials and it was causing a cementing effect in the downstream reaches. Percent fines averaged 14.2% across two sample sites in this reach. This percentage appears relatively low, however, sampling occurred in riffles, or areas of fast flowing water. Thus areas of lower stream velocities and preferred spawning sites by salmonids (pool tail-out) are likely to have greater amount of fine sediment.

A Timber Fish and Wildlife (TFW) Ambient Monitoring Stream Survey was conducted by CCT-Fish and Wildlife Department personnel during 1992. The survey was divided into 5 segments (based on valley form) and conducted over 12.2 miles of Omak Creek. For the habitat survey large wood was counted if it exceeded 2 meters in length and a diameter of at least 10 cm. The frequency of large woody debris was not recorded within the lower 3 reaches (RM 0.0 to 5.1). However, it is suspected that there is a deficiency in the frequency of large wood when compared to historical conditions. During the 1920's a railroad was routed along Omak Creek and is a likely cause of the current deficiency of large woody debris. Beaver dams were also identified as one of the main factors contributing to pool formation, which may also be a cause to the deficiency in LWD in Omak Creek. However, LWD, as defined by this criteria, may not be as critical a factor in Omak Creek. Channel bedform created as much as 38% of the pools in one segment. Rootwads and roots of standing trees also contributed to creating pools. However, Omak Creek is considered to have sufficient amount of large wood and is properly functioning (i.e., 'good') for this parameter but may be deficient compared to what may have been present historically.

Percent pool habitat was measured as good (≥50% of habitat) for both segments (55.4%, 51.6%) in this reach (CCT 1992). Ruggles (1966) and Platts et al. (1983) considered a stream with 50% pools is generally considered to possess good habitat attributes. The main factors contributing to pool formation in both segments were beaver dams and channel bedform. The prevalence of beaver is likely a contributing factor to limited large woody debris in the lower reach.

Reach 2

Again as stated earlier, sediment yield models indicated overland erosion was one of the main factors affecting water quality in Omak Creek (NRCS 1995). A fish spawning substrate evaluation found fines averaged 18.3% across 6 sample sites upstream of Mission Falls (J. Hansen, CCT, 1992). This percentage appears relatively low, however, sampling occurred in riffles, or areas of fast flowing water. Thus areas of lower stream velocities and preferred spawning sites by salmonids (pool tail-out) are likely to have greater amount of fine sediment. Also, the percentage of fine sediment was determined by weight. Therefore, there was likely a large amount of fine sediment to equal 18.3% by weight. More recently, V* (V star) sampling was conducted along 2 reaches of Omak Creek upstream of Mission Falls. One reach, near the confluence of Trail Creek, revealed depths of sediment often exceeding 2 ft. (C. Fisher, CCT, unpublished data).

A likely source of sediment in this reach is from roads. Approximately 900 miles of road were recognized within the Omak Creek watershed (141.7 square miles). However, it is known that more than 900 miles of road exist in the watershed.

During 1995 a habitat survey was conducted in Trail Creek, a perennial tributary of Omak Creek. Large woody debris was in abundance within the lower three reaches of Trail Creek (156, 270 and 218 pieces/mile). However this was likely an overestimate because lengths over 6 feet were recorded (CCT, unpublished data). Based upon reconnaissance level surveys it appears that woody debris occurs in Trail Creek in sufficient frequency to provide adequate habitat complexity (pool formation, fish cover, nutrient input, etc.) and bank stability. During a 1992 survey LWD was evaluated upstream of Mission Falls for 4 miles. The frequency of large wood was 16 and 31 pieces per mile for diameters > 20 cm and > 10 cm, respectively.

In two reaches (4.0 and 3.2 miles) upstream of Mission Falls pool area was estimated at 31.3% and 35.8%.

Habitat Access

Reach 1

Formerly two barriers to anadromous fish passage existed on the mainstem of Omak Creek. The lowermost barrier was created by a timber mill, which routed Omak Creek through approximately 1600 feet of corrugated metal pipe (cmp). This barrier was virtually impassable for both steelhead and Chinook salmon. Omak Creek was relocated in an open channel approximately 100 feet away from the mill site during the spring of 1999. The second barrier, at ~ RM 5.1, was created from the rubble and cribbing used in the construction of a rail system along Omak Creek during the 1920's. This railroad material was deposited into the canyon at Mission Falls and made the upstream reach inaccessible to anadromous salmonids. During the fall of 1998, approximately 28,000 cubic yards of rubble and cribbing material was removed from Mission Falls. Currently, the Mission Falls reach is being evaluated for fish passage by steelhead. Because of the gradient (approximately 12%) reduced streamflow during June and July, it is assumed that Mission Falls was always impassable to spring Chinook salmon.

Reach 2

One barrier to fish passage is a culvert, which routes Stapaloop Creek, a perennial tributary to Omak Creek, under Highway 155. This culvert exists at approximately RM 0.5 and prevents access to about 4 miles of Stapaloop Creek. Currently, it is unknown if other artificial barriers exist which prevent anadromous fish access to habitat in upstream reaches.

Flow

Reaches 1 & 2

During 1998, peak flows, in response to mild air temperatures and spring rains, have been of short duration and have exceeded bank full discharge. This peak flow response was known to occur three times during the spring of 1998 and indicates the natural hydrograph is impaired. Multiple peak flows are evident that Omak Creek watershed has pronounced changes in timing and discharge and indicates that alterations and disturbances exist which modify the hydrological characteristics in the basin.

Based upon map wheel projections from USGS 1:100,000 maps, the paved road network meets the 'good' criteria . However, because this estimate does not include non-paved roads that may bring this total to 900 miles (need reference). this habitat indicator of hydrology was rated as 'fair', with the qualifier of professional judgement (i.e., F2).

Channel Condition

Reach 1

Canopy closure was evaluated at random sites downstream of Mission Falls (C. Fisher, CCT, unpublished data). The survey indicated riparian vegetation was scarce along this 2-mile reach and likely caused by poor livestock management. Along the lowermost 2-miles riparian vegetation is minimal. This reach contains approximately 0.5 miles of newly-constructed stream channel where riparian vegetation is being established and the remaining 1.5 miles is channelized with limited riparian vegetation.

Bank stability has not been evaluated in Omak Creek. However, in the Omak Creek Watershed Plan/Environmental Assessment (NRCS 1995) bank stability measures were identified. Recent observations indicate bank erosion occurring along several isolated reaches. Again, downstream of Mission Falls several areas of vertical bank cutting are actively eroding. The most common cause of this erosion appears from poor livestock management. The reduction of woody plant species and the associated root systems have also caused banks to become unstable. Within the lowermost 2 miles, severe erosion is occurring along 0.5 mile reach that was constructed during the winter of 1998. This severe erosion is due to poor lateral channel stability. Surveys along the stream have allowed for estimates of 80% of the bank vegetated and stable. Parts of the Omak Creek Watershed Plan/Environmental Assessment are being implemented and include grazing management practices, which will allow the over-utilized areas to become reestablished with woody vegetation. Professional judgment considers the current condition for bank stability to be functioning at risk.

Floodplain connectivity is limited in the lower 5.1 miles of Omak Creek. Floodplain connectivity is absent along an approximately 3-mile reach downstream of Mission Falls where severe bank erosion exists. However, where bank erosion is not evident and gradient is not high (> 2%), floodplain connectivity does exist. Restoration efforts are being directed to improve bank stability, reduce erosion and reestablish floodplain connectivity.

Reach 2

As in the lower reach, there are areas in the upper reach that are obviously absent of riparian vegetation. Canopy closure, which was 46 and 57% along two stream segments, substantiates this condition (TFW 1992).

Where vegetation is absent, bank stability is poor. Several reaches containing actively eroding banks have been observed near the community of Disautel (~ RM 16.0). Upstream of Mission Falls (RM 5.1), particularly near the community of Disautel, Omak Creek has been disconnected from the floodplain. The cause appears to be from loss of riparian vegetation and residential development that drained most of the adjacent wetlands.

5.7 SALMON CREEK WATERSHED DESCRIPTION

5.7.1 Sub-basin Overview

Salmon Creek is a perennial tributary of the Okanogan River with a total watershed area of about 167 square miles. It enters the Okanogan River at the town of Okanogan. Mountains surround Salmon Creek forming its hydrologic divides. The basin is generally oriented on a northwest-southeast axis, with a broad upper watershed about 8 to 10 miles wide and 12 to 15 miles long. The North Fork, West Fork, and South Fork of Salmon Creek converge at Conconully draining the 119 square-mile upper Salmon watershed. This portion of watershed is inaccessible to anadromous fish because of Conconully Dam and Reservoir. Conconully Dam is approximately 15 miles upstream from the mouth of Salmon Creek. Although data or written references are unavailable to define historic use of the upper watershed by anadromous salmonids, professional opinion is that it was probably limited to less than three miles above the damsite.

The Okanogan Irrigation District (OID) manages Conconully Reservoir to serve District lands east of the watershed. Controlled releases for irrigation deliveries are made from Conconully Reservoir between April and October. These releases are conveyed through 11 miles of natural and modified stream channel (referred to as the middle reach of Salmon Creek) to the OID diversion dam, located 4.3 stream miles above the mouth of Salmon Creek. For more than eighty years, the 4.3 miles of Salmon Creek downstream of the OID diversion dam (referred to as lower Salmon Creek), have been dewatered, except during snowmelt events that result in uncontrolled spill at the OID diversion dam.

Land Use and Ownership

Land use within this semi-arid region has been, and continues to be, tied directly to water use including: transportation, mineral exploration, irrigation, domestic use, livestock, and recreation. In 1886 mining activities began. Mining in the Salmon Creek area continued until 1983; most notably from 1937 through 1939, and from 1958 through 1964 (USFS 1997). Also, in 1886 water was diverted for irrigation. Water diversions increased until 1921 and resulted in the construction of two dams: Conconully in 1908 and Salmon Lake Dam in 1921. Extensive Livestock grazing throughout the watershed began in the late 1800s and continued through the early 1900s. Generally during this time period, cattle grazed the lower elevations while sheep were driven into the higher ranges (Bennett 1979, USFS 1997).

Present land ownership and use in the upper Salmon watershed is dominated by the USFS (80 percent), with a minor area (2 percent) managed by the Bureau of Land Management (USFS 1997). Land ownership in the middle and lower reaches is primarily private. However, some state and local lands exist in riparian areas, such as near the OID dam and Watercress Springs.

Topography, Geology & Soils

Elevations of the upper Salmon watershed range from 2,318 feet at Conconully to 8,242 feet at Tiffany Mtn (USFS 1997). The valley floor along the middle reach decreases from about 2,200 feet at Conconully dam to 1,350 feet at the OID dam. Ridge elevations along the west and east watershed divides are about 4,900 and 3,700 feet, respectively. The elevation of Salmon Creek at its confluence with the Okanogan River is about 800 feet.

Three major geologic events have played a leading role in shaping the topography and soil characteristics of the Salmon Creek watershed: granitic uplifting during the Cretaceous period, glacial activity during the Quaternary period, and post-glacial volcanic activity (USFS 1997).

The higher elevations in the upper watershed are dominated by cirque headlands and basins, which flow outward to form glacial troughs and valleys. Pleistocene glaciation and ice-margin streams carved the valleys of the upper watershed. Soils are close to bedrock and extensive rock outcrops exist. The lower sideslopes and foothills are dominated by deep glacial deposits that have been influenced and affected to some degree by mixed colluvium and alluvium deposition that followed the retreat of the glaciers about 10 to 15 thousand years ago (USFS 1997).

The Salmon Creek valley gradually widens downstream of Conconully Dam and becomes underlain by clay, sand, gravel, and boulders. Thick deposits of glacial till and outwash occur; particularly along the lower 2 miles of Salmon Creek.

Water Quantity/Hydrology

Water supply

Annual average precipitation in the upper Salmon watershed ranges from about 15 inches near Conconully to 30 inches in the mountains along the western edge of the watershed. Annual precipitation in the middle and lower portions of the watershed averages 12 to 15 inches. Near the confluence of Salmon Creek with the Okanogan River (800 ft msl), precipitation in the form of snowfall typically occurs from November to March. Trace amounts of snowfall may occur in October and April. At elevations above 1,500 feet, snowfall is two to four times greater than that occurring at lower elevations. Rainfall between May and September is low, generally less than 1.5 inches.

Annual runoff from the Salmon Creek basin is highly variable. This variability is so extreme that although all surface runoff from the upper watershed flows into Conconully Reservoir or Salmon Lake, it has often been insufficient to fill the reservoirs. Conconully reservoir has seen everything from record floods to extended dry periods. The longest dry period extended from 1917 until 1938 (Yates 1968).

Municipal water use in the vicinity of Salmon Creek is limited to the City of Okanogan, which relies principally on groundwater wells. However, the municipal water supply is supplemented by extraction from Watercress Springs located along Salmon Creek about 2 miles upstream from its mouth. Groundwater also provides domestic water for of the residents of Conconully and other valley residents.

Streamflow

Salmon Creek contributes about 2% to the average annual streamflow of the Okanogan River at Malott (WDOE 1995). Prior to regulation by impoundment (1904-1909) the annual average discharge of Salmon Creek was recorded as being from 35 to 80 cfs, and averaged 49 cfs (35,500 acre-feet per year) (WDOE 1976). Monthly discharge ranged from about 15 cfs August through March to approximately 114 cfs April through July (Walters 1974).

It is important to note that streamflow data recorded prior to construction of Conconcully Dam represent a period of record containing only average and above average water years (as compared to the full 1904-1998 period of record). For the long-term period of record (1904-1998), the average annual runoff is 21,700 acre-feet (30 cfs) or 63% less than the 1904 to 1909 average. August through March flows range between 5 and 10 cfs rather than near the 15 cfs reported in the early 1900 record (Dames and Moore 1999).

Streamflow Assessment

There is a general tendency for streamflow gain between Conconully Reservoir and the OID diversion, and for streamflow loss between the OID diversion and the mouth of Salmon Creek. The loss of streamflow was first documented by Monk and Fisher (1998) then confirmed by Trihey and Mahacek (Dames and Moore 1999). The 24 percent loss measured by Monk and Fisher in April 1998 during a 19.8 cfs spill at the OID diversion dam is of a similar magnitude as the 31 percent loss measured during a 19.2 cfs release in March 1999.

It is expected that antecedent moisture conditions and weather patterns have a significant influence on streamflow losses in lower Salmon Creek. Antecedent moisture conditions affect groundwater contributions to baseflow, and are likely to vary between months and between water year types. The 1999 study was conducted in the spring following two relatively high precipitation years. The 1998 study was also conducted in the spring following a relatively high precipitation year. Therefore, the stream flow losses measured in 1998 and 1999 may be significantly less than what would be measured in late fall or during drier years. However, it is possible that returning permanent streamflow to Salmon Creek below the OID diversion dam would eventually recharge the streambed and reach losses would become less than the measured values.

5.7.2 Fisheries Resources in Salmon Creek

There are three races/demes of chinook salmon in the Columbia River basin: spring, summer, and fall; and two races of steelhead: summer and winter. Steelhead runs in the Columbia River upstream of the Deschutes River (including the Snake River) are exclusively summer-run fish (Peven 1990). However, there are two subgroups of summer-run steelhead that are differentiated by their time of entry into the Columbia River. The "A" group enters the river in June and July, where as the "B" group enters the river during August and September. The mid-and upper Columbia River steelhead, that could potentially enter Salmon Creek, belong to the "A" group (Chrisp and Bjornn 1978).

Anadromous Salmonids known to have historically occurred in Salmon Creek include spring chinook (*Oncorhynchus tshawytscha*) and summer steelhead (*O. mykiss*). Before the construction of Conconully Dam in 1910, these anadromous fish may have utilized the north, west and south forks of Salmon Creek for two or three miles above the dam site. Both spring chinook and summer steelhead have recently been listed as "endangered" under the Endangered Species Act. Spring chinook are thought to be extirpated from Salmon Creek. Summer steelhead are occasionally observed in the creek during high water years (**Figure B-7**).

NMFS considers all Columbia River steelhead returning to spawning areas upstream of the Yakima river confluence as belonging to the same ESU (NMFS 1997). This ESU is currently listed as "endangered," and includes the Wenatchee, Entiat, Methow, and Okanogan watersheds. The Wells Hatchery steelhead stock is also included in this ESU because it is considered essential for the recovery of the natural population.

5.7.3 Habitat Limiting Factors Assessment of the Salmon Creek Sub-basin

For purposes of this limiting factor assessment, the 15 mile (approximate) segment of Salmon Creek between Conconully Dam and the Okanogan river has been divided into three reaches (**Table 5-8**). These reaches are necessary because of significant differences in streamflow above and below the OID diversion dam that dramatically affect the character of the stream channel and the availability and quality of salmonid habitats. Past and present land use practices are also an important factor influencing stream corridor conditions and salmonid habitats but the adverse effects of these practices are small relative to the adverse influence of streamflow alterations.

Reach 1 begins at the mouth of Salmon Creek and extends upstream 1.75 miles to below Watercress Springs. Reach 2 is 2.55 miles in length and extends from the lower end of Watercress Springs to the OID Diversion Dam RM 4.3. Reach 3 extends from the OID diversion dam upstream 11 miles to Conconully Dam a distance of eleven miles.

The limiting factors assessment for 15 miles of Salmon Creek (Conconully to Okonagan) is presented in Table 1. The evaluation of stream attributes is based upon the interpretation of published information (coded P1) or application of professional judgement and personal knowledge of the stream (coded P2). In some instances published information was not available and personal knowledge was insufficient to support professional judgement. In such instances the code DG was used to indicate Data Gap. The reader should also recognize that a P2 classification indicates some deficiency in data.

Table 5-8. Salmon Creek Limiting Factors Assessment.

Attribute Considered	Okanogan River 1.75 Miles Reach1			OID Diversion Watercress Springs 2.55 Miles Reach 2			Conconully Dam 11 Miles Reach 3		
	Good	**Fair**	**Poor**	**Good**	**Fair**	**Poor**	**Good**	**Fair**	**Poor**
<u>Water Quality</u>									
Dissolved Oxygen		DG			DG			DG	
Stream Temperature		DG			DG		P1		
Turbidity/Suspended Sediment		P2			P2			P2	
Nutrient Loading		DG			DG			DG	
<u>In Channel Habitat</u>									
Fine Sediment (substrate)			P2			P2			P2
Large Woody Debris			P2			P2			P2
Percent Pool			P1		P1			P1	
<u>Habitat Access</u>									
Fish Passage			P1		P1		P2		
<u>Streamflow</u>									
Resembles Natural Hydrograph			P1			P1		P1	
Summer Flow Level			P1			P1	P1		
Winter Base Flow			P1		DG			DG	
Impervious Surface	P2			P2			P2		
<u>Stream Corridor</u>									
Riparian Vegetation			P1			P1		P1	
Streambank Stability			P1		P1			P1	
Floodplain Connectivity			P1			P1			P1

Additional Support for Limiting Factors Assessment Ratings in the Omak Creek Sub-basin

Reach 1

Nearly all stream corridor attributes considered in Reach 1 are poor. Most notable in Reach 1 is the absence of riparian vegetation and persistence of an incised and unstable stream channel. Both are attributable to the prolonged absence of base streamflow and the periodic occurrence of flood events (i.e. large uncontrolled spills at Conconully Dam).

When observed at moderate streamflow levels (15 to 30 cfs) this reach provided poor to fair adult passage because of excessive channel width and lack of pool habitat for resting area. However, the complexity of the boulder/cobble channel boundary and associated hydraulic conditions provided excellent potential living space for juvenile salmonids

At moderate streamflows (15 to 30 cfs) streambanks were not eroding and water clarity was good. At high streamflows such as would occur during snowmelt runoff water clarity is expected to be fair or poor due to surface runoff above Danker Cutoff Road and streambank erosion between RM 0.75 and RM 1.75.

Reach 2

When streamflow exceeding 10 cfs is present in Reach 2, dissolved oxygen and stream temperature are probably adequate to support salmoinds. However, data should be collected to verify or correct this impression. Watercress springs, at the lower end of Reach 2, should provide water of nearly uniform temperature throughout the year and hot temperature should be very close to the mean annual air temperature.

Suspended sediment concentrations or turbidity levels have not been cited in prior assessments as being of concern. Data are not available and observations have not been made by this author to support informed judgement. An initial opinion is that elevated turbidity and suspended sediment levels probably occur with snowmelt runoff events. The degree to which these events might adversely affect fish or fish habitat is unknown. Most sand sized and larger particles originating in Segment 3 are captured by the sand traps at OID's diversion dam. Thus, most coarse grained suspended sediment and fine grained bedload present in Reach 2 would have to originate in this reach. Fine grained suspended sediment, that which influences turbidity, could originate in either Reach 3 or Reach 2. Hansen (1995) and Fisher and Fedderson (1998) reported undesirably high amounts of fine sediment in spawning gravel in Reach 3.

Informal observations by this author indicate that small discontinuous patches of usable spawning gravel exist in Segment 2 but, in general, spawning habitat is limited in quantity and quality by substrate size or percent fines. Substrate is generally large and clean enough in the vicinity of Danker cutoff road and watercress springs to provide good cover for juvenile salmonids.

Large woody debris is typically absent from the channel. The absence of LWD is probably as attributable to landowner behavior as it is to poor recruitment potential.

Channel complexity is fair between the OID diversion dam and Danker cutoff. Run, riffle and pool habitats exist but habitat quality is suppressed by very low streamflow. At moderate streamflow this sub reach is dominated by good quality riffle and run habitats. From Danker cutoff to Watercress Springs channel complexity improves considerably due to substrate composition. This sub reach is dominated by large bed element, riffle run and pocket water habitats. The quality of these habitats is typically suppressed by very low streamflow. However at moderate streamflows excellent rearing habitat exists in this reach.

If streamflow exists in Reach 2 it is present because of spill at the OID diversion dam. Thus streamflow in Reach 2 can be described as seasonal, sporadic and unreliable. In wet years seepage, leakage and shallow groundwater inflow maintains a wet channel with isolated shallow pools for a mile or so below the diversion dam. Watercress springs contributes to a wet channel in that area but continuous streamflow seldom exists year round in Reach 2. As a result, fish passage and habitat conditions are typically poor throughout the reach.

Riparian vegetation in Segment 2 ranges from poor to good. Good conditions exist near Watercress Springs. Elsewhere the condition of riparian vegetation is quite poor; possibly being fair in a few small areas. Flood plain function is uniformly poor due to land use practices.

Reach 3

Neither dissolved oxygen or water temperature have been suggested as being problematic in prior studies (albeit they are very limited).

Data have not been collected on dissolved oxygen but the visual appearances of the reach do not suggest low oxygen levels are likely to be of concern (how so?). It is possible for low level releases from Conconully Dam to have a low oxygen content but the steep channel gradient and large bed material would likely result in streamflow being oxygenated within a couple miles. The collection of seasonal dissolved oxygen profiles near the outlet from Conconully lake would indicate whether Dissolved Oxygen Data should be collected in Salmon Creek.

Stream temperature data collected by CCT fisheries staff during 1997 and 1998 indicate that the temperature of Reach 3 did not exceed 68°F (Fisher & Fedderson 1998).

Neither the Okanogan Watershed Management Plan nor the Water Quality Assessment *(get proper-title)* identify suspended sediment concentrations (or turbidity) as being of concern. This author's observation of the general condition of the Salmon Creek corridor in Reach 3 indicate that elevated turbidity, suspended sediment and BOD loading is likely during April and May due to snowmelt runoff from agricultural lands in the flood plain. Whether or not these inputs are high enough to be harmful to fish or their habitats in this reach is unknown. Data would need to be collected before an informed opinion will exist.

The most extensive survey of stream morphology and associated habitat conditions was conducted in 1999 by Barry Sutherland (NRCS 1999). *Summarize this report relative to substrate, LWD, and pool habita—what does it say?.*

Construction and operation of Conconully Reservoir has altered the shape of the natural hydrograph in Reach 3 but, as described below, it is unlikely that the nature or magnitude of these alterations are detrimental to the utilization of this reach by salmoinds. Both Conconully Reservoir and Conconully Lake (Salmon Lake) are operated as irrigation storage reservoirs. Decisions are made each spring by the Okanogan Irrigation District regarding reservoir operation during the snowmelt runoff season. However no formal agreement exists regarding reservoir operation for flood control. Although efforts are made to provide storage during the anticipated period of peak runoff, the reservoirs fill and spill during normal and above normal snowpack years. The timing, duration and magnitude of spill is strongly influenced by water year type. During the irrigation season (April – October) Reach 3 of Salmon Creek conveys water released from Conconully Dam for irrigation delivery. Stream flows during May and June are substantially lower than what would occur naturally; and they are notably higher during August, September and October. Streamflow conditions for Spring Chinook and Summer Steelhead migration, spawning and rearing are considered good. Winter streamflows (November – March) may be about the same or somewhat lower than natural. This is a topic area yet to be investigated.

In general, riparian vegetation and flood plain function varies from good to poor depending upon location with in the reach. The stream corridor is too inaccessible, narrow, and steep within the 4 miles below Conconully Dam to support extensive utilization of the stream corridor by man. Thus, the general condition of its riparian vegetation and floodplain function is quite good. Between the former town of Ruby and the OID diversion dam, a distance of approximately six miles, the stream corridor is extensively utilized for livestock, pasture, or hay, wheat, and barley fields. In some locations the stream appears to have been moved from its natural water course. The general condition of riparian vegetation and flood plain varies from good to poor depending upon location. The general condition of the riparian vegetation and degree of flood plain development undoubtedly has a negative effect (albeit unquantified) on streambank stability and sediment/BOD loading from overland and rill flow. The general condition of riparian vegetation in Segment 3 may have some negative influence on stream temperature, oloconous input, benthic production and cover. However, this author's observation of Reach 3 would suggest that more than half of this 11 mile stream reach has good riparian shade and potential for oloconous input.

5.8 WANACUT CREEK WATERSHED DESCRIPTION

5.8.1 Sub-basin Overview

Wanacut Creek is an intermittent tributary to the Okanogan River located on the Colville Indian Reservation immediately north of the Omak Creek sub-basin. The total watershed area is 12,595 acres, representing 0.76% of the total Okanogan watershed (OCD 2000). Wanacut Creek is 8 miles long, and the total of 38.7 miles of stream channel in the sub-basin. Wanacut Creek flows westward, entering the eastern side of the Okanogan River at approximately RM 30, (CCT 2001).

Land Use and Ownership

Land use in the Wanacut drainage includes timber harvest, livestock grazing and pasture land, industry, and residential development. The lower portion of the Wanacut watershed is used for crop production and pasture. The uplands consist of range land and residential development. According to the OCD (2000), 44.5 % (5,599 acres) of the sub-basin is in forest production, 52.3 % is in range-land (6,586 acres), 3.2% (411 acres) is in crop production—primarily irrigated hay and non-irrigated pasture. At higher elevations, mixed range land, mixed forest, and coniferous forest dominate (CCT 2001). See **Table 5-9** for land use types percentages.

Table 5-9: Land Use/Types in the Wanacut Creek Watershed by Acreage and Percentage of Total Watershed Area (OWSAC, 2000)

Land Use/Land Type	Acreage	Percentage
Range	6586	52%
Forest	5598	49%
Irrigated hay	317.7	2.5%
Non-irrigated pasture, hay or feedlots	92.8	0.7%

Topography, Geology and Soils

Elevations within the sub-basin range from 860 feet at the Okanogan River confluence, to 5749 feet, the summit of Omak Mountain. The average elevation drop in Wanacut Creek is 490 feet/mile. Average drainage gradient is 9.2% (CCT 2001).

Geology in the Wanacut sub-basin is composed primarily of undifferentiated igneous and metamorphic rocks of various ages that do not generally bear water (USGS 1954). Soils are primarily derived from glacial till and material weathered from granitic rock, and have a mantle or component of volcanic ash or loess. Terrace soils developed in glacial outwash, eolian sand, and glacial lake sediments Soils in the watershed have a moderately low erosion potential (CCT 2001).

Fluvial Geomorphology & In-Channel Habitat

No formal studies were reviewed that quantified or otherwise characterized fluvial geomorphology or in-channel habitat conditions in the Wanacut Creek sub-basin.

Vegetation and Riparian Condition

No formal studies were reviewed that quantified or otherwise characterized riparian condition in the Chiliwist sub-basin. Vegetation communities within the Wanacut sub-basin are similar to those found within the adjacent Omak Creek sub-basin.

Water Quantity/Hydrology

Average annual precipitation in the sub-basin is 16 inches. One irrigator in the drainage has a water right that diverts from the Okanogan River. One instance of illegal water withdrawal on Wanacut Creek is currently being investigated (Trevino, personal communication, 2001).

Wanacut Creek is an intermittent stream, but may have flowed year round historically. The hydrology in the basin has been altered by timber harvest, road construction, livestock grazing, and other land use practices in the uplands and riparian corridor. Presently the creek usually does not flow year round in the lower reaches (Hunner, personal communication, 2001). Base flows at the water quality monitoring station near the mouth of Wanacut Creek are less than 1 cfs. The highest recorded flow at this station is 26 cfs (CCT 2000.)

Water Quality

Wanacut Creek has water quality impairments due to livestock grazing, residential and industrial development, removal of riparian vegetation and grazing practices. The effect of these impairments on water quality in the mainstem Okanogan River has not been established. The Colville Tribe used the Unified Watershed Assessment Categories (UWAC), a part of the EPA Clean Water Action Plan Criteria (EPA 1998) to characterize the condition of the watersheds on the reservation. Wanacut Creek received a Category I rating, indicating that the watershed does not meet clean water and other natural resource goals, and needs restoration.

5.8.2 Fisheries Resources in Wanacut Creek

Brook trout, an introduced species, is the only fish species recorded in Wanacut Creek, both currently and historically (CCT 1997). There may be rainbow trout in the upper reaches (**Figure B-8**) (Marko, personal communication, 2001). The stream is not currently stocked, but the presence of brook trout suggests that it was stocked in the past. There are several culverts in the lower reaches, some of which may be passage barriers to fish (Marko, personal communication, 2001).

5.8.3 Habitat Limiting Factors Assessment of the Wanacut Creek Sub-basin

The following limiting factors analysis is based primarily on water quality data collected from 1992 to the present (CCT 2000) and observations made by tribal personnel (**Table 5-10**). There are no anadromous species using the drainage, and there are no historical records of anadromy. There are 5-10 miles of road adjacent to stream channels in the watershed.

Table 5-10: Limiting Factors Assessment for Wanacut Creek (Reach I: 0.0 - 0.75)

Pathway Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	F1
Stream Temperature	F1
Turbidity/Suspended Sediment	G1/F2
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	F2
Large Woody Debris	DG
Percent Pool	DG
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	P2
Stream Flow	
Resembles Natural Hydrograph	P2
Impervious Surface	DG
Stream Corridor	
Riparian Vegetation	DG
Stream Bank Stability	DG
Floodplain Connectivity	DG

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

Water Quality

Dissolved Oxygen

Dissolved oxygen (DO) values ranged from 7.62 to 14.46 mg/l. DO levels during summer months were generally less than 10 mg/l, so this creek was given a Fair rating for DO.

Stream Temperature

Stream temperatures ranged from 0.2 to 26.8 degrees C, with the average summer temperatures over 14 degrees C. The creek was rated Fair for this parameter.

Turbidity

Turbidity levels ranged from 0 to 103 NTUs. Values were generally less than 20 NTUs, giving the stream a Good rating. Occasional spikes occurred, probably during storm events. Suspended sediment levels are elevated during peak flows (Hunner, personal communication, 2001).

Nutrient Loading

There is a data gap in regards to nutrient loading. Agriculture and range activity in the basin probably contributes nutrients to the stream. Wanacut Creek is not on the Washington State 303(d) list.

In-Channel Habitat (fine sediment, large woody debris, percent pools)

There is a data gap in regards to in-channel habitat conditions. There are qualitative observations recorded that sediment levels are elevated. There is no data on large woody debris quantities or pool habitat. Range land dominates the lower elevations in the watershed, and upper elevations are dominated by dry, sparse forest. Large woody debris levels are likely to be naturally low.

Fish Passage

Habitat access is limited by dewatering in the lower end of the stream during summer months (Hunner, Personal Communication, 2001). Also, as stated above, some culverts in the lower reaches may be passage barriers to fish.

Flow

Land use practices as well as water withdrawal have affected stream flow. There are 5-10 miles of road adjacent to streams in the Wanacut watershed. Stream flow ranged from 0.1 to 16.6 cfs and average summer flow was below 5 cfs.

Channel Condition (riparian habitat, streambank stability, floodplain connectivity)

There is a data gap in regards to stream corridor habitat conditions.

5.9 JOHNSON CREEK WATERSHED DESCRIPTION

5.9.1 Sub-basin Overview

The Johnson Creek sub-basin encompasses 77.5 mi2 of the Lower Okanogan Watershed (Ecology Draft, 1995). It is located on the western portion of the Okanogan Watershed with the Okanogan River as its eastern boundary, Sinlahekin State Wildlife Recreation Area as its northwest boundary, and Salmon Creek sub-basin to southwest. Johnson Creek enters the Okanogan River on the west side at approximately RM 35, just south of Riverside. The Johnson Creek sub-basin runs parallel to the Okanogan River for about 11 miles. The majority of the basin is in the Okanogan River Valley, with patches of mountainous regions to the western, northern and central areas. There is a series of 21 lakes found in the central mountainous region of the sub-basin (USGS 1984).

Land Use and Ownership

The majority of land in the Johnson Creek sub-basin is for agricultural crops such as apple, cherry or other fruit orchards and hay crops (NW Power Council 2001). There is also some rangeland and timber harvesting done in the area. The population of Riverside along the Okanogan in the Johnson Creek sub-basin has increased 63.7% between 1990 and 1998 (an increase of 223-365 residents; NW Power Council 2001).

The majority of land in the Johnson Creek sub-basin is privately owned agricultural land. In the northwest corner of the sub-basin approximately 11 mi^2 is WDFW land (the Sinlahekin State Wildlife Recreation Area; USGS 1984). Sinlahekin State Wildlife Area is the oldest wildlife area in the state of Washington (NW Power Council 2001).

Topography, Geology & Soils

The Johnson Creek sub-basin is primarily flat land in the Okanogan floodplain. Within the network of terraced land the altitude ranges from 500-750 ft, and up to 1000 ft in the northern reaches and 1250 ft in a western pocket along the Salmon Creek sub-basin border (USGS 1984). There is one main mountain to the northeast in the sub-basin called Carter Mountain that reaches a peak of 920 ft. The largest portion of woodland is in the lakes area and lies at a consistent terrace of 750 ft (USGS 1984).

The soils in the Okanogan Basin are formed from glacial activity 10,000 years ago with the Cordilleran ice sheet. The bedrock is primarily granitic andesitic, metamorphosed sedimentary and basaltic rocks. As the glacier melted, it deposited a series of silt, sand, gravel and cobbles (NW Power Council 2001). Some tributaries have taken the glacial deposits and redeposited them as sand and gravel terraces and plains (Ecology Draft 1995). The Johnson Creek sub-basin is an example of the terraces formed during these processes. Valley soils are comprised of course and well drained glacial soils, which contributes to the leaching into the Okanogan from agricultural lands (USDA 1995). The valleyand terrace soils are moderately deep and deep loam, silt loam and sandy loam from glacial outwash, alluvium and lake sediments (NW Power Council 2001). Higher elevations are made up of volcanic ash that hold moisture but erode very easily (USDA 1995).

Fluvial Geomorphology & In-Channel Habitat

No formal studies were reviewed that quantified or otherwise characterized fluvial geomorphology or in-channel habitat conditions in the Johnson Creek sub-basin. The Okanogan Valley and Johnson Creek tributary is broad and flat (NW Power Council 2001). This creates large meanders in the river and a mosaic of grass-forbs, shrub thickets, and deciduous trees where agriculture crops and pasturelands have not altered the riparian habitat (NW Power Council 2001).

Vegetation and Riparian Condition

No formal studies were reviewed that quantified or otherwise characterized riparian condition in the Johnson Creek sub-basin. The climate within Johnson Creek valley is semiarid. The highest mountain reaches change to a subhumid, but most of the sub-basin topography is below 800 ft. There are large seasonal temperature extremes and daily temperature and precipitation variations. For example, temperature can range annually between 112°F - -31°F in the valley. Annual precipitation is less than 12.5 inches in the main valley (Ecology Draft 1995).

Common native vegetation communities potentially found along the stream-side in the Johnson Creek valley are black cottonwood, quaking aspen, willow spp., maple, cedar and birch (NW Power Council 2001). The construction of highways and roads following the river has permanently destroyed stream-side vegetation and created more erosion and runoff.

As a result of these extreme climate shifts, the vegetation found within the valley is made up of a sage and grass community and a minor contribution of bitterbrush (Ecology 1995, NW Power Council 2001). However, most of the native shrub-steppe communities have been removed for fruit orchards hay and pastureland (USDA 1995, NW Power Council 2001).

Water Quantity/Hydrology

No gauges operating on Johnson Creek were identified in the review process for this LFA. Snow melt is the primary source of surface and ground water in the Johnson Creek sub-basin. Snow melts between May and June when streamflow and groundwater is at its peak (Ecology Draft 1995). Flows at the gaging station closest to Johnson Creek record past flows of 2,907 cfs (2,101,100 ac-ft) at Tonasket. Minimum flows established by Ecology in 1977 in the Okanogan mainstem by Johnson Creek ranges from 860 to 3,800 cfs.

Water Quality

Historic data on conventional water quality or chemical pollutants in the Chiliwist sub-basin were not identified. The main problems associated with the section of the Okanogan, that runs east of the Johnson Creek sub-basin, is water temperature and sedimentation. Sediment loads flowing from the Similkameen River and other northern reaches increase water temperature and degrade spawning and rearing habitat (Ecology Draft 1995). Other sources of sedimentation influx is fromirrigation runoff, agricultural activities, overgrazing and logging.

5.9.2 <u>Fisheries Resources in Johnson Creek</u>

All runs of chinook, sockeye and steelhead occur in the mainstem Okanogan River (**Figure B-9**). No spawning, rearing or migratory activities are known to occur in the Johnson Creek tributary (Okanogan TAG). According to the 1998 study on the Methow and Okanogan Basins, the section of the Okanogan River that is in the vicinity of Johnson Creek contains the third highest density (0.8) of Chinook Redds within the Okanogan (Murdoch and Miller 1999). A total of 21 Redds were documented in ground surveys, of the section between the Riverside Bridge and the Tonasket Bridge, completed during the study. There is no information available of sockeye salmon spawning in this area.

Johnson Creek sub-basin has two dams within its network of waterways: Fish Lake Dam and Schallow Lake Dam (NW Power Council 2001). Both dams are state-owned. The three main species of concern do not utilize tributaries within Johnson Creek, therefore these dams are not of direct concern.

5.9.3 Habitat Limiting Factors Assessment of the Johnson Sub-basin

The following table (**Table 5-11**) and text discusses the factors affecting fish distribution in the Johnson Creek Sub-basin.

Table 5-11: Johnson Creek Limiting Factors Assessment

Attribute Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	
Stream Temperature	
Turbidity/Suspended Sediment	
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	
Large Woody Debris	
Percent Pool	
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	
Stream Flow	
Resembles Natural Hydrograph	
Impervious Surface	
Stream Corridor	
Riparian Vegetation	
Stream Bank Stability	
Floodplain Connectivity	

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

Chinook Salmon

Chinook are seriously affected by poor water quality and low flow conditions in the Okanogan mainstem. The thermal barriers and irrigation diversions found along the length of the Okanogan adjacent to the Johnson Creek sub-basin provide migration barriers that decrease the number of returns. Sedimentation, cover and high temperatures provide additional constraints to overall survival and reproduction of the salmon population (Ecology Draft 1995). High levels of sedimentation degrade spawning and rearing habitat and increase water temperatures. The SASSI have listed the Okanogan River Summer chinook salmon status as depressed (**Table 3-1**).

Sockeye Salmon

Sockeye have similar habitat limiting factors as chinook within the Okanogan mainstem by Johnson Creek sub-basin. The factors that affect them the most are thermal barriers and irrigation. Adult sockeye will not migrate in waters higher than 69-70°F (Ecology Draft 1995). Sockeye within the Okanogan River have the best SASSI status (healthy) of the three species of concern (WDFW & WWTIT, 1992) (**Table 3-1**).

Steelhead Trout

Steelhead in the mainstem Okanogan are most affected by irrigation diversions, lack of cover, low flow and access. The primary reason for steelhead reduction in past years is because of dams, commertial fishing pressures, and tributary impoundments. Sockeye have the lowest escapement numbers of the three species of concern (114-837, between 1982-1991; WDF & WWTIT 1994) (**Table 3-1**).

5.10 TUNK CREEK WATERSHED

5.10.1 Sub-basin Overview

Tunk Creek is a perennial tributary of the Okanogan River with a total watershed area of approximately 45,585.7 acres (OK CO Watershed WQ MP). It enters the Okanogan River approximately 5 miles north of the town of Riverside. The basin is generally oriented on an east-west axis. The watershed consists primarily of forest (40%) and rangeland (59.1%). Resource information regarding this sub-basin is very limited. (Okanogan County Watershed Water Quality Management Plan)

Land Use and Ownership

There is rural development adjacent to the stream near the mouth, but no urban areas within the watershed. The main land use within the watershed is range, with areas of agricultural including non-irrigated pasture hay and/or feed lots, irrigated hay and orchards. The small acreage landowners allow livestock uncontrolled direct access to the creek. There are roads adjacent to the stream with steep cut banks.

Tunk Creek is a part of a sub-basin network including Wanacut, Omak and Chewiliken Creeks that have a breakdown of grazing lands. Within this group BLM owns 600 acres, CCT owns 86,766 acres, DNR leased lands include 4,160 acres and DNR permit lands include 7,860 acres (NW Power Council 2001).

Much of Okanogan is also comprised of forest lands. Part os the Scotch Creek Wildlife Area (total acreage is 15,469) owned by WDFW crosses into the Tunk Creek sub-basin. The Scotch Creek Wildlife Area is a refuge for sharp-tailed grouse. It was converted to cattle grounds and then restored with shrub planting, weed control and greassland seedings (NW Power Council 2001). The southeastern portion of the sub-basin lies within the Okanogan National Forest, approximately 18 mi^2. Half of the area to the southeast is owned by the Confederated Tribes of the Colville Reservation (USGS 1984).

Topography, Geology & Soils

The Tunk Creek sub-basin is arranged in a series of plateaus. The first is at 500 ft, closest to the Okanogan River floodplain. The next level is at 750 ft, with a short 1000 ft gain near Bob Neal Spring. Past the 750 ft plateau there is a 1000 ft level area. Past this last area the mountanous regions of the Okanogan National Forest begin at elevations of 1250-1500 ft (USGS 1984).

The area is dominated by glacially deposited soils that do not tolerate much disturbance. This characteristic increases the potential risk to temperature, fecal coliform, and dissolved oxygen/nutrients, and a moderate risk to turbidity/sediment. The erosion rate within the Tunk Creek sub-basin is 0.54 ac-ft/mi^2 (NW Power Council 2001).

Fluvial Geomorphology & In-Channel Habitat

Data gap for fluvial geomorphology.

Stream habitat in the lower mile consists of gravel/cobble substrate with mostly adequate riparian vegetation. Impacts to stream habitat in the lower mile include a ford crossing at approximately 0.2 mile and 4-5 houses located within 15 feet of the OHWM which pose a moderate risk to temperature, dissolved oxygen/nutrients, and turbidity/sediment as well as a limited risk to fecal coliform, instream flows, and toxicity.

Vegetation and Riparian Condition

Streams in the forested areas of the watershed are receiving good shade. Log skidding has been done in the intermittent streambeds in the sub-watershed. This causes limited risk in temperature, dissolved oxygen/nutrients, and turbidity/sediment. Within the lower mile of Tunk Creek the riparian vegetation in somewhat intact and consists mostly of a cottonwood/willow overstory. Upstream, the riparian vegetation is interrupted by agricultural development and range use.

Water Quantity/Hydrology

Data gap, although local knowledge indicates that the lower half to 3/4 mile of the creek is dry throughout the late spring, summer and fall months. In general water is supplied through snowmelt and precipitation. The high gradient plateau levels building away from the streambed create a path that water takes as it melts in the spring. Low flows occur from late summer through winter (NW Power Council 2001).

Water Quality

5.10.2 Anadromous Salmonid Fisheries Resources in Tunk Creek

The lower mile of Tunk Creek is accessible to anadromous salmonids during the winter and spring months when there adequate flow (**Figure B-10**). There is an impassable falls at approximately 1 mile. Continuous water temperature data were collected during 1999, from 19 April through 15 December. Maximum temperature recorded was 75.8EF and minimum temperature was 32EF (C. Fisher, CCT, unpublished data).

Two of the main species of concern (chinook and sockeye) do not migrate or spawn in Tunk Creek. All three exist and spawn in the mainstem of the Okanogan River that runs along the eastern border of the Tunk Creek sub-basin. It is known that steelhead have a current distribution about ½ mile from the mouth to McAllister Falls (NW Power Council 2001).

5.10.3 Habitat Limiting Factors Assessment of the Tunk Creek Sub-basin

The following table discusses factors affecting salmonid fish distribution in the Tunk Creek sub-basin (**Table 5-12**).

Table 5-12: Tunk Creek Limiting Factors Assessment

Attribute Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	
Stream Temperature	
Turbidity/Suspended Sediment	
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	
Large Woody Debris	
Percent Pool	
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	
Stream Flow	
Resembles Natural Hydrograph	
Impervious Surface	
Stream Corridor	
Riparian Vegetation	
Stream Bank Stability	
Floodplain Connectivity	

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

5.11 CHEWILIKEN WATERSHED DESCRIPTION

(**Figure B-11**)

The following information decribes the factors affecting fish distribution in the Chewiliken Creek sub-basin (**Table 5-13**).

Table 5-13. Chewiliken Creek Limiting Factors Assessment

Attribute Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	
Stream Temperature	
Turbidity/Suspended Sediment	
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	
Large Woody Debris	
Percent Pool	
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	
Stream Flow	
Resembles Natural Hydrograph	
Impervious Surface	
Stream Corridor	
Riparian Vegetation	
Stream Bank Stability	
Floodplain Connectivity	

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

5.12 AENEAS CREEK WATERSHED DESCRIPTION

5.12.1 Sub-Basin Overview

Aeneas Creek, enters the Okanogan River along the west side at approximately river mile 50. The subwatershed comprises approximately 0.41% percent of the total Okanogan watershed (OCD 2000). Aeneas Creek flows in a southeasterly direction from the slopes of Aeneas Mountain (950 ft el.) to the Okanogan River (xx ft el.). It has a total stream length of XXX, and flows through an area referred to as the "lime belt region." The affect of this lime belt land-type region is evident by the accumulation of calcium carbonate along the streambed channel.

Land Use and Ownership

The majority of the Aeneas Creek 6,890-acre watershed is privately owned. Land use consists primarily of rural development, farming and ranching. Land type consists primarily of rangeland (66%) forested lands (26.5%), and cropland (6.6%) (OCD 2000). Most crops grown are hay or alfalfa. Ranching occurs at a relatively small scale, with approximately 400 head grazing within the watershed annually (L. Andrews, personal communication, 2001). Of the 400 head, approximately 300 cattle graze the lower elevation range during the spring (mid-April to June). The remaining 100 head graze within the basin throughout the year.

Topography, Geology and Soils

According to soils mapping conducted by the USDA NRCS, soils in the Aeneas Cr. sub-watershed are principally of the WA 346 type.

Fluvial Geomorphology and In-Channel Habitat

Based upon reconnaissance-level surveys conducted by the Colville Confederated Tribes in May of 1998, the channel condition from the Pine Creek road bridge (~ RM 2) downstream to the confluence is undisturbed except for isolated areas where the stream has been crossed by roads, driveways or routed through irrigation pipes.

Vegetation and Riparian Conditions

The majority of the vegetation type in the Aeneas sub-basin is shrub-steppe. In the upper basin, a low density forest of Ponderosa pine is present.

Streambank erosion was evident in two major areas during summer 1998 surveys conducted by the Colville Confederated Tribes. The first section, approximately 1/8 of a mile of streambank, is located between the natural falls (~ RM 0.75) and Pine Creek road. The second section, a total length of approximately two river miles, is located from the Pine Creek Road crossing to near Lemanaski Lake. The cause of this erosion appears to be from overgrazing by livestock as depicted by the absence of riparian vegetation, hoof shear, and streambank collapse. Bank erosion between the falls and Pine Creek Road is currently being addressed through a fencing project funded in part by the local Regional Fisheries Enhancement Group. In areas not otherwise impacted, riparian habitat appears to be functionally representative of undisturbed conditions for the ecoregion.

Water Quantity/Hydrology

Aeneas Creek is primarily spring fed, thus there is little seasonal variation in the hydrograph relative to other Okanogan tributaries influenced primarily by snowmelt runoff. Annual flows range from x to y, with a mean flow of z (reference). There are no known active irrigation withdrawals from Aeneas Creek. A weathered section of 100 ft of corrugated metal pipe currently conveys water in the lower one half mile of the creek, downstream of the highway 7 bridge (Tonasket:Oroville westside rd), but returns it to the creek. The presence of this pipe suggests that flows from Aeneas Creek were formerly used for irrigation.

Water Quality

Water temperature data indicates Aeneas Creek is contrastingly cooler compared to water temperature in the Okanogan River. In a long term water temperature monitoring study conducted by the Colville Confederated Tribes between 3/16/00 and 2/20/01 the maximum temperature recorded at the mouth of Aeneas Creek was 65.7 ^{o}F (18.7 ^{o}C) which compared to a maximum of 83 ^{o}F, (28 ^{o}C) recorded over the same period in the Okanogan River in Malott 23.31 (C. Fisher, unpublished data).

Turbidity increases rapidly in the creek following summer thunderstorms and rapid snow melt. The causes of this turbidity appear to be related to bank erosion of riparian habitat upstream of the falls, in the locations previously discussed .

There is no evidence to suggest that other conventional water quality parameters (e.g., dissolved oxygen, pH) are compromised from their natural conditions by land management in the sub-basin.

No data were available to evaluate whether nutrient contributions or contaminants effect water or sediment quality in the sub-basin to a degree that would affect the use of the sub-basin by salmonids.

5.12.2 Anadromous Salmonid Fisheries Resources in Aeneas Creek

Historical and existing stocks

Information regarding the aquatic resources of Aeneas Creek is limited. Most information that does exist originates from reconnaissance surveys and anecdotal observations (L. Hoffman 1998, C. Fisher 1998). A private trout farm once operated in the system upstream of the falls approximately 1 mile above the Pine Creek Rd bridge crossing (~ RM 3). It is not known whether this was simply a grow-out facility, or a complete hatchery operation.

Long-time resident of the basin, Jerry Jones, has stated cutthroat trout inhabit Aeneas creek upstream of the falls and a variety of size classes have been caught. Rainbow and eastern brook trout have been observed downstream of the falls (J. Jones, personal communication to C. Fisher, 4/6/01) (**Figure B-12**). The observation of multiple size classes suggests that natural reproduction is occurring within the basin. Evidence of cutthroat trout spawning in the basin supports the conclusion that water quality is adequate to support the spawning of other salmonid species, if other habitat factors (e.g., substrate size, etc.) were suitable. Recent concern has been raised by local landowners, however, that the cutthroat trout population is not as abundant as formerly thought.

Fish Passage and Habitat

Two adult fish passage barriers were identified during joint surveys conducted by the Colville Confederated Tribes and Washington Department of Fish Wildlife during the summer of 1998 (Okanogan TAG). The lowermost barrier is a concrete box culvert located approximately ¼ mile upstream from the mouth. In 1998 this culvert was reviewed for possible replacement for fish passage by the WDFW hydraulic engineers participating in the summer survey (B. Heiner and L. Hoffman); at that time costs were considered prohibitive with respect to the potential habitat gained from the culvert replacement action. The second barrier is a natural falls located approximately 3/4 mile from the mouth. Although these barriers to adult fish passage also constitute barriers to juvenile fish, additional potential velocity and jump-height passage barriers to juvenile salmonids have not been addressed in the watershed.

During the spring of 2000 a picket-weir trap was installed near the mouth of Aeneas Creek and monitored for approximately 8 weeks to address the potential use of the this sub-basin by steelhead trout. During the sampling period no adult steelhead were collected. During 1999 adult sockeye salmon were implanted with radio-tags to determine travel time through the Okanogan River. Adult sockeye were located for short periods of time at the confluence of Aeneas Creek during the migration from the mouth of the Okanogan River to Lake Osoyoos (S. Bickford 2000). It was presumed adult sockeye salmon were utilizing the confluence area of Aeneas Creek as a thermal refuge during their migration up the Okanogan River.

5.12.3 Habitat Limiting Factors Assessment of the Aeneas Sub-basin

The assessment of limiting factors in Aeneas Creek considered three distinct reaches as described below (**Table 5-14**). Habitat conditions were rated in each reach in accordance with the criteria developed by the TAG, as previously described.

Table 5-14. Aeneas Creek Limiting Factors Assessment

Attribute Considered	0-0.25 miles Reach 1	0.25-0.75 miles Reach 2
Water Quality		
Dissolved Oxygen	G1	G1
Stream Temperature	G1	G1
Turbidity/Suspended Sediment	G2	G2
Nutrient Loading	G2	G2
In Channel Habitat		
Fine Sediment (substrate)	F2	F2
Large Woody Debris	DG	DG
Percent Pool	DG	DG
Habitat Access		
Fish Passage	P1	DG
Streamflow		
Resembles Natural Hydrograph	G2	G2
Summer Flow Level	G2	G2
Winter Base Flow	G2	G2
Impervious Surface	G2	G2
Stream Corridor		
Riparian Vegetation	G2	F2
Streambank Stability	G2	F2
Floodplain Connectivity	G2	G2

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

Reach 1: RM 0 to ~0.25—mouth to impassable box culvert barrier underlying Tonasket-Oroville Rd

Water Quality

Water quality in this reach is affected by upstream influences nearly completely. Backwater from the Okanogan river could affect approximately the lowermost100 ft of water quality in the creek. Turbidity and suspended sediment loads from upstream are visible for extended durations. Other conventional water quality parameters are presumed to be functioning properly because of the predominant groundwater influence in the system and naturally high alkalinity.

In-Channel Habitat

There are no quantitative data available to address substrate sedimentation, large woody debris, or percent pools in this reach.

Habitat Access

Within the reach access is not restricted until the upstream end of the reach (the impassable box culvert).

Flow

There is no evidence of hydrograph change in the sub-basin with respect to either changes in peak flows, base flows or flow timing.

Channel Condition

Channel conditions in this reach are generally stable, with no evidence of streambank erosion or loss of floodplain connectivity. Riparian conditions exhibit a managed herb layer (grasses) which may be either mowed or otherwise controlled by herbicide application (plate 1). The shrub layer in this reach is sparse and the tree layer is effectively absent, thus, wood recruitment from riparian vegetation is not currently occurring in this reach.

Reach 2: ~ RM 0.25 to 0.75—impassable box culvert to natural falls

Water Quality

Water quality in this reach is affected by upstream influences, however, bank erosion within the reach is contributing sediments, causing visible turbidity. Although no quantitative data exist, other water quality parameters are thought to be functioning properly.

In-Channel Habitat

No data, data gap.

Habitat Access

There are no habitat access problems for adult fish within this reach. Passage for juvenile salmonids within this reach is not known.

Flow

There is no evidence of an altered hydrograph in this reach of the system. Groundwater dominance of flows buffers against impacts from altered channel conditions.

Channel Condition

Riparian conditions are generally intact except where overgrazing has impacted the stream corridor. Floodplain connectivity is not affected by channelization.

Reach 3: RM 0.75 to Source—all habitat upstream of the natural falls

Water Quality

Turbidity is generated in this reach by an extensive corridor of eroding banks. Other conventional water quality parameters are assumed to be functioning properly, but no formal data exist with which to compare to the criteria established by the TAG. Water quality in this reach is affected by overgrazing along riparian corridors, however, bank erosion within the reach is contributing sediments, causing visible turbidity. Although no quantitative data exist, excessive nutrients and contaminants in this sub-basin are not known to be a problem.

In-Channel Habitat

No data, data gap.

Habitat Access

No data, data gap.

Flow

No data, data gap.

Channel Condition

No data, data gap.

Reach 1

Aeneas Creek is a small stream, approximately a bankful width of 10 feet at the mouth. Two active beaver dams exist within Reach 1 downstream of the highway 7 bridge. It appears that one beaver pond was formerly utilized as a reservoir to withdrawal water for irrigation. Currently the pipe routes about 20% of the flow downstream approximately 50 feet where it spills back into the channel.

State highway 7 crosses Aeneas Creek at approximately 0.5 mile. Between the mouth and highway 7, an apple orchard exists along north side of the creek. Agriculture, along with the beaver activity, has likely influenced the limited riparian vegetation along both sides of Aeneas Creek downstream of the highway 7 bridge. At the downstream side of the highway 7 crossing there are rubble and spoils in the stream channel, likely from the concrete culvert installation. These spoils, along with the change in streambed elevation has created a barrier to upstream fish passage. Observation of the concrete boxed culvert indicates the culvert would likely be a velocity barrier to fish passage as well.

Between the highway bridge and the falls (approximately 0.5 mile), the riparian vegetation is mature and in areas virtually impenetrable. Human-induced effects in this area appear to be negligible.

Reach 2

Within Reach 2 the area is interspersed with private residences. Along this reach there are areas of concentrated livestock use. The livestock effects upon Aeneas Creek include hoof shear, bank collapse and loss of riparian vegetation. Along one reach there is a livestock feeding area. This reach is approximately 300 feet long and is basically absent of all riparian vegetation. area where livesone area a There are also isolated areas where farming (hay, alfalfa, etc.) are being conducted and reducing bank stability and riparian vegetation.

Several springs contribute to the flow of Aeneas Creek. These springs provide a constant cold-water source to Aeneas Creek, so much so that formerly there was a fish hatchery located near the headwaters of Aeneas Creek, which raised trout.

5.13 WHITESTONE CREEK WATERSHED DESCRIPTION

5.13.1 Sub-basin Overview

The Whitestone Creek Watershed encompasses six main bodies of water (from north to south): Blue Lake, Wannacut Lake, Spectacle Lake, Whitestone Creek, Whitestone Lake, and Stevens Lake (DOI 1976). The Okanogan River flows along its eastern border, running 33.1 km along the subbasin from Oroville to Tonasket (Murdoch and Miller 1999). The Whitestone Creek subbasin is an island surrounded by larger subbasins of the Okanogan watershed. To the west is the Similkameen River subbasin, to the southwest is the Aeneas Creek, to the southeast is the Siwash Creek, to the east is the Antoine Creek and to the northeast is the Tonasket Creek.

Land Use and Ownership

Agriculture and livestock production are the two main economic sources to Okanogan County and Whitestone Creek subbasin specifically (LMEA 1997). Native vegetation is cleared most often in the flood plains and lower terraces for apple (*Malus*) orchards (DOI 1976). The main crop produced is apple, and other fruit trees such as cherry and pear, and crops such as wheat, barley, oats, corn and hay are additional agricultural uses of the land (LMEA 1997).

Topography, Geology & Soils

The rock types found within the glacial valley are Permian to Triassic metasediments which include argillite, quartzite, and marble (DOI 1976). Soils originate from alluvial and glacial outwash deposits with a high percentage of silt and sand (DOI 1976). The terraced land surrounding the Okanogan River are coarse deposits of glacial outwash with a consistency of cobble and gravel (DOI 1976). The texture of the terraces range from loamy fine sand, fine sandy loam and very fine sandy loam (DOI 1976).

Fluvial Geomorphology & In-Channel Habitat

The subbasin valley is made up of glacially-formed terraces and narrow flood plains, surrounded by mountainous terrain (DOI 1976). The land lining the Okanogan River to the east is a flood plain and gently rises to sloping and undulating terraces (DOI 1976). Elevation from the Okanogan River in the east to the surrounding mountains gradually increases to 1000 ft. The majority of the agricultural lands in this region range from 50 to 600 ft above the river (DOI 1976).

Vegetation and Riparian Condition

Whitestone Creek subbasin is positioned in the rain shadow of the Cascade Mountains. The resulting low annual precipitation (12.3 inches) (www.worldclimate.com, 5/4/01) creates a semiarid region, evident by its transition between shrub-steppe and pine forest (DOI,1976). Along the riverbanks and the flood plain the dominant tree species is black cottonwood (*Populus trichocarpa*). The lowest elevation above the river, on the eastside of the subbasin, is a big sagebrush (*Artemisia tridentata*)-blue bunch wheatgrass (*Agropyron spicatum*) vegetation association (DOI 1976). Above this shrub network at higher elevations to the west are the cutleaf sagebrush (*Artemisia tripartita*)-Idaho fescue (*Festuca idahoensis*) zone (DOI 1976). Above the sagebrush-fescue association is the lower timberline of ponderosa pine (*Pinus ponderosa*).

Water Quantity/Hydrology

Water supply

Whitestone Creek Subbasin rests in a valley surrounded by mountainous reaches. The majority of the water that flows from the higher elevations to form the lake and river system of the subbasin is from snowmelt (WDFW 1990). Annual precipitation to this area does not contribute much water (12.3 inches) (www.worldclimate.com, 5/4/01).

Streamflow

The Okanogan River flows along the eastern edge of the Whitestone Creek subbasin. Although no information is available for Whitestone Creek flows specifically, the range of flow from the Okanogan north to south of the subbasin is representative of the smaller tributary trends. The Okanogan River at Oroville (located at the north end of Whitestone Creek subbasin) has a flow of 129 ft^3/s, and at the lower reach of the Whitestone Creek subbasin near Tonasket, the Okanogan River flows are 887 ft^3/s (http://wa.water.usgs.gov, 4/23/01).

Water Quality

The general trend of lower alkalinity values in the northeastern portions of Washington hold for both Spectacle and Whitestone Lakes. In a 1997 report by Ecology, Spectacle Lake supported an alkalinity range of 77-70 mg/l CaCO3 and Whitestone Lake a slightly higher range of 110-114 mg/l CaCO3 (Ecology 1997).

Aquatic weeds in the Spectacle and Whitestone Lake areas are of interest. In 1997 Whitestone Lake was found to house the noxious weed species *Myriophyllum spicatum* (Eurasian milfoil) and *Lythrum salicaria* (purple loosestrife); Spectacle Lake did not support any listed noxious plants of concern (Ecology 1997). The plant species found to be regularly supported in both Spectacle and Whitestone Lake was *Zannichellia palustris,* an aquatic plant with mid-range alkalinity level tolerance.

The majority of the sediment load into the Whitestone Creek subbasin originate from surface erosion in the Similkameen River two miles to the north (WDFW 1990). High sediment loads and a low gradient channel accumulate sediments which causes thermal heating (WDFW 1990). Thermal barriers form in areas of accumulated sediment blocking anadromous fish runs. For example, chinook salmon require temperatures below 66º F before they migrate from the Columbia into the Okanogan in September (DOI 1976). Sockeye salmon migrate between July and August and cannot travel through waters in excess of 66º F to 68º F (DOI 1976). A high influx of sediments also degrade spawning habitat (WDFW 1990).

5.13.2 Anadromous Salmonid Fisheries Resources in Whitestone Creek

This northern section of the Okanogan River and related tributaries is part of the river structure that represents an upper terminus of anadromous salmonids in the Columbia River Basin (WDFW 1990) (**Figure B-13**). These water systems of the Okanogan support anadromous species such as summer chinook (Oncorhynchus tshawytscha), sockeye (Oncorhynchus nerka), and Coho salmon (Oncorhynchus kisutch), and steelhead trout (Salmo gairdneri) (DOI 1976).

Summer chinook spawn from about early October to early November in the Okanogan and related tributaries. The 33.1 km of the Okanogan River that runs along the Whitestone Creek subbasin's eastern border supported the highest density of summer chinook redds throughout the Okanogan River in 1998 (Murdoch and Miller 1999). The ground and aerial survey taken from September to November counted a total of 29 redds, 33% of the total found that year (Murdoch and Miller 1999). The 1998 study estimated that, based on a 3.6 fish/redd ratio, 317 Redds expanded through tributary escapements. Compared to the total of 88 Redds found in the Okanogan, the tributaries potentially play a more dominant role in summer chinook spawning than the Okanogan itself.

The main run of the Okanogan River through the Whitestone Creek Subbasin is the majority of the chinook, sockeye and steelhead migration through the region (**Figure B-13**). Steelhead are shown to branch off into the Whitestone Creek at the main tributary to the Okanogan River, but no other documented records show a further extent for either chinook or sockeye **Figure B-13**).

5.13.3 Habitat Limiting Factors Analysis of the Whitestone Creek Sub-basin

The following information addresses the factors affecting fish distribution in the Whitestone Creek sub-basin (**Table 5-15**).

Table 5-15: Whitestone Creek Limiting Factors Assessment

Attribute Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	
Stream Temperature	
Turbidity/Suspended Sediment	
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	
Large Woody Debris	
Percent Pool	
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	
Stream Flow	
Resembles Natural Hydrograph	
Impervious Surface	
Stream Corridor	
Riparian Vegetation	
Stream Bank Stability	
Floodplain Connectivity	

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

5.14 BONAPARTE CREEK WATERSHED ASSESSMENT

5.14.1 Sub-basin Overview

The Bonaparte Creek watershed encompasses 102,120 acres of mixed ownership. The acres are a mixed ownership as follows: Private ownership, 59,000 acres (58%); Washington Department of Natural Resources, 9000 acres (9%); Bureau of Land Management managed lands, 1000 acres (1%); and the remaining 33,000 acres (32%) are managed by the US Forest Service (USFS).

Bonaparte Creek enters the Okanogan River in the city of Tonasket, Washington, at River Mile (RM) 56.7 of the Okanogan River. The watershed at its longest axis is approximately 20 miles long; its widest point is approximately 17 miles wide.

Land Use and Ownership

Private lands adjacent to Bonaparte Creek are used primarily as rangelands, home sites, or for agriculture (hay fields). Primary use of USFS, DNR and BLM lands are timber production and/or livestock allotments.

State Highway 20 runs parallel to Bonaparte Creek for approximately 15 miles, and County Road 4953 runs parallel to the creek for almost 6 miles. There are many more roads adjacent to streams in this watershed.

Topography, Geology & Soils

Tonasket, Antoine, Siwash and Bonaparte watersheds are all part of the Okanogan sub-continent (Alt and Hyndman 1984). The eastern and southern boundaries are formed by the Columbia River. The western boundary, the Okanogan River valley, is geologically known as the Okanogan trench. The Okanogan sub-continent extends hundreds of miles north into British Columbia, Canada.

The Okanogan sub-continent was an island about the size of California that crashed into the Kootenay Arc (which was then the western edge of the continent), about 100 million years ago. Following this "docking" of the sub-continent came the filling of what was then the "coastal area" on the west edge of the Okanogan sub-continent, the Okanogan trench (now the Okanogan Valley) (Alt and Hyndman 1984). The intersection of these two geologic features (the Okanogan sub-continent and the Okanogan trench) appears to be where barriers of waterfalls or high gradient stream channels occur. These barriers preclude upstream migration of anadromous salmonids.

The elevation of the confluence of Bonaparte Creek with the Okanogan River is 880 feet. The highest point in the Bonaparte Creek watershed is Bonaparte Mountain at 7,240 feet. The Bonaparte Watershed is oriented on an east to west axis.

Tectonic uplifting: continental glaciations, and volcanic ash deposition all played major roles in shaping the existing topography and soils characteristics of this watershed.

Continental glaciations have had the greatest impact. Large areas of exposed rock and shallow soils were left as a result of the flow and retreat of the Okanogan and Sanpoil lobes of this cordilleran ice sheet. Bedrock is overlain by Quaternary glacial till outwash and glaciolacustrine sedimentary deposits of varying thickness.

The upper elevation bedrock is tertiary medium to coarse grain grandiorite and granite of the Mt. Bonaparte pluton.

The lower elevations are underlain with pre-tertiary banded gneiss and schist of the Tonasket gneiss. Both rock types are included in a metamorphosed and structural uplift called the Okanogan gneiss dome (USFS 1998 and 1999).

Fluvial Geomorphology & In-Channel Habitat

Due to channel alterations, more water is transported during spring runoff and storm events than before. By increasing the force of the stream, affects to channel morphology and channel stability have occurred. As mentioned before, this has had the great impact to water quality. Large amounts of sandy sediment are transported to the lower reaches of Bonaparte Creek and into the Okanogan River from the channel erosion occurring between river miles 5.1 to river mile 10.8.

Riparian Vegetation and Riparian Condition

Streamside vegetation has been altered greatly in the reaches where land uses are agricultural, and pastureland in the upper portion. Home sites, and commercial uses in the Tonasket area have altered the lowest reach.

In-channel large woody debris appears to be lacking in much of Bonaparte Creek. Non-forested habitat types, rock and shrub steppe, occur frequently along Bonaparte Creek. It is unlikely large woody debris recruitment would occur from those sites.

Water Quantity/Hydrology

The following is from the Tonasket Watershed Assessment (USFS 1998) hydrology section and applies to Bonaparte Creek watershed: Tonasket Creek watershed is characterized by high spring runoff due to melting snowpack that accumulates in late fall and the winter months. Summer and fall runoff is low, fed by the release of stored water from riparian areas in floodplains, seeps, and springs at the headwater tributary streams.

Stream flow timing has changed through channel alterations in headwater tributary streams and on Bonaparte Creek. These alterations have cut the channels deeper resulting in reduced ground water recharge.

The road network has influenced the timing of run-off. Several roads intercept ground water and re-routes the water overland through ditches. This interception reduces the amount of late season flow by routing water from storm and melt water directly to stream channels. Using the USFS existing road layer, seventy-eight miles of road (20% of roads in watershed) were found to be within 100 meters of the one hundred, ninety miles of streams. Surface water also reaches these road drainage ways and leaves more quickly than if it were to recharge ground water storage areas.

Altered floodplains exceed 300 acres. These areas could hold more water than at present, and stored it for later release.

Irrigation withdrawals from the creek are made from Bonaparte Creek and its tributaries. Uses of water from withdrawals are irrigation of hayfields, stock watering and household water. Five documented water withdrawls were found from two sources. permit is for The Bonaparte Water Users Association has water right to 1080 acre-feet of water from Bonaparte Lake. (An unpublished memorandum, USFS 1967) Four other withdrawls from Bonaparte Creek are documented on the Washington State Department of Ecology's Water Rights Tracking web page http://www.ecy.wa.gov/programs/wr/info/wrats/Wria-ok.htm

Water Quality

Due to channel alterations more surface water flows downstream during spring runoff and storm events. This increase in stream energy erodes areas where bank stability is poor, and degrades the water quality by increasing the amount of fine sediment.

Functioning depositional areas exist on Bonaparte Creek to allow these fine sediments to fall out and deposit on the streams banks and channel bottom. The "new" soil is then held in place by opportunistic plants. Identified functional depositional areas are approximately at river mile 10.8, 12.9, both near the confluence of Peony and Bonaparte Creek. In Upper Bonaparte Sub-watershed functioning depositional areas exist on Bonaparte Creek approximately at river mile 20.0, downstream from intersection of Bonaparte Lake road and Hwy. #20, river mile 23.0, confluence with Lightning Creek, river mile 24.5, non-channeled portion of Bonaparte Meadows. Peony Creek has two depositional areas. Both are located near Aeneas Valley road crossing (**Figure 5-1**).

Figure 5-1. These areas effectively improve water quality by slowing the stream.

Water quality discussion will be limited to the portions downstream of this last depositional area. Water quality is altered down stream of River Mile 10.8. Discussion of water quality will be limited to the reaches between river miles 0.00 and 10.8, focusing on the limiting factors to salmon, steelhead and bull trout production.

Large amounts of fine sediment are produced downstream of the last functioning depositional area. A large area beginning at river mile 5.1 and continuing for more than a 5 miles upstream is down cutting, and has created tall vertical banks confining the stream to a trench. The most significant example of this is located within a riparian exclosure approximately at river mile 5.1 to 6.3. This area was identified by the OCCD for project work to reduce sediment delivery to the Okanogan River in 1987. Here the stream still has 10-foot tall bare vertical upper banks. Sediment generating from this portion of the stream is carried to anadromous fishes redds below. ((get some numbers of TMDLs from the OCCD NRCS or OCD USGS who ever has the data))

Downstream of from the sediment source Bonaparte Creek flows through a narrow canyon. Within the canyon the creek flows over 3 large waterfalls on its way to the Okanogan River. Sufficient mixing occurs in this area to replenish oxygen content in the water for fisheries below.

Water Quality is altered again in the lowest reach of Bonaparte Creek. Here urban impacts of street and parking lot runoff, combined with septic leach fields and apple shed effluents alter the water quality.

Bonaparte Creek is not on the Washington State List of Threatened and Imperiled Waterbodies (the 303d list) (M.Linden, personal communication, 2001)

5.14.2 Anadromous Salmonid Fisheries Resources of Bonaparte Creek

Anadromous fisheries resources are restricted to the lower 1.0 mile of the Bonaparte Creek sub-basin due to an impassible waterfall (**Figure B-14**). By estimate less than 100 square meters of suitable spawning habitat occurs in Bonaparte Creek. A large area, 200 square meters, with suitable spawning substrate is 300 meters downstream in the Okanogan River.

Steelhead

No data is available about the use of Bonaparte Creek for rearing or spawning of Upper Columbia River Summer Steelhead. It is assumed that passage of adults is not restricted up to river mile 1.0, at the first falls.

Chinook Salmon

Summer/fall chinook salmon are known to use the mainstem Okanogan River as well as the Similkameen River to Enloe Falls (**Figure 5-2**). . The mainstem Okanogan River is used for migration northward to Canadian waters. Most of the known summer/fall chinook spawning areas are in the Similkameen River. It is unlikely that chinook salmon use Bonaparte Creek, as flows in the fall are less than 5 cubic feet per second (cfs), but spawning has occurred in the mainstem Okanogan River below Bonaparte Creek. Note about the spawning below the Bonaparte creek portion talk to Linda Hoffman.

Figure 5-2. Chinook Salmon Spawning Habitat in Bonaparte Creek.

Spring Chinook Salmon

Adult spring chinook salmon (Oncorhynchus tshawytscha) in the Upper Columbia Basin are not currently known to use the Okanogan River. The temperature regime at the time spring chinook salmon spawn in the mainstem Okanogan River is too high for successful spawning and rearing. Water temperatures are elevated due to irrigation water withdrawals (K.Williams and J.Spotts, personal communication). In their Endangered Status of One Chinook Salmon ESU Final Rule (U.S. Federal Register, 1999), the National Marine Fisheries Service excluded the Okanogan River from their Endangered species listing for the Upper Columbia Evolutionarily Significant Unit (ESU) of spring chinook salmon. The Okanogan River was excluded from the listing because spring chinook adults are collected as they migrate upstream at Wells Dam on the Columbia River, approximately 20 miles downstream of the confluence of the Okanogan River. The adult salmon are transported to the Winthrop National Hatchery in Winthrop, Washington, and are spawned there. The eggs and resulting fry are raised at the hatchery and later released into the Methow River.

Sockeye salmon

Sockeye salmon are known to use the mainstem Okanogan River as a migration pathway to their spawning areas in Lake Osoyoos and the upstream reaches of the Canadian Okanagan River. Sockeye salmon are not known to use Bonaparte Creek.

Bull trout

There are no data or anecdotal information indicating bull trout ever were, or that bull trout currently are, in the Bonaparte Creek watershed. Data that does exist suggests that bull trout did not exploit the Okanogan River north of the city of Omak, approximately 30 river miles down-river of the confluence of Bonaparte Creek with the Okanogan River (K.Williams, personal communication). The Okanogan River is not suitable habitat for bull trout due to the bull trout requirement of very cold, clean waters with clean gravel/cobble substrate for successful spawning and rearing.

Scott and Crossman (1973) reported that bull trout are not present within the Canadian Okanagan River system.

5.14.3 Habitat Limiting Factors Analysis of the Bonaparte Creek Sub-basin

Bonaparte Creek was divided into four reporting units (reaches) addressing potential limiting factors to salmonid production in Bonaparte Creek and in the Okanogan River.

Reach 1 (from the mouth of Bonaparte Creek to River Mile 1.0) is considered usable anadromous salmonid habitat provided that there is adequate flow. Reach 1 ends at the base of a waterfall that is a natural passage barrier.

Reach 2 (River Mile 1.0 to RM 4.8) includes the steep gradient channel. This reach ends at State Highway 20 bridge. The channel gradient is greater than 5% in this reach. This reach is considered a transport reach, but is not considered to be usable habitat for anadromous fish because of the natural barriers.

Reach 3 (River Mile 4.8 to RM 10.8) Water Quality is greatly altered in this reach. This reach is the major source of fine sediment delivered to the downstream fishery.

Reach 4 (River Mile 10.8 to Bonaparte Lake) Water quantity, timing and amount, and water quality, temperature, are important factors to track in this reach.

The following rankings reference habitat criteria accepted by the Okanogan TAG group as most relevant to the production potential of anadromous salmonid fishes in the Okanogan (**Table 5-16**).

Table 5-16: Bonaparte Creek Limiting Factors Assessment

Attribute Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	
Stream Temperature	
Turbidity/Suspended Sediment	
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	
Large Woody Debris	
Percent Pool	
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	
Stream Flow	
Resembles Natural Hydrograph	
Impervious Surface	
Stream Corridor	
Riparian Vegetation	
Stream Bank Stability	
Floodplain Connectivity	

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

Reach 1-

Water Quality

Data was collected in the same time period for dissolved oxygen, temperature, turbidity, and nutrient information.

1) Dissolved Oxygen - Dissolved oxygen is rated Good based on greater than 95% saturation levels as represented in data collected by the Okanogan Conservation District (OCD) spot checks in 2000.

2) Stream Temperature.- Stream temperatures were below 18°C with a maximum temperature of 15.5°C recorded on 7/12/2000.

3) Turbidity - Turbidity measurements were all less that 100 NTUs. Two ratings greater than 20 NTUs on 5/10/2000 and 6/14/2000 were recorded. The maximum was 35.7 NTUs. This reach is rated fair for turbidity.

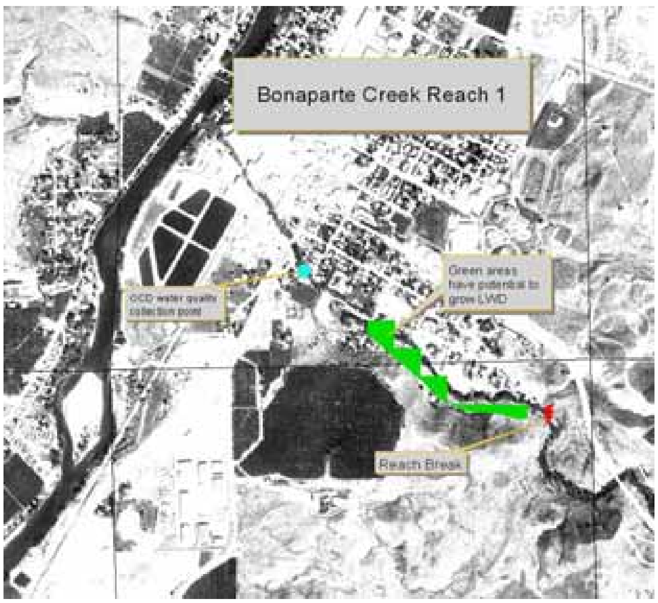
4) Nutrient Loading - Chemical Contamination/Nutrient Loading for dissolved nitrates, nitrites, Fecal coliform, phosphates and calcium carbonate and bicarbonate were recorded by OCD in 2000.

In-Channel Habitat

Fine Sediment - The substrate in the channel on the private lands has not been extensively observed, but while fishing in the Okanogan River at the confluence and while walking up the street along Bonaparte Creek I have noticed large amounts of fine substrate. The creek runs brown with silts and sands regularly in spring and on occasion in the summer and fall.

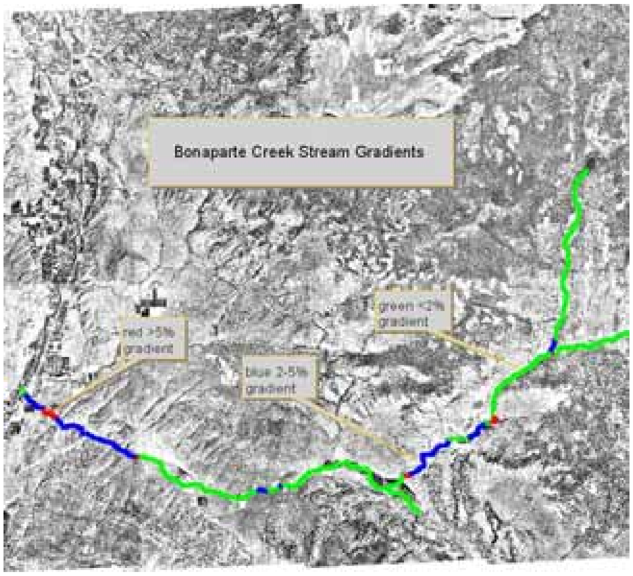
Large Woody Debris - Sites with potential for providing large woody debris (LWD) are depicted on **Figure 5-3**. Non-forested habitat types, shrub steppe, and/or rock comprise 83% of 50 meter wide buffers on each side of Bonaparte Creek. Conifer trees of a size to be classified as LWD, 35 feet long with a diameter of 12 inch, are not likely to grow in these non-forested habitat types. Bonaparte Creek is not large enough to transfer LWD downstream to this reach. The potential for large woody debris recruitment is lower naturally in this reach because of this. By the matrix definitions, this reach rates poor for large woody debris.

Figure 5-3. Potential for large conifers



Percent Pools - **Figure 5-4** depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total stream length in this Reach is 1.0 mile. The amount of stream channel that has 2% or less gradient is .15 miles (15% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is .85 miles (85% of the channel length in this reach). None of stream channel is greater than 5% gradient in this reach. Remote sensing using a 10-meter digital elevation models was used to make these determinations. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The numbers of pools in this reach are few; the actual number of pools in this reach is a Data Gap.

Figure 5-4. Stream Channel Gradients



Habitat Access

This criterion rated fair because two culverts are velocity barriers at times, and the channel itself, in areas, is a velocity barrier. Bonaparte Creek has been confined to a channeled trench through the town of Tonasket.

Stream Flow

Resembles Natural Hydrograph - The stream flow in Reach 1 is altered as a result of water withdrawls upstream in most years. The channel alterations upstream have changed timing of runoffs reducing summer thermal refuge at the confluence with the Okanogan River for steelhead smolt and adult sockeye salmon.

Impervious Surfaces - City streets and large parking lots along this reach of Bonaparte Creek create quick runoff and little interaction with the floodplain. This parameter has been rated poor.

Stream Corridor

Riparian Vegetation - The riparian vegetation in this reach rated poor, based on spot visual observations by myself. Shade has been greatly reduced in the lower portion of Reach 1; homes and lawns, and parking lots have replaced the natural vegetation. Trees and other vegetation have also been removed for clearing of the road right-of-ways.

Stream Bank Stability - Little or no channel bank erosion occurs in this reach. Stream bank stability is rated fair because stability of the channel is not maintained by vegetation. The stream bank is maintained in a stable condition with riprap through the city of Tonasket.

Floodplain Connectivity - Flood plain connectivity is rated as poor based on spot visual observations. Bonaparte Creek has been channeled through the city of Tonasket.

Reach 2-

Reach 2 affects the water quality downstream in Reach 1, but due to its steep gradient and an impassible barrier at the beginning, Reach 1 is not considered anadromous fish habitat.

Water Quality

No data was collected for dissolved oxygen, temperature, turbidity, and nutrient information in this reach. Best guesses are made on personal observations.

Dissolved Oxygen - Dissolved oxygen (DO) data was not collected, but the average channel gradient is greater than 3% in this reach and there are 3 waterfalls greater than 10 feet high. Sufficient mixing occurs in this reach to saturate DO levels in the water, and a rating of good is my determination.

Stream Temperature - No data for stream temperature is available in this reach. In the Limiting Factors Table DO for Reach 3 is a Data Gap (DG). Temperatures taken downstream rated good. This area is a deep canyon and the stream is shaded much of the day from brush small trees and the canyon walls itself. Stream temperatures taken downstream in Reach 1 and upstream in Reach 4 rated good. It is unlikely that stream temperatures rise above 18°C in this reach and a rating of good is suggested.

Turbidity - No data for turbidity is available in this reach. It is likely in poor condition in years that have normal rainfall conditions, and fair condition in years with lesser rainfall or slow snowmelt.

Nutrient Loading - No data for nutrient loading and chemical contamination information is available in this reach. A few homes and State Highway 20 are the only developments along the stream in this reach. Runoff from State Highway 20 leads directly to the stream in this reach, and if any spills were to occur on the road the material would enter the water. This parameter is a Data Gap.

In-Channel Habitat

Substrate - Because Reach 2 is not considered to provide anadromous fish habitat, the substrate condition criterion does not apply to spawning substrate. This reach does contain fine sediment and it is transported to the fisheries below. Sanding of State Highway 20 in this reach adds to the amount of fine sediment delivered to the fisheries below.

Large Wood - Using a Plant Association Group cover generated for use by the U.S. Forest Service, determination of suitable habitat for conifer growth was made. In Reach 2 non-forested habitat types, rock mainly, comprise 23% of 50-meter wide buffers on each side of Bonaparte Creek. There is a Data Gap regarding the number of pieces of large woody debris within this reach.

Percent Pools - Figure 2 depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total stream length in this Reach is 3.8 miles. None of stream channel gradient is 2% or less in this reach. The amount of stream channel that is of 2-5 % gradient is 2.9 miles (76% of the channel length in this reach). The amount of stream channel that is greater than 5% gradient is 0.9 miles (24% of this reach). Remote sensing using a 10-meter digital elevation models was used to make these determinations. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The numbers of pools in this reach are few; the actual number of pools in this reach is a Data Gap.

Habitat Access

Fish Passage - This criterion is not applicable. Anadromous fish habitat ends at the waterfall at the beginning of the reach.

Stream Flow

Resembles Natural Hydrograph - Stream flow information was not collected in this reach. Flows in this reach and the other reaches were determined to be in fair condition using the criteria that flow timing and amount are altered but not drastically so.

Impervious Surfaces - State Highway 20 along this Reach is the largest unnatural impervious surfaces. The length and proximity of the road was used to determine a ranking of fair.

Stream Corridor

Riparian Vegetation - The vegetation has been altered, but still appears to be within 25-50% of the potential natural community composition. The vegetation composition of this Reach is rated as fair.

Stream Bank Stability - Bonaparte Creek is well shaded in this reach and banks are held stable from deciduous vegetation in most locations. Other locations are held stable from riprap. Driving State Highway 20,one sloughing area is noticeable. Bank stability is rated fair for this reach.

Floodplain Connectivity - The construction and maintenance of the State Highway 20 has altered the sideslopes and narrowed the floodplain in places. In places where the sideslopes are quite steep, the floodplain and the road share limited space. This criterion is considered as fair.

Reach 3-

Water Quality

Reach 3 affects the water quality downstream in Reach 1. Although the gradient in much of the reach is less than 2%, the water in the stream interacts with the floodplain in few locations. The channel is confined to a narrow 10 foot deep cut through sandy-loam from river mile 5.1 to 6.3. From river mile 6.3 to 10.8 the channel is downcutt but to a smaller degree. Due to its steep gradient and an impassible barrier at the beginning of Reach 2, Reach 3 is not considered anadromous fish habitat. Reach 3 water quality parameters of; stream temperature, turbidity and nutrient loading have the potential to affect the anadromous fisheries downstream in Bonaparte Creek and in the Okanogan River. No data was collected for dissolved oxygen, temperature, turbidity, and nutrient information in this reach. Best guesses are made on personal observations.

Dissolved Oxygen - Dissolved oxygen (DO) data was not collected. The average channel gradient is near 2% in this reach. In the Limiting Factors Table DO for Reach 3 is a Data Gap (DG). It is likely that insufficient mixing occurs to saturate DO levels in the water. A rating of fair is suggested.

Stream Temperature - No data for stream temperature is available in this reach. In the Limiting Factors Table DO for Reach 3 is a Data Gap (DG). This area is a deep canyon and the stream is shaded much of the day from brush small trees and the canyon walls itself. Stream temperatures taken downstream in Reach 1 and upstream in Reach 4 rated good. It is unlikely that stream temperatures rise above 18°C in this reach and a rating of good is suggested.

Turbidity - No data for turbidity is available in this reach. In the Limiting Factors Table DO for Reach 3 is a Data Gap (DG). The stream flows through a downcutt trench from river mile 5.1 to 6.3. The channel upper channel banks range from 6 to 12 feet tall through this portion of the reach. In many areas these banks are not stable, more than 20% unstable total. Turbidity rating is likely in poor condition in years that have normal rainfall and snow conditions, and fair condition in years with lesser rainfall or slow snowmelt. In the Limiting Factors Table DO for Reach 3 is a Data Gap (DG).

Nutrient Loading - No data for nutrient loading and chemical contamination information is available in this reach. A few homes and State Highway 20, hay fields and some livestock yards are the identified developments along the stream in this reach. In the Limiting Factors Table DO for Reach 3 is a Data Gap (DG). No suggestion is made in this reach for this parameter.

In-Channel Habitat

Substrate - Because Reach 3 is not considered to provide anadromous fish habitat, the substrate condition criterion does not apply to spawning substrate. This reach does contain and generate fine sediment. It is transported to the fisheries below. The eroding channel throughout the reach adds to the amount of fine sediment delivered to the fisheries below. Large amounts of fine sediment are produced downstream of the last functioning depositional area (river mile 10.8). A large area beginning at river mile 5.1 and continuing for more than a 5 miles upstream is down cutting, and has created tall vertical banks confining the stream to a trench. The most significant example of this is located within a riparian exclosure approximately at river mile 5.1 to 6.3. This area was identified by the OCCD for project work to reduce sediment delivery to the Okanogan River in 1987. Here the stream still has 10-foot tall bare vertical upper banks. Sediment generating from this portion of the stream is carried to anadromous fishes redds below.

Large Wood - Using a Plant Association Group cover generated for use by the U.S. Forest Service, determination of suitable habitat for conifer growth was made. In Reach 2 non-forested habitat types, shrub steppe, comprise 48% of 50-meter wide buffers on each side of Bonaparte Creek. Much of the reach can be seen from State Highway 20. No pieces of wood seen in Bonaparte Creek in this reach meet the criteria and a rating of poor is given. Large woody debris that may fall into the channel upstream of the wet meadow (river mile 10.8) is not likely to be delivered downstream to other reaches.

Percent Pools - Figure 2 depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total stream length in this Reach is 6 miles. The amount of stream channel gradient is 2% or less is 5.3 miles (89% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is .7 miles (11% of the channel length in this reach). None of stream channel that is greater than 5% gradient in this reach. Remote sensing using a 10-meter digital elevation models was used to make these determinations. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The numbers of pools and amount of pool habitat is a Data Gap.

Habitat Access

Fish Passage - This criterion is not applicable. Anadromous fish habitat ends at the waterfall at the beginning of the Reach 2.

Stream Flow

Resembles Natural Hydrograph - Stream flow information was not collected in this reach. Flows in this reach and the other reaches were determined to be in fair condition using the criteria that flow timing and amount are altered but not drastically so.

Impervious Surfaces - State Highway 20 along this Reach is the largest unnatural impervious surface. Runoff and ditching is not extensive even though State Highway is very near Bonaparte Creek. This parameter deserves a ranking of good.

Stream Corridor

Riparian Vegetation - Riparian vegetation is in fair to poor condition (Tonasket Ranger District 1996), with the potential natural community and composition being at or near 20%. State Highway 20, agriculture, housing, and livestock grazing pastures all have contributed to the alterations of vegetation along the stream in this reach.

Stream Bank Stability - Stream bank stability is in poor condition. From 1988 OCCD survey information and personal experience. The 1988 survey listed 1.5 miles of the riparian as having severe erosion. Restoration efforts by the Okanogan County Conservation District in 1989 built riparian exclosure fence. Since then alder and dogwood has vegetated the area. Bare vertical banks still exist in much of the area. “Problem” beaver have been removed while trying to recolonize this area (D.Swedberg, personal communication, 2001). Moderate erosion was noted in 8 areas, totaling 1.6 miles of this reach. One mile of moderate erosion from grazing impacts was identified. It was noted that improvement in the riparian habitat in 4 of these areas, nearly 1 mile of stream, would improve water quality.

Floodplain Connectivity - The floodplain connectivity is currently in poor condition from the lack of stream water interaction due to the downcutting that has and still occurs in this reach.

Reach 4-

Water Quality-

Dissolved Oxygen (DO)-: Stream Temperature-: Turbidity-: Nutrient Loading-

Reach 4 includes Bonaparte Creek and it tributaries upstream of a braided channel woodland in T39N, R28E, Section 23, NE 1/4. The braided channel area intercepts much of the sediment that might be delivered, the DO and temperature and nutrient loading are altered as a result of the transport through the 6 miles of Reach 3 and the 3.8 miles of Reach 2. Water quality parameters; DO, temperature, turbidity and nutrient loading, of Reach 1 is not affected to a discernable degree by the relatively small amount of pollutants in generated in Reach 4. These criteria are not applicable, and are not discussed here. The Limiting Factors Table for reach 4 is populated with the data supplied by the OCD. The water collection area for the OCD data is upstream of the Aeneas Valley road on Bonaparte Creek.

In-Channel Habitat

Fine Sediment - Little fine sediment from this reach is delivered to the spawning area in Reach 1. Fine sediment falls out of solution in the spread channel wetland river mile 10.8 to 11.4. Sand from road maintenance in winter along State Highway 20 directly enters the stream in at least .8 miles of this reach. This material likely drops out of the water column at or before river mile 10.8.

Large Wood - Sites with potential for providing large woody debris (LWD) were not done for Reach 4. Conifer trees of a size to be classified as LWD, 35 feet long with a diameter of 12 inch, are likely to grow along Bonaparte Creek, but the creek is not large enough to transfer LWD downstream to other reaches. The amount of LWD in Reach 4 is a Data Gap.

Percent Pools - Figure 2 depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total length of streams in this reach is 21.9 miles. The amount of stream channel gradient is 2% or less is miles (83% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is 3.1 miles (14% of the channel length in this reach). The amount of stream channel that is greater than 5% gradient is .6 miles (3% of the channel length in this reach). Remote sensing using a 10-meter digital elevation models was used to make these determinations. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The numbers of pools and amount of pool habitat is a Data Gap.

Habitat Access

Fish Passage - This criterion is not applicable. Anadromous fish habitat ends at the waterfall at the beginning of the Reach 2.

Stream Flow

Resembles Natural Hydrograph - Flows in this reach and the other reaches were determined to be in fair condition using the criteria that flow timing and amount are altered but not drastically so. The Bonaparte Water Users Association has water right to 1080 acre-feet of water from Bonaparte Lake. (An unpublished memorandum, USFS, 1967).

Impervious Surfaces - State Highway 20 along this Reach is the largest unnatural impervious surface. Runoff and ditching is not extensive, but one area along State Highway is adjacent to Bonaparte for .8 miles. This area has direct runoff to the creek, for this reason; this parameter deserves a ranking of fair.

Stream Corridor

Riparian Vegetation - Maintenance of State Highway 20 right of way, agricultural development and livestock grazing have altered the riparian vegetation in this reach, but still appears to be within 25-50% of the potential natural community composition. The vegetation composition of this Reach is rated as fair.

Stream Bank Stability - Stream bank stability is in good condition. The survey by OCCD in 1988 identified 1.5 miles of heavy grazing on 12.8 mile of stream surveyed. It is unknown if these areas have been restored to a better condition. From observations along State Highway 20 this area has sufficient vegetation to stabilize the stream banks where State Highway 20 is adjacent to Bonaparte Creek and vegetation is lacking the channel is stabilized with riprap.

Floodplain Connectivity - The floodplain connectivity is currently in fair condition. Several large areas in this reach have downcutt or straightened channels. Bonaparte Meadows, just below Bonaparte Lake, have been and currently are being mined for peat. This area still becomes saturated with water. Other areas where channel alterations are evident occur in hay fields near the confluence with Peony Creek and upstream of the County Road 4953, Bonaparte Lake road, on a tributary to Bonaparte Creek. State Highway 20 in areas has also reduced the streams connectedness to the floodplain. These areas have reduced the creeks interaction with the floodplain, and overbank flows are reduced but are still present in this reach, that is the reason for the fair rating.

5.15 SIWASH CREEK WATERSHED ASSESSMENT

5.15.1 Sub-basin Overview

The Siwash Watershed is 30,946 acres. Of these acres, 10,567 (34%) acres are managed by the USFS, the remaining 20,379 (66%) acres are a combination of ownership that includes private owners (60%), Washington Department of Natural Resources (5.5%), and Bureau of Land Management managed lands (<1%).

Land Use and Ownership

Private lands adjacent to Siwash Creek are used primarily as rangelands, agriculture, and home sites. Primary use of USFS, DNR and BLM lands are timber production and/or livestock allotments.

Topography, Geology & Soils

Tonasket, Antoine, Siwash and Bonaparte watersheds are all part of the Okanogan sub-continent (Alt and Hyndman 1984). The eastern and southern boundaries are formed by the Columbia River. The western boundary, the Okanogan River valley, is geologically known as the Okanogan trench. The Okanogan sub-continent extends hundreds of miles north into British Columbia, Canada.

The Okanogan sub-continent was an island about the size of California that crashed into the Kootenay Arc (which was then the western edge of the continent), about 100 million years ago. Following this "docking" of the sub-continent came the filling of what was then the "coastal area" on the west edge of the Okanogan sub-continent, the Okanogan trench (now the Okanogan Valley) (Alt and Hyndman 1984). The intersection of these two geologic features (the Okanogan sub-continent and the Okanogan trench) appears to be where barriers of waterfalls or high gradient stream channels occur. These barriers preclude upstream migration of anadromous salmonids.

The elevation of the confluence of Siwash Creek with the Okanogan River is 880 feet. The highest point in the Siwash Creek watershed is Fourth of July Ridge on Bonaparte Mountain at 6720 feet. The Siwash Watershed is oriented on an east to west axis.

Tectonic uplifting: continental glaciations, and volcanic ash deposition all played major roles in shaping the existing topography and soils characteristics of this watershed.

Continental glaciations have had the greatest impact. Large areas of exposed rock and shallow soils were left as a result of the flow and retreat of the Okanogan and Sanpoil lobes of this cordilleran ice sheet. Bedrock is overlain by Quaternary glacial till outwash and glaciolacustrine sedimentary deposits of varying thickness.

The upper elevation bedrock is tertiary medium to coarse grain grandiorite and granite of the Mt. Bonaparte pluton.

The lower elevations are underlain with pre-tertiary banded gneiss and schist of the Tonasket gneiss. Both rock types are included in a metamorphosed and structural uplift called the Okanogan gneiss dome (USFS 1998 and 1999).

Riparian Vegetation and In-channel Habitat

Streamside vegetation has been altered greatly in the reaches where land uses are agricultural, and pastureland in the upper portion. Home sites, and commercial uses in the Tonasket area have altered the lowest reach.

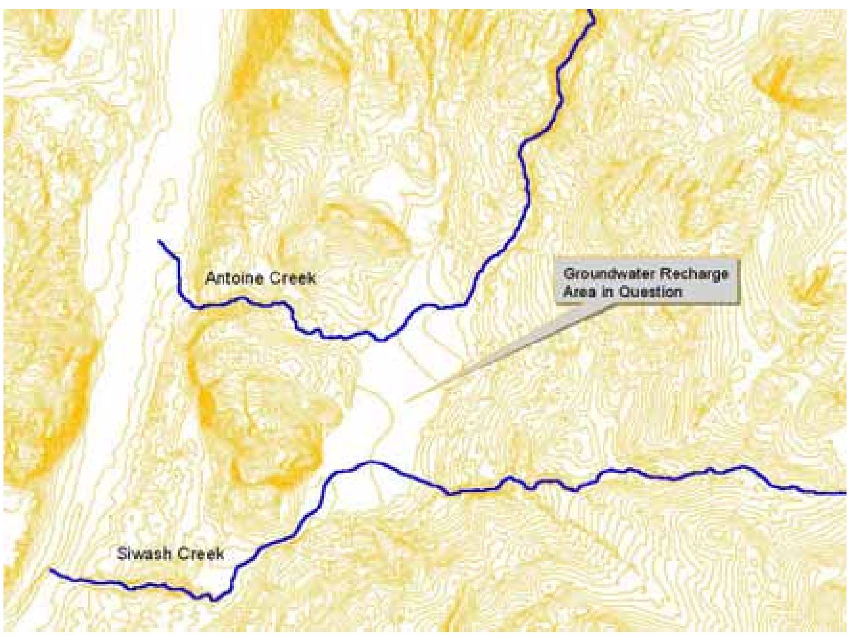
In-channel large woody debris appears to be lacking in much of Siwash Creek. Non-forested habitat types, shrub steppe, occur frequently along Siwash Creek. It is unlikely large woody debris recruitment would occur from those sites.

Water Quantity/Hydrology

Water Quantity is the main limiting factor associated with Siwash Creek Watershed. Data from the downstream OCD site show that Siwash Creek was completely dry from July 10, 2000 thru November 30, 2000.

Irrigation withdrawls peak at this time and may be the reason for such reduced surface flows. Another hypothesis is that Siwash Creek recharges groundwater draining to Antoine Creek, and Siwash Creek will only have surface flows during times when the groundwater "aquifer" is sufficiently recharged to spill water into the Siwash rivulet (**Figure 5-5**). This data gap should be resolved before attempts of summer and fall flow predications in the downstream reach of Siwash Creek are made.

Figure 5-5. Groundwater recharge questions.



The following is from the Tonasket Watershed Assessment (USFS 1998) hydrology section and applies to Siwash Creek watershed: Tonasket Creek watershed is characterized by high spring runoff due to melting snowpack that accumulates in late fall and the winter months. Summer and fall runoff is low, fed by the release of stored water from riparian areas in floodplains, seeps, and springs at the headwater tributary streams.

Stream flow timing has changed through channel alterations in headwater tributary streams and on Siwash Creek. These alterations have cut the channels deeper resulting in reduced ground water recharge to a small extent in this watershed.

The road network has influenced the timing of run-off. Several roads intercept ground water and re-routes the water overland through ditches. This interception reduces the amount of late season flow by routing water from storm and melt water directly to stream channels. Using the USFS existing road layer, twenty-eight miles of road (24% of roads in watershed) were found to be within 100 meters of the seventy-six miles of streams. Surface water also reaches these road drainage ways and leaves more quickly than if it were to recharge ground water storage areas.

Although channel alterations have altered the drainage of surface water in the Siwash Creek Watershed, a large agricultural complex functions, during spring runoff, to slow water velocities and allow for groundwater recharge. Road network effects downstream of this recharge area seen but to a much smaller extent.

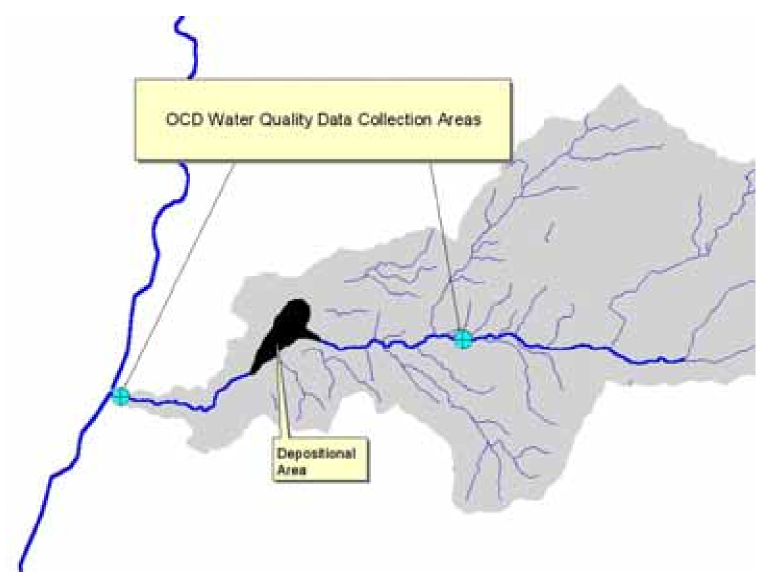
Irrigation withdrawals from the creek are made from Siwash Creek and its tributaries. Uses of water from withdrawals are irrigation of fields, stock watering and household water. One withdrawl from Siwash Creek and one withdrawl from North Fork Siwash are documented on the Washington State Department of Ecology's Water Rights Tracking web page http://www.ecy.wa.gov/programs/wr/info/wrats/Wria-ok.htm.

Water Quality

Channel alterations have altered the drainage of surface water in the Siwash Creek Watershed to a small extent. An agricultural area located in Township 37 Range 27 section 12, functions during spring runoff to slow water velocities and allow for groundwater recharge.

OCD has data for water quality at two locations on Siwash Creek (**Figure 5-6**). There was no water in the channel from July to November at the downstream location. In Reach 1, a turbidity value of 6.84 NTU (good rating) was recorded on June 12, 2000. On the same day in Reach 3 the turbidity value was over 160.00 NTU (poor rating).

Figure 5-6. Data Collection areas for determination of Water Quality on Siwash Creek.



Areas upstream of this agricultural area in Township 37 Range 27 section 12 will have no influence on the water quality parameters of dissolved oxygen, nutrient loading, pH, and turbidity within the historical range of anadromous fishes on Siwash Creek or the Okanogan River. Late summer and fall flows from Siwash Creek could effect the stream temperatures and create summer thermal refuge in the Okanogan River at the confluence with Siwash Creek and immediately downstream.

Water quality conditions in Siwash Creek, downstream from the groundwater recharge/depositional area changes as it flows downstream. Trout are found in the creek immediately downstream of this area, suggesting that water is present year around at this location. Downstream from this point Siwash Creek flows through deeply incised glacial till deposits.

Direct road runoff from Count Road 9467 is likely but for only a short distance and is not likely to alter water quality conditions with exceptions, (ie. resurfacing, transport spills) Runoff from the USFS parking lot enters Siwash Creek. Several home sites are adjacent to the stream and it is likely that septic systems drain to the creek. Agricultural lands are located on lands up to the break in slope along much of Siwash Creek, and runoff from these orchards and fields is likely to enter Siwash Creek. All have potential to affects water quality of Siwash Creek.

Siwash Creek is not on the Washington State List of Threatened and Imperiled Waterbodies (the 303d list).

5.15.2 Anadromous Salmonid Fisheries Resources of Siwash Creek

Anadromous fisheries resources are restricted to the lower 1.4 miles of the Siwash Creek sub-basin due to an impassible steep gradient channel (**Figure B-15**). Suitable spawning habitat occurs in Siwash Creek only when flows are sufficient to allow migration upstream.

Steelhead

No data is available about the use of Siwash Creek for rearing or spawning of Upper Columbia River Summer Steelhead. It is assumed that passage of adults is not restricted up to river mile 1.4, to the steep gradient channel area. Juvenile fish, either resident rainbow trout or steelhead do invade the lower reaches in the spring.

Chinook Salmon

Summer/fall chinook salmon are known to use the mainstem Okanogan River as well as the Similkameen River to Enloe Falls. . The mainstem Okanogan River is used for migration northward to Canadian waters. Most of the known summer/fall chinook spawning areas are in the Similkameen River. Chinook salmon do not use Siwash Creek for spawning, and juvenile use is a data gap.

Spring Chinook Salmon

Adult spring chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Columbia Basin are not currently known to use the Okanogan River. The temperature regime at the time spring chinook salmon spawn in the mainstem Okanogan River is too high for successful spawning and rearing. Water temperatures are elevated due to irrigation water withdrawals (K.Williams and J.Spotts, pers. comms.). In their Endangered Status of One Chinook Salmon ESU Final Rule (U.S. Federal Register 1999), the National Marine Fisheries Service excluded the Okanogan River from their Endangered species listing for the Upper Columbia Evolutionarily Significant Unit (ESU) of spring chinook salmon. The Okanogan River was excluded from the listing because spring chinook adults are collected as they migrate upstream at Wells

Dam on the Columbia River, approximately 20 miles downstream of the confluence of the Okanogan River. The adult salmon are transported to the Winthrop National Hatchery in Winthrop, Washington, and are spawned there. The eggs and resulting fry are raised at the hatchery and later released into the Methow River.

Sockeye salmon

Sockeye salmon are known to use the mainstem Okanogan River as a migration pathway to their spawning areas in Lake Osoyoos and the upstream reaches of the Canadian Okanagan River. Sockeye salmon adults do not use Siwash Creek, and juvenile use is a data gap.

Bull trout

There are no data or anecdotal information indicating bull trout ever were, or that bull trout currently are, in the Siwash Creek watershed. Data that does exist suggests that bull trout did not exploit the Okanogan River north of the city of Omak, approximately 30 river miles down-river of the confluence of Siwash Creek with the Okanogan River (K.Williams, personal communication). The Okanogan River is not suitable habitat for bull trout due to the bull trout requirement of very cold, clean waters with clean gravel/cobble substrate for successful spawning and rearing.

Scott and Crossman (1973) reported that bull trout are not present within the Canadian Okanagan River system.

5.15.3 Limiting Factors Assessment

Siwash Creek was divided into three reporting units (reaches) addressing potential limiting factors to salmonid production in Siwash Creek and in the Okanogan River.

Reach 1 (from the mouth of Siwash Creek to River Mile 1.4) is considered usable anadromous salmonid habitat provided that there is adequate flow. Reach 1 ends at a natural channel gradient break. The channel gradient is 14%, and most likely the extent of adult and juvenile fish.

Reach 2 (River Mile 1.4 to RM 4.4) includes the steep gradient channel. This reach ends at County Road 9467 bridge upstream of the depositional area. This reach has potential to affect water quality to the anadromous fishery, but is not considered to be usable habitat for anadromous fish because of the natural barriers.

Reach 3 (River Mile 4.4 and above) Water quantity, timing and amount, is important factors to track in this reach.

The following rankings reference habitat criteria accepted by the Okanogan TAG group as most relevant to the production potential of anadromous salmonid fishes in the Okanogan (**Table 5-17**).

Table 5-17: Siwash Creek Limiting Factors Assessment

Attribute Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	
Stream Temperature	
Turbidity/Suspended Sediment	
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	
Large Woody Debris	
Percent Pool	
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	
Stream Flow	
Resembles Natural Hydrograph	
Impervious Surface	
Stream Corridor	
Riparian Vegetation	
Stream Bank Stability	
Floodplain Connectivity	

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

Reach 1-

Water Quality

Data was collected in the same time period for dissolved oxygen, temperature, turbidity, and nutrient information (**Figure 5-7**).

Figure 5-7. OCD water quality data collection location in Reach 1.

Dissolved Oxygen - Dissolved oxygen is rated Good based on greater than 95% saturation levels as represented in data collected by the Okanogan Conservation District (OCD) spot checks in 2000.

Stream Temperature - Stream temperatures were below 18°C with a maximum temperature of 15.3°C recorded on 5/18/2000.

Turbidity - Turbidity measurements were all less that 100 NTUs. Two ratings both less than 20 NTUs on 5/18/2000 and 6/12/2000 were recorded. The maximum was 6.84 NTUs. This reach is rated good for turbidity.

Nutrient Loading - No data for Chemical Contamination/Nutrient Loading for dissolved nitrates, nitrites, Fecal coliform, phosphates and calcium carbonate and bicarbonate were recorded by OCD in 2000 and is listed in the table as a Data Gap (DG).

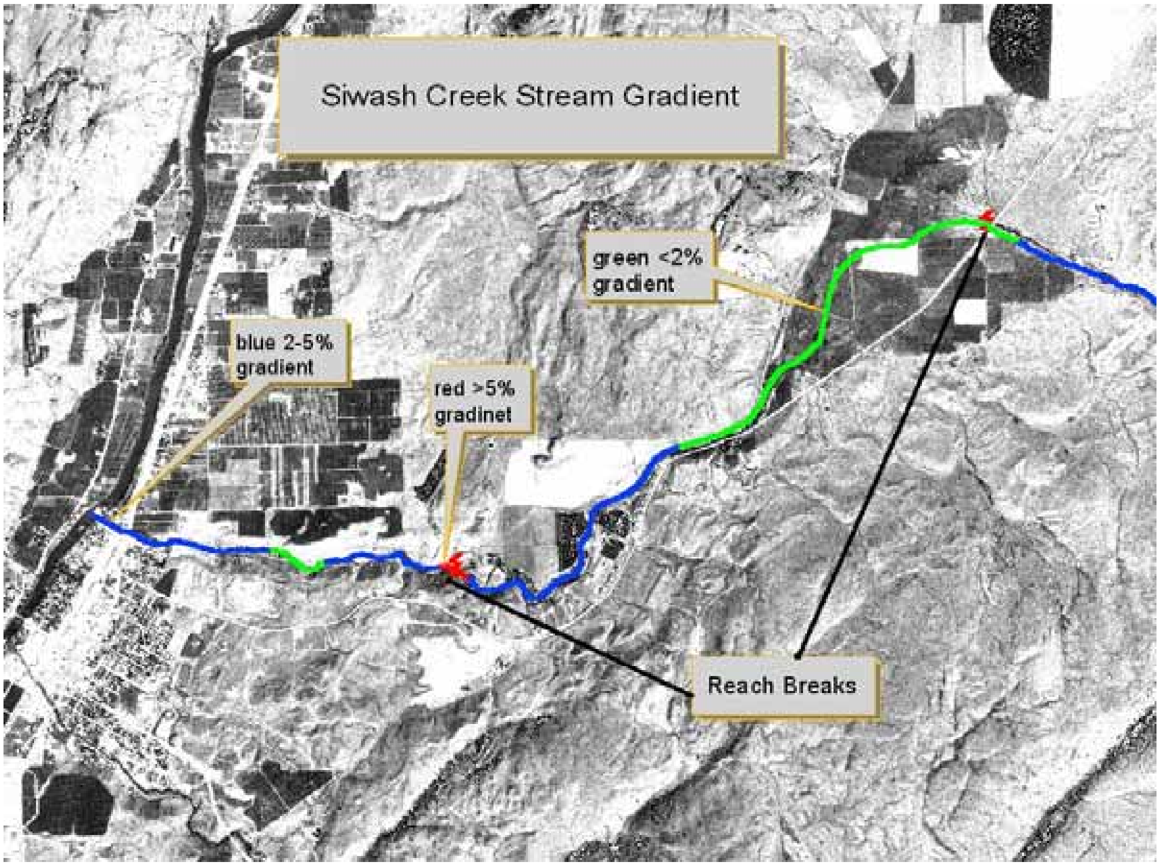
In-Channel Habitat

Fine Sediment - The substrate in the channel on the private lands has not been extensively observed, but while fishing in the Okanogan River at the confluence and while walking along Siwash Creek at the Tonasket Ranger District, I have noticed some sand and silt in the creek. The creek runs clear regularly in spring. A rating of fair for this category was given because 12-20% of the streambed composition is smaller than 0.85mm in likely spawning locations.

Large Woody Debris - Non-forested habitat types, shrub steppe, and/or rock comprise 53% of 50 meter wide buffers on each side of Siwash Creek in this reach. Conifer trees of a size to be classified as LWD, 35 feet long with a diameter of 12 inch, are not likely to grow in these non-forested habitat types. Siwash Creek is not large enough to transfer LWD downstream to this reach. The potential for large woody debris recruitment is lower naturally in this reach because of this. The actual numbers of LWD is unknown. This reach rates poor for large woody debris using the matrix definitions.

Percent Pools - **Figure 5-8** depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total stream length in this Reach is 1.4 miles. The amount of stream channel that has 2% or less gradient is .2 miles (15% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is 1.2 miles (85% of the channel length in this reach). None of stream channel is greater than 5% gradient in this reach. Remote sensing using a 10-meter digital elevation models was used to make these determinations. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The number of pools in this reach is a Data Gap.

Figure 5-8. Stream Channel Gradients



Habitat Access

Fish Passage - Fish passage is assumed good. Siwash Creek has been confined to a channeled trench through the town of Tonasket, but the width of the trench allows for some sinuosity lowering velocities and allowing upstream movement by juvenile fishes. One stream crossing, identified on aerial photo, could pose a passage problem (**Figure 5-9**).

Figure 5-9. This area has not been visited, and is a Data Gap.

Stream Flow

Resembles Natural Hydrograph - The stream flow in Reach 1 is dewatered as a result of water withdrawls upstream in most years. Reduced summer thermal refuge at the confluence with the Okanogan River for steelhead smolt, adult chinook salmon, and adult sockeye salmon is a result.

Impervious Surfaces - City streets and large parking lots along this reach of Siwash Creek create quick runoff and little interaction with the floodplain. This parameter has been rated fair because of the relatively small amount of the reach in this condition.

Stream Corridor

Riparian Vegetation - The riparian vegetation in this reach rated fair, based on spot visual observations by myself. Shade has been reduced in the lower portion of Reach 1; homes and lawns, and parking lots have replaced the natural vegetation. The upper half has steeper banks and was not developed for home sites. Overall the reach has moderate loss of connectivity, and moderate loss of shade.

Stream Bank Stability - Little or no channel bank erosion occurs in this reach. Stream bank stability is rated fair because stability of the channel is not maintained by vegetation in many areas. The stream bank is maintained in a stable condition with riprap through the city of Tonasket.

Floodplain Connectivity - Flood plain connectivity is rated as poor based on spot visual observations. Siwash Creek has been channeled through the city of Tonasket, and vegetation succession has altered significantly.

Reach 2-

Reach 2 affects the water quality downstream in Reach 1, but due to its steep gradient and an impassible barrier at the beginning, Reach 2 is not considered anadromous fish habitat.

Water Quality

No data was collected for dissolved oxygen, temperature, turbidity, and nutrient information in this reach. No guesses are made because of the variety of uses and the lack of knowledge of water withdrawls.

Dissolved Oxygen - Dissolved oxygen (DO) data was not collected, and is listed as a Data Gap (DG).

Stream Temperature - Stream temperature data was not collected, and is listed as a Data Gap (DG).

Turbidity - Turbidity data was not collected, and is listed as a Data Gap (DG).

Nutrient Loading - Nutrient loading and chemical contamination data was not collected, and is listed as a Data Gap (DG).

In-Channel Habitat

Substrate - Because Reach 2 is not considered to provide anadromous fish habitat, the substrate condition criterion does not apply to spawning substrate. No data was not collected, and is listed as a Data Gap (DG).

Large Wood - Using a Plant Association Group cover generated for use by the U.S. Forest Service, determination of suitable habitat for conifer growth was made. In Reach 2 non-forested habitat types comprise 75% of 50-meter wide buffers on each side of Siwash Creek. There is a Data Gap regarding the number of pieces of large woody debris within this reach.

Percent Pools - Figure xxx depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total stream length in this Reach is 3.0 miles. The amount of stream channel that has 2% or less gradient is 1.7 miles (57% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is 1.2 miles (40% of the channel length in this reach). The amount of stream channel that is greater than 5% gradient is 0.1 miles (3% of this reach). Remote sensing using a 10-meter digital elevation models was used to make these determinations. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The numbers of pools in this reach is a Data Gap.

Habitat Access

Fish Passage - This criterion is not applicable. Anadromous fish habitat ends at the steep gradient channel at beginning of the Reach 2.

Stream Flow

Resembles Natural Hydrograph - Stream flow information was not collected in this reach, and is listed as a Data Gap (DG).

Impervious Surfaces - Little impervious surface was identified from the aerial photograph. This is rated to be in fair condition as some alteration was noticed.

Stream Corridor

Riparian Vegetation - The vegetation has been altered. Most noteably the 300 acre depositional area has been converted to a series of hayfields with some natural vegetation occurring. The reach appears to be within 25-50%, likely 25%, of the potential natural community composition. The vegetation composition of this Reach is rated as fair.

Stream Bank Stability - Siwash Creek is well shaded in this reach and banks are held stable from deciduous vegetation in most locations. The depositional area is held stable from grasses and shrubs. At least 80% of the banks are stable and an argument that 90% of the banks are stable could be made. The bank stability is rated fair for this reach and could be rated good. (up to you Jeff if you want to change to good its close to 90% for aerial photo, on the ground I have seen some instability in areas but have not seen the entire reach, so I gave it a fair and I could be swayed, it is a Data Gap I'll admit)

Floodplain Connectivity - Turbidity data in reach 3 upstream of the depositional area and the resulting data in Reach 1 is the best evidence that this floodplain remains connected, at least in part. The riparian vegetation succession does not occur here and for this reason this reach is considered as fair for this parameter.

Reach 3-

Water Quality-

The water flowing form Reach 3 does not affect the water quality in Reach 1. The timing of the water release in Reach 3 may have an effect on the water temperatures later in the year. The table is populated with water quality data from OCD but is not discussed for the reasons mentioned.

In-Channel Habitat

Substrate - Because Reach 3 is not considered to provide anadromous fish habitat, the substrate condition criterion does not apply to spawning substrate. This reach does contain and generate fine sediment. It is not transported to the fisheries below.

Large Wood - This parameter was not analyzed in this reach. No numbers of LWD are available for this reach. For these reasons this is a Data Gap (DG).

Percent Pools - This parameter was not analyzed in this reach. No numbers of pools or stream are available for this reach. For these reasons this is a Data Gap (DG).

Habitat Access

Fish Passage - This criterion is not applicable. Anadromous fish habitat ends at the steep gradient channel at beginning of the Reach 2.

Stream Flow

Resembles Natural Hydrograph - Flows in this reach were determined to be in fair condition using the criteria that flow timing and amount are altered but not drastically so.

Impervious Surfaces - For much of the length of the creeks in this reach gravel roads parallel the stream. For this reason a rating of fair is given for this parameter.

Stream Corridor

Riparian Vegetation - Riparian vegetation is in fair with the potential natural community and composition being at or near above 50% but, roads that parallel the streams creates in-complete protection of habitats and refugia for aquatic species. (Is the word sensitive her referring to list or candidate species? If so make this a good)

Stream Bank Stability - Siwash Creek is well shaded in this reach and banks are held stable from deciduous vegetation in hotter dryer locations, and from conifers in forested environments. The roads have reduced the amount of floodplain that streams use in the lower elevations of this reach and undoubtedly erode during higher bankfull flows. 80% of the banks are stable in most years. The bank stability is rated fair for this reach.

Floodplain Connectivity - The floodplain connectivity is currently in poor condition from the lack of stream water interaction due to the downcutting that has and still occurs in this reach.

Reach 4-

Water Quality-

Dissolved Oxygen (DO)-: Stream Temperature-: Turbidity-: Nutrient Loading-

Reach 4 includes Siwash Creek and it tributaries upstream of a braided channel woodland in T39N, R28E, Section 23, NE 1/4. The braided channel area intercepts much of the sediment that might be delivered, the DO and temperature and nutrient loading are altered as a result of the transport through the 6 miles of Reach 3 and the 3.8 miles of Reach 2. Water quality parameters; DO, temperature, turbidity and nutrient loading, of Reach 1 is not affected to a discernable degree by the relatively small amount of pollutants in generated in Reach 4. These criteria are not applicable, and are not discussed here. The Limiting Factors Table for reach 4 is populated with the data supplied by the OCD. The water collection area for the OCD data is upstream of the Aeneas Valley road on Siwash Creek.

In-Channel Habitat

Fine Sediment - Little fine sediment from this reach is delivered to the spawning area in Reach 1. Fine sediment falls out of solution in the spread channel wetland river mile 10.8 to 11.4. Sand from road maintenance in winter along State Highway 20 directly enters the stream in at least .8 miles of this reach. This material likely drops out of the water column at or before river mile 10.8.

Large Wood - Sites with potential for providing large woody debris (LWD) were not done for Reach 4. Conifer trees of a size to be classified as LWD, 35 feet long with a diameter of 12 inch, are likely to grow along Siwash Creek, but the creek is not large enough to transfer LWD downstream to other reaches. The amount of LWD in Reach 4 is a Data Gap.

Percent Pools - Figure 2 depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total length of streams in this reach is 21.9 miles. The amount of stream channel gradient is 2% or less is miles (83% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is 3.1 miles (14% of the channel length in this reach). The amount of stream channel that is greater than 5% gradient is .6 miles (3% of the channel length in this reach). Remote sensing using a 10-meter digital elevation models was used to make these determinations. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The numbers of pools and amount of pool habitat is a Data Gap.

Habitat Access

Fish Passage - This criterion is not applicable. Anadromous fish habitat ends at the waterfall at the beginning of the Reach 2.

Stream Flow

Resembles Natural Hydrograph - Flows in this reach and the other reaches were determined to be in fair condition using the criteria that flow timing and amount are altered but not drastically so. The Bonaparte Water Users Association has water right to 1080 acre-feet of water from Bonaparte Lake. (An unpublished memorandum, USFS, 1967).

Impervious Surfaces - State Highway 20 along this Reach is the largest unnatural impervious surface. Runoff and ditching is not extensive, but one area along State Highway is adjacent to Siwash for .8 miles. This area has direct runoff to the creek, for this reason; this parameter deserves a ranking of fair.

Stream Corridor

Riparian Vegetation - Maintenance of State Highway 20 right of way, agricultural development and livestock grazing have altered the riparian vegetation in this reach, but still appears to be within 25-50% of the potential natural community composition. The vegetation composition of this Reach is rated as fair.

Stream Bank Stability - Stream bank stability is in good condition. The survey by OCCD in 1988 identified 1.5 miles of heavy grazing on 12.8 mile of stream surveyed. It is unknown if these areas have been restored to a better condition. From observations along State Highway 20 this area has sufficient vegetation to stabilize the stream banks where State Highway 20 is adjacent to Siwash Creek and vegetation is lacking the channel is stabilized with riprap.

Floodplain Connectivity - The riparian vegetation succession does not occur where roads parallel the channel and for this reason the floodplain connectivity is currently in fair condition.

5.16 ANTOINE CREEK WATERSHED ASSESSMENT

5.16.1 Sub-basin Overview

The Antoine Creek watershed encompasses 46,695 acres of mixed ownership. The acres are a mixed ownership as follows: Private ownership, 30,000 acres (72%); Washington Department of Natural Resources, 2800 acres (6%); Bureau of Land Management managed lands, 459 acres (<1%); and the remaining 9806 acres (21%) are managed by the US Forest Service (USFS).

Antoine Creek enters the Okanogan River 4 miles north of the city of Tonasket, Washington, at River Mile (RM) 61.2 of the Okanogan River. The watershed at its longest axis is approximately 14 miles long and its widest point is approximately 10 miles wide.

Antoine Creek is dammed at approximately RM 12 by Fancher Dam. Approximately 40% of the watershed acres drain to Antoine Creek above Fancher Dam, with the remaining 60% of the watershed draning to Antoine Creek below Fancher Dam. The water in Facher Dam reservoir is used for irrigation of croplands.

Land Use and Ownership

Land within this watershed is predominantly in private ownership. Private lands adjacent to Antoine Creek are used primarily for as range lands, for agriculture (hay fields), and for ocharding. Primary use of USFS, DNR and BLM lands are timber production and/or livestock allotments.

Roads parallel Antoine Creek (approximately 5 miles) and Whiskey Cache Creek (approximately 4 miles). There may be more roads adjacent to these streams. Available maps do not depict all the roads to residences in the area.

Fancher Dam is on private land and has been in place for almost 90 years. The reservoir behind the dam is used for private land irrigation purposes. Most of the water stored in the reservoir is used for irrigation of large hayfields. There is flow from the reservoir at spring run-off when the water level of the reservoir reaches and overtops the spillway.

There are other private land irrigation withdrawals made downstream of Fancher Dam. There is also a cement diversion structure at approximately RM 1 on Antoine Creek, on private land. The stream below this point is often dry or "near dry" in the summer and early fall months (D. Van Woert, personal communication).

There may also be some domestic use withdrawals from Antoine Creek.

Topography, Geology & Soils

Tonasket, Antoine, Siwash and Bonaparte watersheds are all part of the Okanogan sub-continent (Alt and Hyndman 1984). The eastern and southern boundaries are formed by the Columbia River. The western boundary, the Okanogan River valley, is geologically known as the Okanogan trench. The Okanogan sub-continent extends hundreds of miles north into British Columbia, Canada.

The Okanogan sub-continent was an island about the size of California that crashed into the Kootenay Arc (which was then the western edge of the continent), about 100 million years ago. Following this "docking" of the sub-continent came the filling of what was then the "coastal area" on the west edge of the Okanogan sub-continent, the Okanogan trench (now the Okanogan Valley) (Alt and Hyndman 1984).

The intersection of these two geologic features (the Okanogan sub-continent and the Okanogan trench) appears to be where barriers of waterfalls or high gradient stream channels occur. These barriers preclude upstream migration of anadromous salmonids.

The elevation of the confluence of Tonasket Creek with the Okanogan River is 885 feet. The highest point in the Tonasket Creek watershed is Bonaparte Mountain at 7,258 feet. The Antoine Watershed is oriented on a northeast to southwest axis.

Tectonic uplifting, continental glaciation, and volcanic ash deposition all played major roles in shaping the existing topography and soils characteristics of this watershed. Continental glaciation has had the greatest impact. Large areas of exposed rock and shallow soils were left as a result of the flow and retreat of the Okanogan and Sanpoil lobes of the Cordillean Icesheet. Bedrock is overlain by Quarternary glacial till outwash and glaciolacustrine sedimentary deposits of varying thickness.

The upper elevation bedrock is tertiary medium to coarse grain grandiorite and granite of the Mt. Bonaparte pluton.

The lower elevations are underlain with pre-tertiary banded gneiss and schist of the Tonasket gneiss. Both rock types are included in a metamorphosed and structural uplift called the Okanogan gneiss dome (USFS 1998 and 1999).

Vegetation and Riparian Condition

In-channel large woody debris appears to be lacking in much of Antoine Creek. Non-forested habitat types do occur along Antoine Creek and its tributaries, but the agricultural use of adjacent lands may preclude large woody debris recruitment to the stream. Shrub and forb vegetation are present along much of Antoine Creek, providing some bank stability and shade cover.

Water Quantity/Hydrology

The following is from the Antoine Watershed Assessment (USFS 1999) hydrology section:

> Antoine Creek watershed is characterized by high spring runoff due to melting snowpack that accumulates in late fall and the winter months. Summer and fall runoff is low, fed by the release of stored water from riparian areas in floodplains, seeps, and springs at the headwater tributary streams.
>
> The timing of some run-off has been influenced by the road network that intercepts ground water and re-routes it overland. Some of that surface water reaches drainage ways and leaves more quickly than ground water flow. The interception reduces the amount of late season flow.

Fancher Dam reservoir entrains water from both Antoine and Mill Creeks and their tributaries. The water in Fancher Dam reservoir is used for crop irrigation on Fancher Flats during the months of May to October, annually. During this time, flow at the mouth of Antoine Creek is minimal, and sometimes non-existent (D. Van Woert, personal communication).

Other irrigation withdrawals occur downstream of Fancher Dam. Known withdrawal devices are at T38N, R28E, Section 31, SW$^1/_4$, NE $^1/_{16}$, and T38N, R27E, Section 35 NW$^1/_4$, NW $^1/_{16}$ The second withdrawal device may have an associated fish passage barrier. Water from Antoine Creek is also used in the early spring months for frost abatement on orchards (D. Van Woert, personal communication) Other withdrawals may also be occurring.

Water Quality

Antoine Creek is not on the Washington State List of Threatened and Imperiled Waterbodies (the 303d list).

The following is from the Antoine Watershed Assessment (USFS 1999) hydrology section:

> Surface stream flows in the lowest reach of Antoine Creek is often reduced to no flow during the driest part of the year. Antoine Creek has sometimes been completely dewatered in dry years due primarily to irrigation withdrawals.

About 0.6 miles of stream channel in the Tonasket Watershed are classified as sediment source reaches (USFS 1999). All of these sediment source reaches are upstream of functional depositional areas. A single sediment source reach approximately 0.40 miles long is situated upstream of Fancher Dam reservoir in an unnamed tributary to Antoine Creek. The remaining sediment source reaches (each about 0.05 miles long) are in unnamed tributaries to Antoine Creek and Whiskey Cache Creek.

Whiskey Cache Creek, prior to its confluence with Antoine Creek (at approximately RM 4 of Antoine Creek) has a large wetland that filters sediment that might be delivered from upstream.

5.16.2 Anadromous Salmonid Fisheries Resources of Antoine Creek

Anadromous fisheries resources are restricted to the lower 11.5 miles of the Antoine Creek sub-basin due a waterfalls and steep gradient channel that begins at RM 11.5 (**Figure B-16**).

Steelhead

Steelhead adults are known to use the confluence area of Antoine Creek with the Okanogan River (C. Hinkley, pers. comm.).

Chinook Salmon

Summer/fall chinook salmon are known to use the mainstem Okanogan River as well as the Silmilkameen River to Enloe Falls. The mainstem Okanogan River is used for migration northward to Canadian waters. Most of the known summer/fall chinook spawning areas are in the Similkameen River.

Adult spring chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Columbia Basin are not currently known to use the Okanogan River. The temperature regime at the time spring chinook salmon spawn in the mainstem Okanogan River is too high for successful spawning and rearing. Water temperatures are elevated due to irrigation water withdrawals (K.Williams and J.Spotts, personal communication).

In their Endangered Status of One Chinook Salmon ESU Final Rule (US Federal Register 1999), the National Marine Fisheries Service excluded the Okanogan River from their Endangered species listing for the Upper Columbia Evolutionarily Significant Unit (ESU) of spring chinook salmon. The Okanogan River was excluded from the listing because spring chinook adults are collected as they migrate upstream at Wells Dam on the Columbia River, approximately 20 miles downstream of the confluence of the Okanogan River. The adult salmon are transported to the Winthrop National Hatchery in Winthrop, Washington, and are spawned there. The eggs and resulting fry are raised at the hatchery and later released into the Methow River.

Sockeye salmon

Sockeye salmon are known to use the mainstem Okanogan River as a migration pathway to their spawning areas in Lake Osoyoos and the upstream reaches of the Canadian Okanagan River. Sockeye salmon are not known to use Antoine Creek.

Bull trout

There are no data or anecdotal information indicating bull trout ever were, or that bull trout currently are, in the Antoine Creek watershed. Data that does exist suggests that bull trout did not exploit the Okanogan River north of the city of Omak, approximately 30 river miles down-river of the confluence of Antoine Creek with the Okanogan River (K.Williams, personal communication). The Okanogan River is not suitable habitat for bull trout due to the bull trout requirement of very cold, clean waters with clean gravel/cobble substrate for successful spawning and rearing.

Scott and Crossman (1973) reported that bull trout are not present within the Canadian Okanagan River system.

5.16.3 Limiting Factors Assessment

Antoine Creek was divided into three reporting units (reaches) in addressing potentially limiting factors to salmonid production for this document.

Reach 1 (from the mouth of Antoine Creek to River Mile 11.5) is considered usable salmonid habitat provided that there is adequate flow and the irrigation withdrawal structure is passable. Reach 1 ends at the base of a waterfalls that is considered to be a natural passage barrier.

Reach 2 (River Mile 11.5 to RM 12.0) includes the waterfalls and associated steep gradient channel. This reach ends at the base of Fancher Dam. This reach has an affect on downstream water quality, but is not considered to be usable habitat for anadromous fish.

Reach 3 (River Mile 12.0 and above) includes Fancher Dam reservoir and all of Antoine Creek and all its tributaries upstream of the reservoir. These places are inaccessible to fish moving upstream from the Okanogan River.

The following rankings reference habitat criteria accepted by the Okanogan TAG group as most relevant to the production potential of anadromous salmonid fishes in the Okanogan (**Table 5-18**).

Table 5-18. Antoine Creek Limiting Factors Assessment

Attribute Considered	Anad Potential Reach	Water Quality Reach	Non-Issue Reach
Water Quality			
Dissolved Oxygen	F1	P1	N/A
Stream Temperature	G1	G1	N/A
Turbidity/Suspended Sediment	G1	G1	N/A
Nutrient Loading	DG	DG	DG
In Channel Habitat			
Fine Sediment (substrate)	F2	N/A	N/A
Large Woody Debris	P2	DG	N/A
Percent Pool	DG	N/A	N/A
Habitat Access			
Fish Passage	F2	N/A	N/A
Streamflow			
Resembles Natural Hydrograph	P1	P1	G2
Impervious Surface	G2	DG	G2
Stream Corridor			
Riparian Vegetation	F2	DG	G2
Streambank Stability	F2	G2	P2
Floodplain Connectivity	F2	G2	F2

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

Reach 1-

Water Quality

Dissolved Oxygen - Dissolved oxygen is Fair based on the saturation level found during the summer months, as represented by data collected by the Okanogan Conservation District (OCD) from May 2000 to February 2001. Dissolved oxygen information is collected only when sufficient flowing water was present.

Stream Temperature - Stream temperatures were well below 18^{o} C., in the same time period as the DO information was collected.

Turbidity - Turbidity measurements were all less that 20 NTUs. Data was collected in the same time period as the dissolved oxygen information.

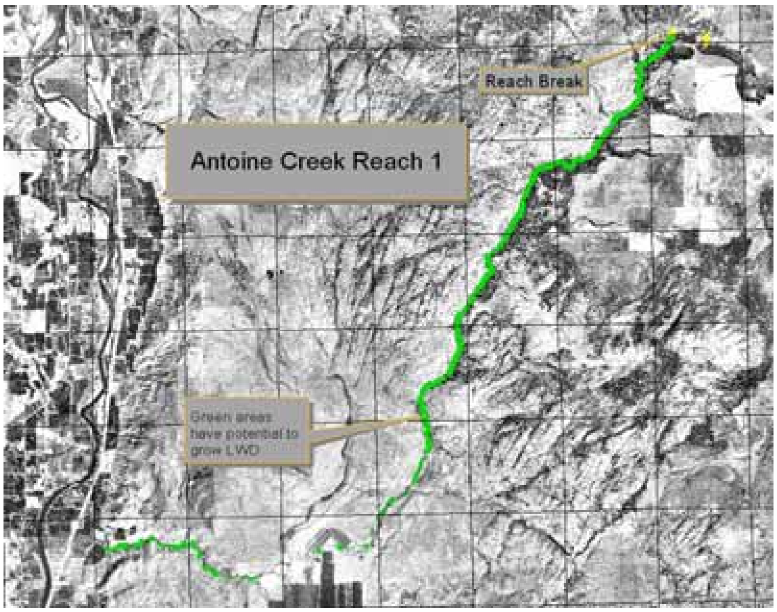
Nutrient Loading - A data gap exists for Chemical Contamination/Nutrient Loading.

In-Channel Habitat

Fine Sediment - The substrate in the channel on the private lands has not been extensively observed. Spot visual observations (K.Cooper, personal communication) at potential spawning sites reveal the substrate to be in a Fair condition.

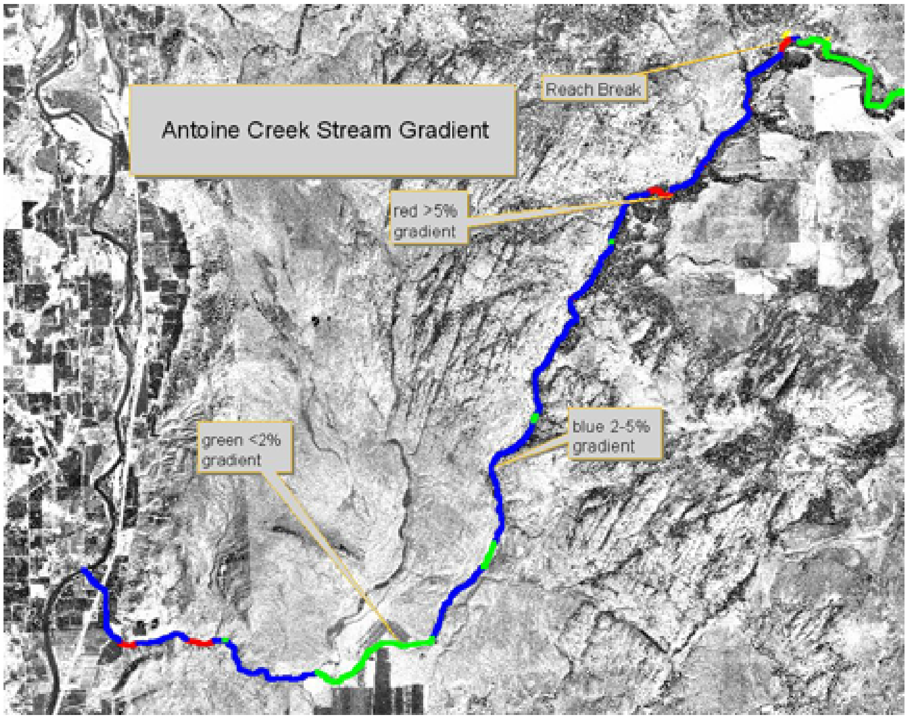
Large Woody Debris - Sites with potential for providing large woody debris (**Figure 5-10**). Determination was made by remote sensing (GIS/Arcview mapping), not from on-the-ground collected data. Non-forested habitat types comprise 37% of 50 meter wide buffers on each side of Antoine Creek. This indicates that the potential for large woody debris recruitment is low. By the matrix definitions, this reach rates Poor for large woody debris, but this rating must be tempered by considering the potential natural condition (non-forested) along this reach. Trees of a size to be classified as large woody debris are unlikely to grow in non-forested habitat types.

Figure 5-10. Potential for large conifers



Percent Pools - **Figure 5-11** depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total stream length in this Reach is 11.5 miles. The amount of stream channel that has 2% or less gradient is 1.6 miles (14% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is 8.8 miles (77% of the channel length in this reach). The amount of stream channel that is greater than 5% gradient is 1.0 miles (9% of the channel length in this reach). These determinations were made by remote sensing. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The actual number of pools in this reach is a Data Gap.

Figure 5-11. Stream Channel Gradients



Habitat Access

Fish passage is assumed beyond the two known irrigation diversions downstream of Fancher Dam. This is a Data Gap needing answered to fully appreciate available fish habitat in Antoine Creek. Because barriers are known to exist, but the extent of a barrier they present is not known, because the water levels in Reach 1 are known to fluctuate and at times to go dry, this criterion rateed as Fair

Stream Flow

Resembles Natural Hydrograph - The stream flow in Reach 1 is altered greatly by the operation of Fancher Dam for irrigation. In low water years, there is little, but more often no flow at the confluence of Antoine Creek with the Okanogan River (D. VanWoert, personal communication). This reach rates Poor for this criterion.

Stream Corridor

Riparian Vegetation - The riparian vegetation in this reach rated Fair, based on spot visual observations (K.Cooper, personal communication). Shade has been reduced in places due to agricultural conversion of lands to orchards, pastures, and crop lands, but the vegetative community appears to be within 25-50% of the potential natural vegetation.

Stream Bank Stability - Stream bank stability also seems Fair. Stability may have been modified by agricultural uses, either weakened by removal of vegetation, or perhaps reinforced by rip-rap.

Floodplain Connectivity - Flood plain connectivity is rated as Fair based on spot visual observations (K.Cooper, personal communication). Due to agricultural conversion of adjacent lands, the channel may be down-cutting somewhat.

The lowest portion of Antoine Creek was re-routed by Great Northern Railroad in the 1920s. The confluence was originally about ¼ mile south of where it is today (D. Van Woert, personal communication). Thus, the half mile of stream from the east side of Highway 97 to the confluence with the Okanogan River is a dug channel with no opportunity created for a flood plain. The exception is where the current Antoine Creek channel meets the floodplain of the Okanogan River, but it must be noted that the Okanogan River floodplain has also been influenced by the placement of the railroad line, Highway 97, and conversions of adjacent lands to agricultural use.

Reach 2-

Reach 2 affects the water quality downstream in Reach 1, but due to its steep gradient is not considered anadromous fish habitat.

Water Quality

Dissolved Oxygen - Dissolved oxygen, as shown in the OCD data for their sample site in Reach 2 indicates a saturation level of 60% (7.39 mg/l at 12.^{o} C., data collected from May of 2000 to February 2001). This gives this criterion a rating of Poor. However, the OCD collection site is above the waterfall. The waterfall mixes oxygen back into the water, as it continues downstream, raising the DO content as a result.

Stream Temperature - Stream temperature was in the Good category according to the OCD data.

Turbidity - Turbidity was also in the Good range according to OCD data.

Nutrient Loading - Nutrient loading and Chemical Contamination information is a data gap for Reach 2, as well.

In-Channel Habitat

Substrate - Because Reach 2 is not considered to provide anadromous fish habitat, the substrate condition criterion does not apply.

Large Wood - Determination was made by remote sensing, not from on-the-ground data collection. Non-forested habitats are not present within 50 meter buffers on each side of Antoine Creek. There is a data gap regarding the numbers of large woody debris currently present in this reach.

Percent Pools - The total stream length in this Reach is 0.5 miles. The amount of stream channel that has 2% or less gradient is 0.3 miles (60% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is 0.1 miles (20% of the channel length in this reach). The amount of stream channel that is greater than 5% gradient is 0.1 miles (20% of the channel length in this reach). These determinations were made by remote sensing. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The actual number of pools in this reach is a Data Gap. The portion of the channel that is 2% or less in gradient, and the portion that is 2-5% gradient are both located above the fish barrier waterfall, and not available as anadromous fish habitat. Thus, this criterion does not apply.

Habitat Access

Fish Passage - This criterion is not applicable because the reach, due to its high gradient, is not considered to provide anadromous fish habitat.

Stream Flow

Resembles Natural Hydrograph - Stream flow information collected by OCD indicates that this criterion rates Poor, due to the operation of Fancher Dam reservoir for irrigation, which often totally dewaters the channel. In 2000, in addition to being used for irrigation, Fancher Dam reservoir supplied water to extinguish a large wildfire (helicopter buckets, as well as water tender trucks), essentially emptying the reservoir. The OCD sampling site in Reach 2 (below the dam) has had no water between September 2000 and February 2001. The reservoir is being allowed to recharge, with no water being released.

Stream Corridor

Riparian Vegetation - A Data Gap exists regarding the vegetative composition of this reach.

Stream Bank Stability - The stream banks, due to the sideslope steepness have not been altered much over the years. Also due to the steep sideslopes, the channel is confined without much of a flood plain. This criterion rates Good.

Floodplain Connectivity - The stream banks, due to the sideslope steepness have not been altered much over the years. Also due to the steep sideslopes, the channel is confined without much of a flood plain. This criterion rates Good.

Reach 3-

Water Quality-

Dissolved Oxygen - Stream Temperature - Turbidity-

Reach 3 includes all the stream and its tributaries above Fancher dam and its reservoir. The mixing of water in the reservoir changes the oxygen content and the temperature, but that gets changes again upon exit from the reservoir into Reach 2. The water quality of Reach 1 is not affected by that of Reach 3. These criteria are not applicable.

Nutrient Loading - Chemical Contamination and Nutrient Loading for this reach is a Data Gap.

In-Channel Habitat

Fine Sediment - Fine sediment that is delivered down Reach 3 settles in Fancher Dam reservoir, so this criterion is not applicable.

Large Wood - Due to the presence of Fancher Dam and reservoir, the amount of woody debris that may be present in Reach 3 does not affect Reach 1. This criterion is not apply.

Percent Pools - This reach does not affect the reach of Antoine Creek used by anadromous salmonids, so this criterion is not applicable.

Habitat Access

Reach 3 is above two natural fish barriers (a water fall and high gradient riffle), as well as a man-made barrier, Fancher Dam. Thus, this reach is not usable anadromous fish habitat.

Stream Flow

Resembles Natural Hydrograph - Reach 3 flows are not known to be altered. A Data Gap exists regarding the withdrawal of water from Antoine Creek above Fancher reservoir, or from Mill Creek, a major tributary to Antoine Creek. This criterion is rated Good.

Stream Corridor

Riparian Vegetation - Riparian vegetation is in Fair condition , having been altered by agriculture on private lands, road building, and older timer harvest units adjacent to streams on USFS managed lands.

Stream Bank Stability - Stream bank stability is in Poor condition due to livestock movement (hoof shear), roads (Tonasket Ranger District 1996), and conversion of riparian areas to agricultural uses in the private lands.

Floodplain Connectivity - The floodplain connectivity is currently in Fair condition, but is observed to be in a downward trend in the private land portions of Antoine Creek (K. Cooper, personal communication), where livestock appear to have increasing access to the stream channel in the aspen stands and meadows near Havillah.

5.17 TONASKET CREEK WATERSHED ASSESSMENT

5.17.1 Sub-basin Overview

The Tonasket Creek watershed encompasses 35,460 acres of mixed ownership. The acres are a mixed ownership as follows: Private ownership, 20,000 acres (56%); Washington Department of Natural Resources, 5700 acres (16%); Bureau of Land Management managed lands, 960 acres (3%); and the remaining 8,800 acres (25%) are managed by the US Forest Service (USFS).

Tonasket Creek enters the Okanogan River east of the city of Oroville, Washington, at River Mile (RM) 77.8 of the Okanogan River. The watershed at its longest axis is approximately 12 miles long and its widest point is approximately 8 miles wide.

Land Use and Ownership

Private lands adjacent to Tonasket Creek are used primarily for orcharding, as range lands, or for agriculture (hay fields). Primary use of USFS, DNR and BLM lands are timber production and/or livestock allotments.

County Road 9480 parallels Tonasket Creek for approximately 9 miles, and a Forest Road parallels the creek for almost 1 mile on the USFS managed lands. There may be more roads adjacent to streams in this watershed. Available maps do not depict all the roads to residences in the area, or for the subdivision being established at Nine Mile Ranch.

Topography, Geology & Soils

Tonasket, Antoine, Siwash and Bonaparte watersheds are all part of the Okanogan sub-continent (Alt and Hyndman 1984). The eastern and southern boundaries are formed by the Columbia River. The western boundary, the Okanogan River valley, is geologically known as the Okanogan trench. The Okanogan sub-continent extends hundreds of miles north into British Columbia, Canada.

The Okanogan sub-continent was an island about the size of California that crashed into the Kootenay Arc (which was then the western edge of the continent), about 100 million years ago. Following this "docking" of the sub-continent came the filling of what was then the "coastal area" on the west edge of the Okanogan sub-continent, the Okanogan trench (now the Okanogan Valley) (Alt and Hyndman 1984). The intersection of these two geologic features (the Okanogan sub-continent and the Okanogan trench) appears to be where barriers of waterfalls or high gradient stream channels occur. These barriers preclude upstream migration of anadromous salmonids.

The elevation of the confluence of Tonasket Creek with the Okanogan River is 910 feet. The highest point in the Tonasket Creek watershed is Wilcox Mountain at 4,378 feet. The Tonasket Watershed is oriented on a southeast to northwest axis.

Tectonic uplifting, continental glaciation, and volcanic ash deposition all played major roles in shaping the existing topography and soils characteristics of this watershed. Continental glaciation has had the greatest impact. Large areas of exposed rock and shallow soils were left as a result of the flow and retreat of the Okanogan and Sanpoil lobes of the Cordillean Icesheet. Bedrock is overlain by Quarternary glacial till outwash and glaciolacustrine sedimentary deposits of varying thickness.

The upper elevation bedrock is tertiary medium to coarse grain grandiorite and granite of the Mt. Bonaparte pluton.

The lower elevations are underlain with pre-tertiary banded gneiss and schist of the Tonasket gneiss. Both rock types are included in a metamorphosed and structural uplift called the Okanogan gneiss dome (USFS 1998 and 1999).

Vegetation and Riparian Condition

In-channel large woody debris appears to be lacking in much of Tonasket Creek. Non-forested habitat types occur frequently along Tonasket Creek and its tributaries, so it is unlikely large woody debris recruitment would occur from those sites. Streamside vegetation has been altered greatly in the lowest reach where land uses are agricultural. Shrub and forb vegetation are present along much of Tonasket Creek, providing some bank stability and shade cover.

Water Quantity/Hydrology

The following is from the Tonasket Watershed Assessment (USFS 1998) hydrology section:

> Tonasket Creek watershed is characterized by high spring runoff due to melting snowpack that accumulates in late fall and the winter months. Summer and fall runoff is low, fed by the release of stored water from riparian areas in floodplains, seeps, and springs at the headwater tributary streams.
>
> The timing of some run-off has been influenced by the road network that intercepts ground water and re-routes it overland. Some of that surface water reaches drainage ways and leaves more quickly than ground water flow. The interception reduces the amount of late season flow.

Irrigation withdrawals are made in the lower part of the creek. There are likely other water withdrawals from Tonasket Creek and its tributaries in the Nine Mile Ranch subdivision area, as well as Mud Lake Valley and Dry Creek areas. These withdrawals may be for irrigation, stock watering or perhaps domestic use. Tonasket Creek has been channelized through the orchards, and through the alluvial fan to the Okanogan River (K. Williams, personal communication). There may be some domestic use water withdrawals also made from Tonasket Creek.

Water Quality

Tonasket Creek is not on the Washington State List of Threatened and Imperiled Waterbodies (the 303d list).

The following is from the Tonasket Watershed Assessment (USFS 1998) hydrology section:

> Surface stream flow in the lowest reach of Tonasket Creek is often reduced to no flow during the driest part of the year. Tonasket Creek has sometimes been completely dewatered in dry years due primarily to irrigation withdrawals.

About 1.5 miles of stream channel in the Tonasket Watershed are classified as sediment source reaches (USFS 1998). Of that, about 0.75 miles of these reaches are upstream of functional depositional areas. The remaining 0.75 miles of sediment source reaches do not have a functional depositional area between them and the confluence of Tonasket Creek with the Okanogan River.

There is a large wetland on the US Forest Service (USFS) managed lands (at approximately River Mile 13.5) this area filters sediment that might be delivered from upstream.

5.17.2 <u>Anadromous Salmonid Fisheries Resources of Tonasket Creek</u>

Anadromous fisheries resources are restricted to the lower 1.9 miles of the Tonasket Creek sub-basin due to the steep gradient of the channel that initiates at this point and continues to approximately RM 2.3. Above RM 2.3 (**Figure B-17**), it is suspected that eastern brook trout are present, though some fish shocking done in preparation for the replacement of a culvert on the paralleling County Road 9480 did not reveal any fish (L. Hofmann, personal communication).

Steelhead

Steelhead fry are observed in the confluence area where Tonasket Creek joins the Okanogan River by Ken Williams, Area Fish Biologist Region 2 Washington Department Fish and Wildlife (retired). He surmised that the fry were using the confluence area for rearing, and to evade predators found in the mainstem Okanogan River, and perhaps to make use of relatively warmer water temperatures in Tonasket Creek compared to the Okanogan River (K.Williams, personal communication). An adult steelhead was caught at approximately RM 1.8 in the late 1970s (D. Buckmiller, personal communication)

Chinook Salmon

Summer/fall chinook salmon are known to use the mainstem Okanogan River as well as the Silmilkameen River to Enloe Falls. The mainstem Okanogan River is used for migration northward to Canadian waters. Most of the known summer/fall chinook spawning areas are in the Similkameen River.

Adult spring chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Columbia Basin are not currently known to use the Okanogan River. The temperature regime at the time spring chinook salmon spawn in the mainstem Okanogan River is too high for successful spawning and rearing. Water temperatures are elevated due to irrigation water withdrawals (K.Williams and J.Spotts, personal communication).

In their Endangered Status of One Chinook Salmon ESU Final Rule (US Federal Register 1999), the National Marine Fisheries Service excluded the Okanogan River from their Endangered species listing for the Upper Columbia Evolutionarily Significant Unit (ESU) of spring chinook salmon. The Okanogan River was excluded from the listing because spring chinook adults are collected as they migrate upstream at Wells Dam on the Columbia River, approximately 20 miles downstream of the confluence of the Okanogan River. The adult salmon are transported to the Winthrop National Hatchery in Winthrop, Washington, and are spawned there. The eggs and resulting fry are raised at the hatchery and later released into the Methow River.

Sockeye salmon

Sockeye salmon are known to use the mainstem Okanogan River as a migration pathway to their spawning areas in Lake Osoyoos and the upstream reaches of the Canadian Okanagan River. Sockeye salmon are not known to use Tonasket Creek.

Bull trout

There are no data or anecdotal information indicating bull trout ever were, or that bull trout currently are, in the Tonasket Creek watershed. Data that does exist suggests that bull trout did not exploit the Okanogan River north of the city of Omak, approximately 30 river miles down-river of the confluence of Tonasket Creek with the Okanogan River (K.Williams, personal communication). The Okanogan River is not suitable habitat for bull trout due to the bull trout requirement of very cold, clean waters with clean gravel/cobble substrate for successful spawning and rearing.

Scott and Crossman (1973) reported that bull trout are not present within the Canadian Okanagan River system.

5.17.3 Habitat Limiting Factors Assessment of the Tonasket Sub-basin

Tonasket Creek was divided into three reporting units (reaches) in addressing potentially limiting factors to salmonid production for this document (**Table 5-19**).

Reach 1 (from the mouth of Tonasket Creek to River Mile 1.9) is considered usable salmonid habitat provided that there is adequate flow. Reach 1 ends at the base of a long, steep gradient channel that is considered to be a natural passage barrier.

Reach 2 (River Mile 1.9 to RM 13.2) includes the steep gradient channel. This reach ends at a large wet meadow on lands managed by the USFS. This reach has an affect on downstream water quality, but is not considered to be usable habitat for anadromous fish.

Reach 3 (River Mile 13.2 and above) includes Tonasket Creek and all its tributaries above RM 13.2. This reach is entirely on lands managed by the USFS. This reach is inaccessible to fish moving upstream from the Okanogan River.

The following rankings reference habitat criteria accepted by the Okanogan TAG group as most relevant to the production potential of anadromous salmonid fishes in the Okanogan (**Table 5-19**).

Table 5-19. Tonasket Creek Limiting Factors Assessment

Attribute Considered	Anad potential reach 0.0 - 11.9 Reach 1	Water quality reach 11.9 - 13.2 Reach 2	Non-issue reach above 13.2 Reach 3
Water Quality			
Dissolved Oxygen	G1*	G1*	N/A
Stream Temperature	G1*	G1*	N/A
Turbidity/Suspended Sediment	G1*	G1*	N/A
Nutrient Loading	DG	DG	DG
In Channel Habitat			
Fine Sediment (substrate)	G2	N/A	N/A
Large Woody Debris	P2	DG	N/A
Percent Pool	DG	DG	N/A
Habitat Access			
Fish Passage	F2	N/A	N/A
Stream Flow			
Resembles Natural Hydrograph	F2	2	G2
Impervious Surface	G2	G2	G2
Stream Corridor			
Riparian Vegetation	P2	F2	G2
Stream Bank Stability	G2	F2	G2
Floodplain Connectivity	P2	F2	G2

* Okanogan Conservation District (OCD) data

Support for Limiting Habitat Factor Rankings in the Loup Loup Creek Sub-basin

Reach 1-

Water Quality

Dissolved Oxygen - Dissolved oxygen is rated Good based on the 110% saturation level (10.98 mg/l at 15.4^{o}C), as represented in data collected by the Okanogan Conservation District (OCD) from May of 2000 to February 2001. Dissolved oxygen information was collected only when sufficient flowing water is present.

Stream Temperature - Stream temperatures were below 18^{o} C., in the same time period as the DO information was collected.

Turbidity - Turbidity measurements were all less that 20 NTUs. Data was collected in the same time period as the dissolved oxygen information.

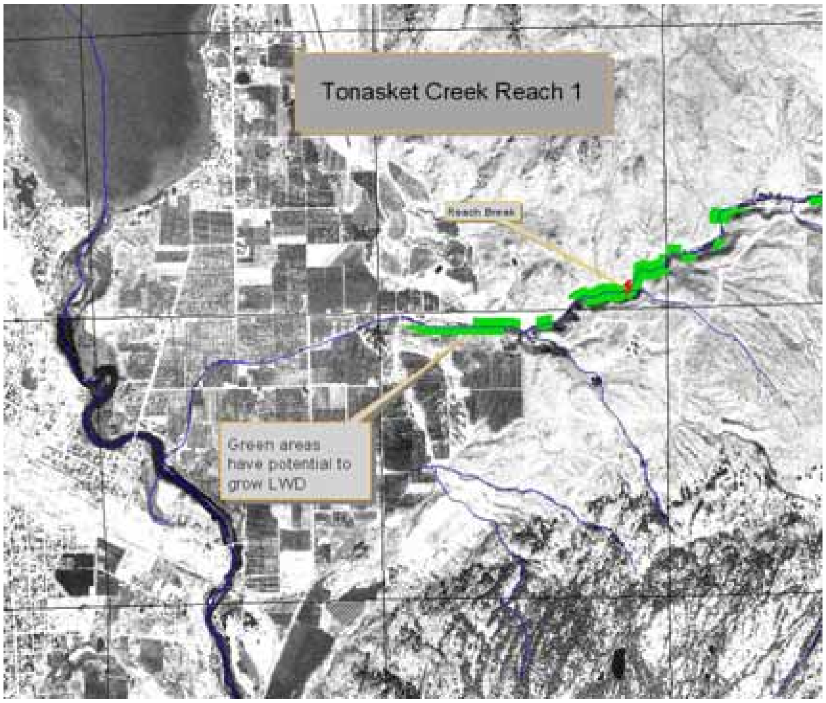
Nutrient Loading - A data gap exists for Chemical Contamination/Nutrient Loading.

In-Channel Habitat

Fine Sediment - The substrate in the channel on the private lands has not been extensively observed. Spot visual observations (K.Cooper, personal communication) at potential spawning sites reveal the substrate to be in a Good condition.

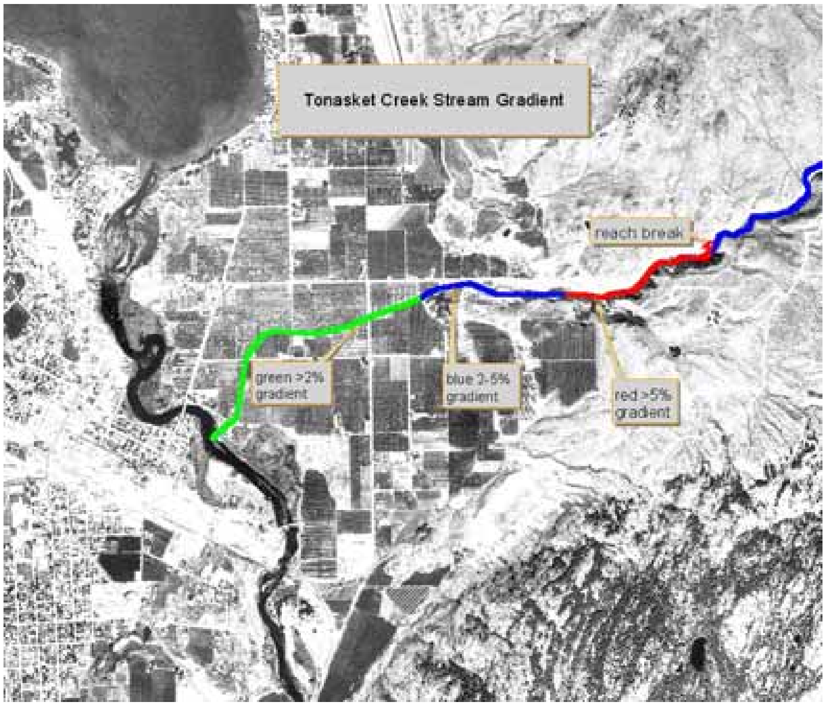
Large Woody Debris - Sites with potential for providing large woody debris (**Figure 5-12**). Determination was made by remote sensing (GIS/Arcview mapping), not from on-the-ground collected data. Non-forested habitat types comprise 75% of 50 meter wide buffers on each side of Tonasket Creek. This indicates that the potential for large woody debris recruitment is low. By the matrix definitions, this reach rates Poor for large woody debris, but this rating must be tempered by considering the potential natural condition (non-forested_ along this reach. Trees of a size to be classified as large woody debris are unlikely to grow in non-forested habitat types.

Figure 5-12. Potential for large conifers



Percent Pools – **Figure 5-13** depicts where the stream channel is of a gradient of 2% or less, where it is 2-5%, and where it is greater than 5%. The total stream length in this Reach is 1.9 miles. The amount of stream channel that has 2% or less gradient is 0.9 miles (48% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is 0. miles (26% of the channel length in this reach). The amount of stream channel that is greater than 5% gradient is 0.5 miles (26% of the channel length in this reach). These determinations were made by remote sensing. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The actual number of pools in this reach is a Data Gap.

Figure 5-13. Stream Channel Gradients



Habitat Access

Fish passage is assumed to RM 1.9, the bottom end of the steep gradient channel, whether useable habitat is available beyond that point is a Data Gap. This criterion rated Fair, because the water levels in Reach 1 are known to fluctuate and at times to go dry, though the exact location of the withdrawal(s) is not known.

Stream Flow

Resembles Natural Hydrograph - The stream flow in Reach 1 is altered as a result of water withdrawal, though the exact location of the withdrawal(s) is not known. It is unknown if the withdrawals are direct from the stream channel, or if they are indirect, from the hyporheic zone adjacent to the stream channel(s) (C. Fisher, personal communication). This reach rates Poor for this criterion.

Stream Corridor

Riparian Vegetation - The riparian vegetation in this reach rated Poor, based on spot visual observations (K.Cooper, personal communication). Shade has been greatly reduced in the lower portion of Reach 1, the natural vegetation has been replaced by orchards. In other places agricultural conversion of lands to pastures, and crop lands, has occurred. Trees and other vegetation have also been removed for clearing of the right of way for County Road 9480.

Stream Bank Stability - Stream bank stability is Good, but this is based in part on observation of some rip-rapped stream sideslopes, and trapezoidal maintained stream channel through orchards.

Floodplain Connectivity - Flood plain connectivity is rated as Poor based on spot visual observations (K.Cooper, personal communication). Tonasket Creek has been channelized through orchards and along

County Road 9480 for at least 1 mile to the Okanogan River. No flood plain was created when the channel was constructed.

Reach 2-

Reach 2 affects the water quality downstream in Reach 1, but due to its steep gradient is not considered anadromous fish habitat.

Water Quality

Dissolved Oxygen - Dissolved oxygen (DO), as shown in the OCD data (collected May 2000- February 2001) for their sample site in Reach 2 indicates a saturation level of 95% (10.16 mg/l at 13.3^{o} C.), rating this Reach as Good for DO.

Stream Temperature - Stream temperature was in the Good category according to the OCD data.

Turbidity - Turbidity was also in the Good range according to OCD data.

Nutrient Loading - Nutrient loading and Chemical Contamination information is a data gap for Reach 2, as well.

In-Channel Habitat

Substrate - Because Reach 2 is not considered to provide anadromous fish habitat, the substrate condition criterion does not apply.

Large Wood - Determination was made by remote sensing (GIS/Arcview mapping), not from on-the-ground collected data. In Reach 2, non-forested habitat types comprise 13% of 50 meter wide buffers on each side of Tonasket Creek. There is a Data Gap regarding the number of pieces of large woody debris within this reach. It appears the potential for producing large woody debris size class material may be present in this reach.

Percent Pools - The total stream length in this Reach is 11.3 miles. The amount of stream channel that has 2% or less gradient is 2.4 miles (22% of the channel length in this reach). The amount of stream channel that is of 2-5 % gradient is 6.2 miles (56% of the channel length in this reach). The amount of stream channel that is greater than 5% gradient is 2.6 miles (23% of the channel length in this reach). These determinations were made by remote sensing. Where the gradient is 5% or greater, there is less likelihood of large pools than in gradients of 5% or less. The actual number of pools in this reach is a Data Gap.

Habitat Access

Fish Passage - This criterion is not applicable because the reach, due to its high gradient, is not considered to provide anadromous fish habitat.

Stream Flow

Resembles Natural Hydrograph - Stream flow information collected by OCD indicates that this criterion rates Fair. Timing of upstream withdrawals may be the problem.

Impervious Surfaces - Casual observations along this Reach indicate a lack of impervious surfaces, ranking this Reach as being in Good condition.

Stream Corridor

Riparian Vegetation - The vegetation composition of this Reach is rated as Fair, the vegetation has been altered, but still appears to be within 25-50% of the potential natural community composition.

Stream Bank Stability - Because of some streamside alteration of vegetation types, the stream bank stability is considered Fair.

Floodplain Connectivity - The construction and maintenance of the County Road has altered the sideslopes of the creek in places, and as well, the construction of the County Road usurped part of the flood plain. In places where the sideslopes are quite steep, the sideslopes have not been altered much over the years, but in those places, the channel is confined without much of a flood plain. This criterion is considered as Fair.

Reach 3-

Water Quality-

Dissolved Oxygen - Stream Temperature - Turbidity-

Reach 3 includes Tonasket Creek and it tributaries above and inclusive of the wet meadow in T39N, R28E, Section 23, NE¼. The wet meadow intercepts any sediment that might be delivered, and the DO and temperature are altered as a result of the transport in the 11.3 miles of Reach 2. Thus, the water quality (DO, temperature and turbidity) of Reach 1 is not affected by that of Reach 3. The above criteria are not applicable.

Nutrient Loading - Chemical Contamination and Nutrient Loading for this reach is a data gap.

In-Channel Habitat

Fine Sediment - Fine sediment that is delivered down Reach 3 settles in the wet meadow, so this criterion is not applicable.

Large Wood - Large woody debris that may fall into the channel above the wet meadow is not likely to be delivered through the meadow and downstream to Reach 1, so this criterion is not applicable.

Percent Pools - This reach does not affect the reach of Tonasket Creek used by anadromous salmonids, so this criterion is not applicable.

Habitat Access

Reach 3 is above one natural fish barrier (long high gradient riffle), as well as two man-made barriers (a culvert under County Road 9480, and another culvert on Forest Road 3524-100), thus, this Reach is not usable or accessible by anadromous fish.

Stream Flow

Resembles Natural Hydrograph - Reach 3 flows are not known to be altered, so this criterion rates Good.

Impervious Surfaces - Impervious surfaces are not known to be present in Reach 3 (Tonasket Ranger District 1996).

Stream Corridor

Riparian Vegetation - Riparian vegetation is in Good condition (Tonasket Ranger District 1996), with the potential natural community and composition being greater than 50%.

Stream Bank Stability - Stream bank stability is in Good (Tonasket Ranger District 1996).

Floodplain Connectivity - The floodplain connectivity is currently in Good condition (Tonasket Ranger District 1996).

5.18 SIMILKAMEEN RIVER BASIN

5.18.1 Sub-basin Overview

The Similkameen River is the largest tributary to the Okanogan River that originates in the Washington Cascades, flows north into Canada, and loops around to the south into the northern reaches of Okanogan County, Washington. The Similkameen Basin is 666.53 square miles, containing 17 rivers and streams, with a perimeter of 226.89 miles (EPA website). The Similkameen drainage basin is 3600 square miles, 80 percent of which is in the Canadian portion of the watershed (Interim Instream Flow Report, 1986). It is bordered to the south by the Sinlahekin River, which joins the larger tributary at the Palmer Lake Reservoir. The Similkameen watershed is ranked by the USDA as a high priority sub-watershed with a 303(d) listing from the Washington Department of Ecology (WDOE) in 1997 (WDOE 1997).

Land Use and Ownership

The Similkameen River Basin is primarily comprised of forested lands and rangelands. Just as in the Okanogan River Basin, ownership of the Similkameen encompasses public and private lands. The public sector is made up of the US Forest Service, Washington Department of Natural Resources (WDNR) and the US Bureau of Land Management.

There is a total of about 210,000 acres (private and WDF&W estimates not known) of land in the Similkameen and Sinlahekin Basins currently used for grazing. As a result of present and historical overgrazing, the land around the Similkameen shows signs of degradation; in 1982, the Bureau of Land Management classified 32% of the rangeland condition as poor. The livestock cause hoof shear as they travel along the water's edge, and graze out the native plants that would add stability. These two combined activities cause erosion of the streambank and sediment deposition into the river. In 1982, 111.6 miles of the Similkameen and Sinlahekin were assessed for streambank stability, and almost 3% were found to be unstable due to grazing impacts.

Other factors that promote instability in the streambank are active mining, road construction and irrigation. According to the USFS, there are a total of 50.5 miles of road within 200 ft of the Similkameen (WQ management, 2000). These activities lead to increased runoff and less infiltration.

Topography, Geology & Soils

Steep mountainous regions characterize the shape of the Similkameen Basin. The basin is a transitional zone between the Cascade Mountains to the west and Okanogan Highlands to the east (Enloe Hydroelectric Project, 2000). The valley was carved out through glacial activity during the Pleistocene ice age (www.env.gov.bc.ca wesite). Cordillian ice sheets and their meltwater also effected the basin's drainage patterns. During the ice sheets migration south from the interior of British Columbia, the advance and retreat activity cut deep narrow canyons. The valley walls climb to elevations around 2,800 ft from the water's edge. There is little water storage, and runoff and floods are quite common.

The Similkameen Basin has a semi-arid climate, with the exception of the western mountainous regions that are relatively wet (Enloe Hydroelectric Project, 1989). The soils in the basin that result from this climate display an assorted diversity.

Fluvial Geomorphology & In-Channel Habitat

The noxious weed, Diffuse knapweed, is an invader species and a serious water quality threat in the Similkameen watershed. The watershed is listed as a Class C river for in-channel vegetation. The introduced species crowd out the native vegetation and create instability along the riverbanks. Noxious weeds are characteristic for having deep tap root systems as opposed to the fibrous roots of the native species. Woody vegetation increases stability by deflecting the water energy away from the bank, thereby retaining the bank soils during high flows.

The Similkameen has the greatest impact on the Okanogan in terms of erosion problems, with an erosion rate of 1.18 acre-ft per square mile. In a Pacific Southwest Interagency Committee (PSIAC) model study in 1998, the Bonaparte Creek and the Similkameen subwatersheds yielded 33% of the total sedimentation yield, even though they cover only 9.5% of the total modeled land area. In 1972 at Nighthawk, six miles above Enloe Dam, average annual suspended-sediment discharge was 134,000 tons per year. The recorded accumulation of sediment from 1920-1972 created an average water level rise of 0.65 feet per year.

Vegetation and Riparian Condition

The vegetation in this semi-arid climate is a mixture of three steppe vegetation zones within four major vegetation communities. High hillsides promote the growth of ponderosa pine with bitterbrush as the dominant understory. On the lower slopes big, sagebrush/bluebunch wheatgrass are found on the gentle rises, while bitterbrush/Idaho fescue community thrives on the steeper, rocky regions. Treetip sagebrush, rubber rabbitbrush, arrowleaf balsamroot, prickly pear, and a variety of grasses are considered to be associate species. The fourth community is made up of smooth sumac and cheatgrass on the slopes above the reservoir.

Water Quantity/Hydrology

Water supply

The total drainage area for the Similkameen River is 3550 mi^2, mostly in the Canadian portion of the basin (Enloe Hydroelectric Project, 1989). This includes two principal drainages on the Washington side: the Pasayten and Ashnola.

There is no principal aquifer in the majority of the Similkameen River Basin, but there are 29 square miles of Pacific Northwest fill aquifers composed of unconsolidated sand and gravel (USGS 1998). There is also a metamorphic, granitic and consolidated sedimentary rock component that has low permeability and porosity (Enloe Hydroelectric Project, 1989).

Streamflow

The Similkameen provides 75% of the average flow to the Okanogan River Basin. Peak flows occur around May to June (8,000-9,000 cfs), with a constant flow around 600-900 cfs the rest of the year. The peak makes up about 61 percent of the annual flow, while the months of August through March make up between 2.2 to 3.3 percent of the total annual discharge (Enloe Hydroelectric Project, 2000). Suspended Sediment flows closely follow streamflow peaks, forming a plateau of 11,500 mg/L between April and June (Okanogan Water Quality Management Plan, 2000). Because it is such a major contributor, the problem of suspended sediment transported in the Similkameen is magnified.

Water Quality

There is one 303(d) listing because of four excursions past the standard out of 34 samples for water temperature between 1991-1996 (Proposed 1998 Section 303(d) List), 1997). The Similkameen River is a Class A River and must hold to these water quality standards. The standard temperature for Class A is 18°

C. The Similkameen has been measured above this temperature through most of August and into July. Temperatures required for successful salmon spawning range from 3.9° - 20° C. The Similkameen has temperatures of 22° C (as high as 26 C) in mid-summer, precluding summer rearing by juvenile salmonids (WQ management, 2000).

5.18.2 Anadromous Salmonid Fisheries Resources of the Similkameen Basin

Even though there are problems with sedimentation and water temperature, chinook salmon runs have increased slightly in the Similkameen River and declined in the Okanogan (WQ Management, 2000) (**Figure B-18**). This could be due to the migration barrier that the Conconully Dam provides; passage for salmon runs have been constructed through abandoned power plant, Enloe Dam, 8.8 miles above the confluence with the Okanogan River.

Excess silt and sedimentation has degraded salmon spawning habitat by reducing pool sizes. As the pools become shallower and wider, more surface area is exposed to direct sunlight, increasing temperatures.

5.18.3 Habitat Limiting Factors Assessment of the Similkameen Basin

The following information discusses the factors affecting fish distribution in the Similkameen River (**Table 5-20**)

Table 5-20. Similkameen River Limiting Factors Assessment

Attribute Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	
Stream Temperature	
Turbidity/Suspended Sediment	
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	
Large Woody Debris	
Percent Pool	
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	
Stream Flow	
Resembles Natural Hydrograph	
Impervious Surface	
Stream Corridor	
Riparian Vegetation	
Stream Bank Stability	
Floodplain Connectivity	

5.19 NINEMILE CREEK WATERSHED

5.19.1 Sub-basin Overview

Ninemile Creek Subbasin is in the Northeast corner of the Washington-Canada border of the Okanogan Watershed. The main tributary that forms the subbasin generates from Osoyoos Lake on its western border. The majority of the Ninemile Creek subbasin is in Canada, to the northeast of Osoyoos Lake. The land ranges from arid desert to coniferous forest. No other major bodies of water are found on the Canadian side besides Ninemile Creek.

Land Use and Ownership

The close proximity of Osoyoos Lake to this arid region provides the irrigation needs for orchards in both the US and Canada portions of Ninemile Creek (www.ncw.wsu.edu/PNWTrees, 4/30/01). The major crops consist of apples, pears, sweet cherries, and peaches, while wine grapes are considered more minor crops (www.ncw.wsu.edu/PNWTrees, 4/30/01).

Topography, Geology & Soils

The altitude varies from 300 to 1000 ft from west to east across the subbasin. The Ninemile Valley is comprised of arid terraced land rising across the valley to forested regions on the east edge of the subbasin (www.ncw.wsu.edu/PNWTrees, 4/30/01).

Due to continental and alpine glacial activity, Pleistocene glacial deposits and Holocene alluvial deposits make up the soil structure of the Okanogan watershed (Ecology, 1999). Bedrock is composed primarily of granitic and andesitic rocks, and metamorphosed sedimentary rocks (Ecology, 1999).

Vegetation and Riparian Condition

Ninemile Creek subbasin is in a Montane Cordillera terrestrial ecozone (www.atlas.gc.ca, 4/30/01). On the Washington of the Ninemile subbasin there are two main vegetation types: forest land and shrub/grass land. Along with the elevation gain, the grasslands become forested areas along the eastern fringe. The nearness of the Cascade Range provides a rain shadow for the Ninemile Creek subbasin, forming dry, arid lands with an abundance of water due to snowmelt into the adjacent Osoyoos Lake and Ninemile Creek region (www.ncw.wsu.edu/PNWTrees, 4/30/01).

Water Quantity/Hydrology

Water supply

Streamflow

Water Quality

Ninemile Creek was added to the Washington State 1998 303(d) list for DDT (NW Power Council, 2001). Another parameter of concern is the sedimentation rate, which is at 0.33 ac-ft/mi2. Sedimentation degrades habitat for salmonid species and increases temperatures (NW Power Council, 2001). Ninemile Creek is further north from the confluence of the Similkameen with the Okanogan and so is not influenced by the high levels of sedimentation coming from the Similkameen River.

5.19.2 Anadromous Salmonid Fisheries Resources of Ninemile Creek

The Zosel Dam/Osoyoos Lake region is important during the summer chinook spawning months of September to November (**Figure B-19**). The Similkameen is one of the most productive areas for summer chinook, and according to the 1998 survey of summer chinook redds, a total of 238 redds were counted during the spawning season (Murdoch and Miller 1999). The influence of the Similkameen and Okanogan River close to Zosel Dam creates great potential for tributary escapement into Ninemile Creek branching off to the east of Osoyoos Lake.

5.19.3 Habitat Limiting Factors Assessment of the Ninemile Creek Sub-basin

The following information addresses the factors affecting fish distribution in the Ninemile Creek sub-basin (**Table 5-21**).

Table 5-21. Ninemile Creek Limiting Factors Assessment

Attribute Considered	Anadromous potential, Water Quality concerns
Water Quality	
Dissolved Oxygen	
Stream Temperature	
Turbidity/Suspended Sediment	
Nutrient Loading	
In Channel Habitat	
Fine Sediment (substrate)	
Large Woody Debris	
Percent Pool	
< 2%	
2-5%	
>5%	
Habitat Access	
Fish Passage	
Stream Flow	
Resembles Natural Hydrograph	
Impervious Surface	
Stream Corridor	
Riparian Vegetation	
Stream Bank Stability	
Floodplain Connectivity	

6.0 SUMMARY OF ACTION ITEM RECOMMENDATIONS BY SUB-BASIN

This chapter provides a bulleted summary of the action item recommendations by sub-basin, based upon the limiting factors assessment results and data gaps identified in chapter 5. The recommendations provided here are not prioritized, and are based upon the current technical understanding of the Okanogan TAG. Action item recommendations for the Canadian sub-basins are beyond the scope of this current effort, but will be addressed in other related forums.

6.1 OKANOGAN MAINSTEM ACTION ITEMS

Okanogan TAG to complete.

6.2 CHILIWIST CREEK SUB-BASIN ACTION ITEMS

6.3 DAN CANYON SUB-BASIN ACTION ITEMS

6.4 LOUP LOUP SUB-BASIN ACTION ITEMS

As evidenced by the current use of the upper reach of Loup Loup Creek by eastern brook trout and resident rainbow trout, water quality conditions are generally conducive for salmonids to exist. However, passage barriers and altered hydrology effectively eliminate the use of this system by anadromous salmonids except at the confluence of the system with the Okanogan mainstem. Based upon the limiting factors discussion and tabulation provided in section 5.3, the following (unprioritized) action items are recommended to improve habitat conditions in the Loup Loup sub-basin. in contrast, the lower reach (RM 0 to ~ 2.5) of Loup Loup Creek has several factors that limit the ability for salmonids to become reestablished. Two fish passage barriers (~ RM 0.1 and 0.25) impede upstream migration by adult steelhead thus preventing natural reproduction for this endangered species. Furthermore, flows at ~ RM 2.0 are diverted for irrigation during the irrigation season and thus causing flows to become non-existent in this lower reach by mid-summer. Thus, before Loup Loup Creek can be beneficial to the recovery of anadromous salmonids particularly for summer steelhead, continuous flows need to be provided in the lower reach in sufficient amount for incubation and juvenile survival and current barriers need to modified or removed for migrating adult steelhead to access this lower reach.

- Formally evaluate fish passage conditions in system proceeding from the mouth upstream to the first natural blockage (RM 2.5).

- Examine water use in basin and eliminate excess uses water to re-establish flow regimes where possible in naturally anadromous zones

- Correct human-caused fish passage blockages as identified from further study, in concert with flow remediation to lower creek below falls at RM 2.5.

- Conduct quantitiative habitat assessment study to identify functional and non-functional reaches and to prioritize habitat reaches for practicable in-channel and stream corridor (i.e., riparian) restoration.

- Examine Tallant Creek for potential habitat value through quantitative study. Identify source(s) of DDT contaminantion and determine if continued DDT contamination prevents or limits function of system for anadromous salmonids

6.5 DULEY LAKES/JOSEPH FLATS ACTION ITEMS

6.6 FELIX CREEK ACTION ITEMS

6.7 OMAK CREEK ACTION ITEMS

6.8 SALMON CREEK ACTION ITEMS

6.9 WANACUT CREEK ACTION ITEMS

6.10 JOHNSON CREEK ACTION ITEMS

6.11 TUNK CREEK ACTION ITEMS

6.12 CHEWILIKEN CREEK ACTION ITEMS

6.13 AENEAS CREEK ACTION ITEMS

6.14 WHITESTONE CREEK ACTION ITEMS

6.15 BONAPARTE CREEK ACTION ITEMS

6.16 SIWASH CREEK ACTION ITEMS

6.17 ANTOINE CREEK ACTION ITEMS

6.18 TONASKET CREEK ACTION ITEMS

6.19 SIMILKAMEEN RIVER ACTION ITEMS

6.20 NINEMILE CREEK ACTION ITEMS

7.0
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APPENDIX A

OKANOGAN OVERVIEW MAPS FOR FISH DISTRIBUTION

WITHIN THE ENTIRE BASIN

APPENDIX B

CHINOOK, SOCKEYE AND STEELHEAD FISH DISTRIBUTION MAPS OF THE WASHINGTON OKANOGAN/SIMILKAMEEN SUB-BASINS

APPENDIX C

PHOTOGRAPHS OF SELECT SUB-BASIN CONDITIONS

APPENDIX D

CANADIAN OKANOGAN/SIMILKAMEEN SUBASIN SUMMARY

APPENDIX E

CHINOOK, SOCKEYE AND STEELHEAD FISH DISTRIBUTION MAPS OF THE CANADIAN OKANOGAN/SIMILKAMEEN SUB-BASINS