CAMAS CREEK WATERSHED ASSESSMENT

Prepared By

Ecovista

For

U.S. Army Corps of Engineers & the
Confederated Tribes of the Umatilla Indian Reservation

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Contributors

Anne Davidson, GIS, Ecovista

Dr. Michael Barber, Washington Water Research Center, Washington State University

Ed Farren, Hydrology, Umatilla National Forest, Ukiah Ranger District

Kristi Groves, Fisheries, Umatilla National Forest, Ukiah Ranger District

Chris Helberg, GIS, Umatilla National Forest, Ukiah Ranger District

Tom Macy, Fisheries, Confederated Tribes of the Umatilla Indian Reservation

Stan Heller, Planning, USACE, Walla Walla, Washington

Jim Brown, Oregon Department of Transportation, LaGrande, Oregon

Caty Clifton, Umatilla National Forest Supervisors Office, Pendleton, Oregon

Tim Unterwegner, Fisheries, ODFW, John Day, Oregon

Wayne Wilson, Fisheries, ODFW, John Day, Oregon

Jim Ruzycki, Fisheries, ODFW, LaGrande, Oregon

Rick Barnes, Barnes and Associates, Inc., Roseburg, Oregon

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For more information about the Camas Creek Watershed Assessment or to obtain copies of this report, contact:

Walla Walla District, United States Army Corps of Engineers
201 North 3rd Avenue
Walla Walla, WA 99362
509-527-7020
cenww-pa@usace.army.mil

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List of Acronyms and Abbreviations

af	acre-feet
BE	Biological Evaluation
BiOp	Biological Opinion
BLM	Bureau of Land Management
BP	before present
BPA	Bonneville Power Administration
BRT	Biological Review Team
cfs	cubic feet per second
COE	U.S. Army Corps of Engineers
CRB	Columbia River Basalt
CRITFC	Columbia River Intertribal Fish Commission
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
dbh	diameter at breast height
DSL	Oregon Division of State Lands
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
fps	feet per second
GIS	Geographic Information System
GPS	Global positioning system
HUC	Hydrologic Unit Code (as defined by the USGS)
ICBEMP	Interior Columbia Basin Ecosystem Management Project
m	meters
MBF	Million board feet
MEG	Monitoring and evaluation group
mm	millimeters
mps	meters per second
N.A.	not available
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPPC	Northwest Power Planning Council
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory

(List of Acronyms & Abbreviations Continued)

OAR	Oregon Administrative Rules
OCH	off-channel habitat
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
ONHP	Oregon National Heritage Program
ORVs	Outstandingly Remarkable Values
OSP	Oregon State Police
OWAM	Oregon Watershed Assessment Manual
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
PACFISH	Environmental Assessment for the Implementation of Interim Strategies for Managing Anadromous Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California
PEA	Programmatic Environmental Assessment
PRISM	Parameter-elevation Regressions on Independent Slopes Model
R6	USFS Region Six
Reclamation	U.S. Bureau of Reclamation
Register	National Register of Historic Places
RM	River Mile
ROS	Rain-On-Snow
RSI	Riffle Stability Index
SAR	Smolt to adult survival rates
SDM	Smolt Density Model
SPG	System Planning Group
UNF	Umatilla National Forest
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
W:D	Width:Depth Ratio

1 Executive Summary

On May 30, 2003, Ecovista was subcontracted through Normandeau Associates, Inc. to conduct a watershed assessment on select drainages in the Camas Watershed, Oregon for the US Army Corps of Engineers, Walla Walla District (Contract # DACW68-02-D-0002). A primary objective of the assessment is to document current habitat conditions for spring chinook and steelhead, and to make limiting factor determinations.

The Camas study area, which encompasses nine sixth-field HUCs (USGS defined), covering a total of 197,550 acres, is located in the Blue Mountain ecoregion, approximately 50 miles south of Pendleton, Oregon and 50 miles west of LaGrande, Oregon. It is defined by basalt geology, relatively gentle topography, and a continental climate with a marine influence. The US Forest Service (Umatilla National Forest) manages 55% of the lands in the watershed, followed by private landowners (39% of the total area), the state of Oregon (5%), and the Bureau of Land Management (BLM; 1%).

Streams are generally small in size. The annual mean discharge measured at the town of Ukiah, Oregon is 96.3 cfs and the average runoff volume is 70,200 acre-feet (10.88 in). Flows rapidly drop off in June and July, reaching base levels by early August (5.3 cfs). A maximum discharge of 3,840 cfs occurred on January 30, 1965 compared to the minimum discharge of 1 cfs which occurred between June 24 and July 2, 1940.

Temperatures in excess of state criteria have been identified as one of the primary factors limiting resident and anadromous production in the Camas Watershed. The entire mainstem Camas and several key tributaries are on the state of Oregon's 303d list for temperature violations. Low baseflows, limited amounts of stream shading, channel morphology and aspect, geothermal inputs, and ground water interception are contributing factors to the temperature problems.

Summer steelhead escapement to the Camas Assessment Area has fluctuated both spatially and temporally. Between-stream comparisons show that the number of redds observed in the mainstem Camas and Cable Creek index areas were consistently higher than in other streams surveyed. The most successful period for redd construction occurred during the late 1960s and then again in the mid-1980s. On average, 17 steelhead redds are observed during annual surveys.

The Camas Drainage accounts for only a small percentage of spring chinook production in the John Day Subbasin, which therefore precludes quantitative determinations of population trends. Based on the limited data, it appears that spring chinook use the Camas somewhat opportunistically, and will spawn and rear during years where escapement to the John Day is exceptionally high and/or when environmental (i.e. temperature and flow) conditions in the watershed permit. Current chinook distribution is largely restricted to portions of the mainstem Camas, but may include primary tributaries during years defined by adequate streamflow and stream temperatures.

Riffle habitat quality and quantity is high throughout the Camas Assessment Area, although the quantity and quality of pool habitat is generally poor. One explanation for the lack of pool habitat is the overall low relative abundance of large woody debris (LWD) in most reaches. The quality of steelhead spawning and incubation habitat is highest in the mainstem, and lowest in the Bowman (upper Camas area) subwatershed. Steelhead summer rearing and overwintering habitat is generally lacking throughout the Camas Drainage, but is highest in the Hidaway subwatershed, and lowest in the Bowman subwatershed.

Although there have been extensive modifications to upland and lowland resources throughout the drainage, it was not possible to identify a shift in peak or base flow magnitude or frequency. Of the various processes of erosion that may affect salmonid habitat, surface erosion is the highest and most widespread form.

Excessive stream temperatures and habitat simplification represent the most common limiting factors to anadromous salmonid production/productivity throughout the Camas Assessment Area. Six of the nine subwatersheds assessed are on the state of Oregon's 303d list for temperature violations (Lower Camas, Camas/Wilkins, Lane, Bowman, Cable, and Hidaway). High streamside road densities limit stream channel interaction with floodplain areas, and contribute to an overall lack of overwintering and summer rearing habitat.

2 Macro Environment

2.1 Setting

The Camas Creek Drainage is located entirely within the state of Oregon, approximately 50 miles south of Pendleton and 50 miles west of LaGrande (Figure 1). The assessment area is bounded to the west by Sugarbowl Ridge and to the south by Pearson Ridge. The majority of the study area occurs in Umatilla County, with some headwater portions extending into Union County (Figure 1). The town of Ukiah, population 260, is the only incorporated town in the assessment area.

Camas Creek is a tributary to the North Fork John Day River (US Geological Survey [USGS] hydrologic unit code [HUC] 17070202), the confluence occurring at river mile (RM) 57. The North Fork represents the most significant tributary to the John Day River (HUC 170702) due to its contribution of flow (60%) and cool water. The John Day system in its entirety contains over 500 river miles and is one of the largest undammed rivers in the western United States. The John Day River is also the longest free-flowing river containing wild salmon and steelhead within the Columbia River Basin.

The analysis area encompasses nine sixth-field HUCs (USGS defined), covering a total of 197,550 acres. Included in the study area is the mainstem Camas Creek (confluence to headwaters), and the Cable, Hidaway, and Owens Creek subwatersheds (Figure 2).

The primary land owner in the Camas Drainage is the UNF, North Fork John Day Ranger District (Table 1). An almost equal amount of the subbasin is in private ownership (Figure 3). The remainder is owned by the Oregon Department of Fish and Wildlife (ODFW) and BLM.

Table 1. Division of land management/ownership in the Camas Assessment Area

Subwatershed	Land Management (Acres)			
	Forest Service	Private	BLM	State
Lane	10,636	6,075	37	0
Snipe	3,650	23,382	625	0
Bowman	41,913	2,667	0	0
Upper Owen	6,464	7,423	0	0
Lower Owen	1,782	14,608	131	0
Hidaway Cr	15,102	4,088	44	0
Camas/Wilkins	6,009	16,481	262	2,235
Cable	18,317	4,659	1,341	0
Lower Camas	183	2,425	63	6,949
Total	**104,056**	**81,807**	**2,503**	**9,183**

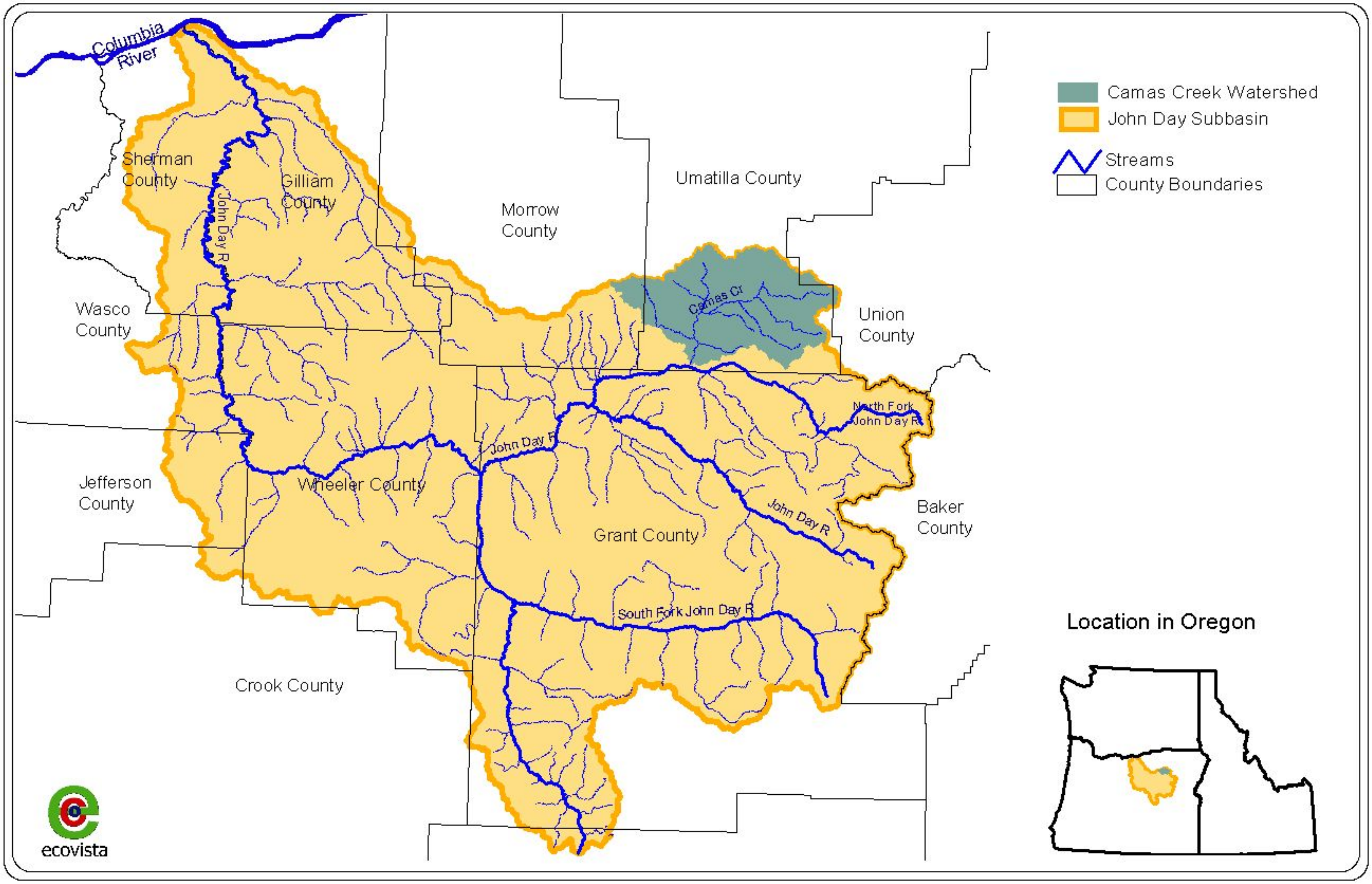

Figure 1. Locator map for the Camas Creek assessment area

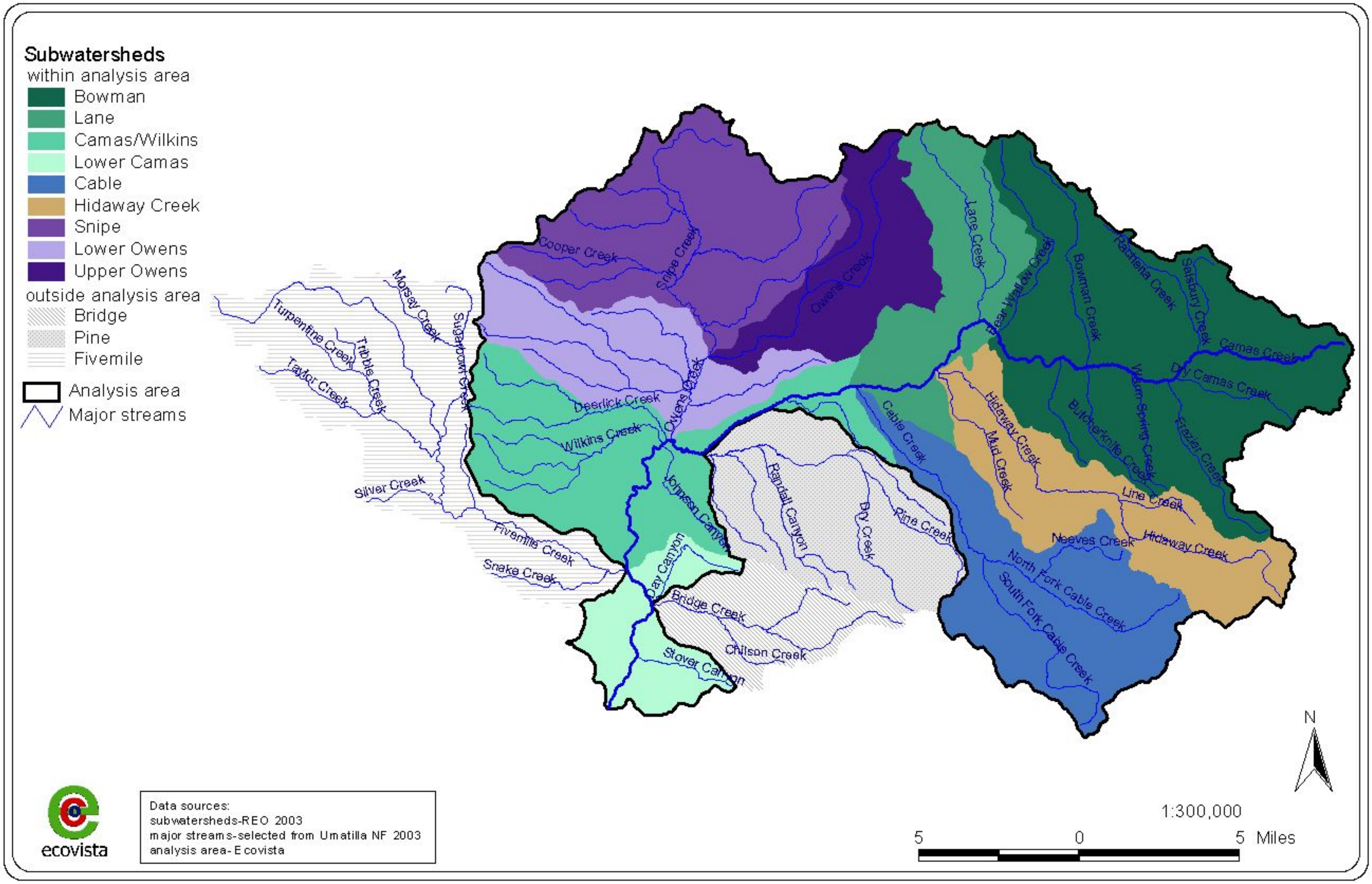

Figure 2. Camas Creek assessment area

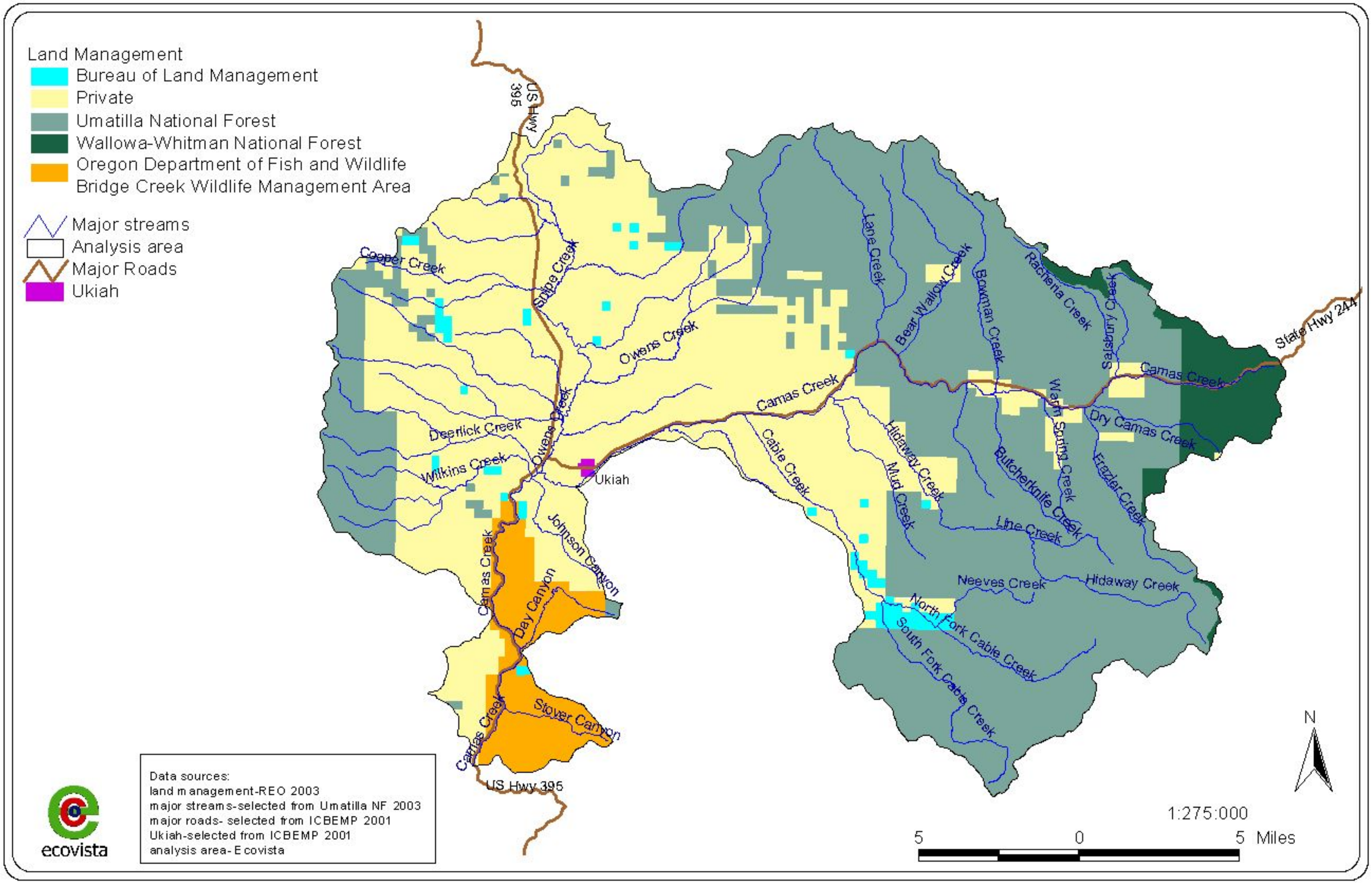

Figure 3. Land ownership in the Camas Drainage

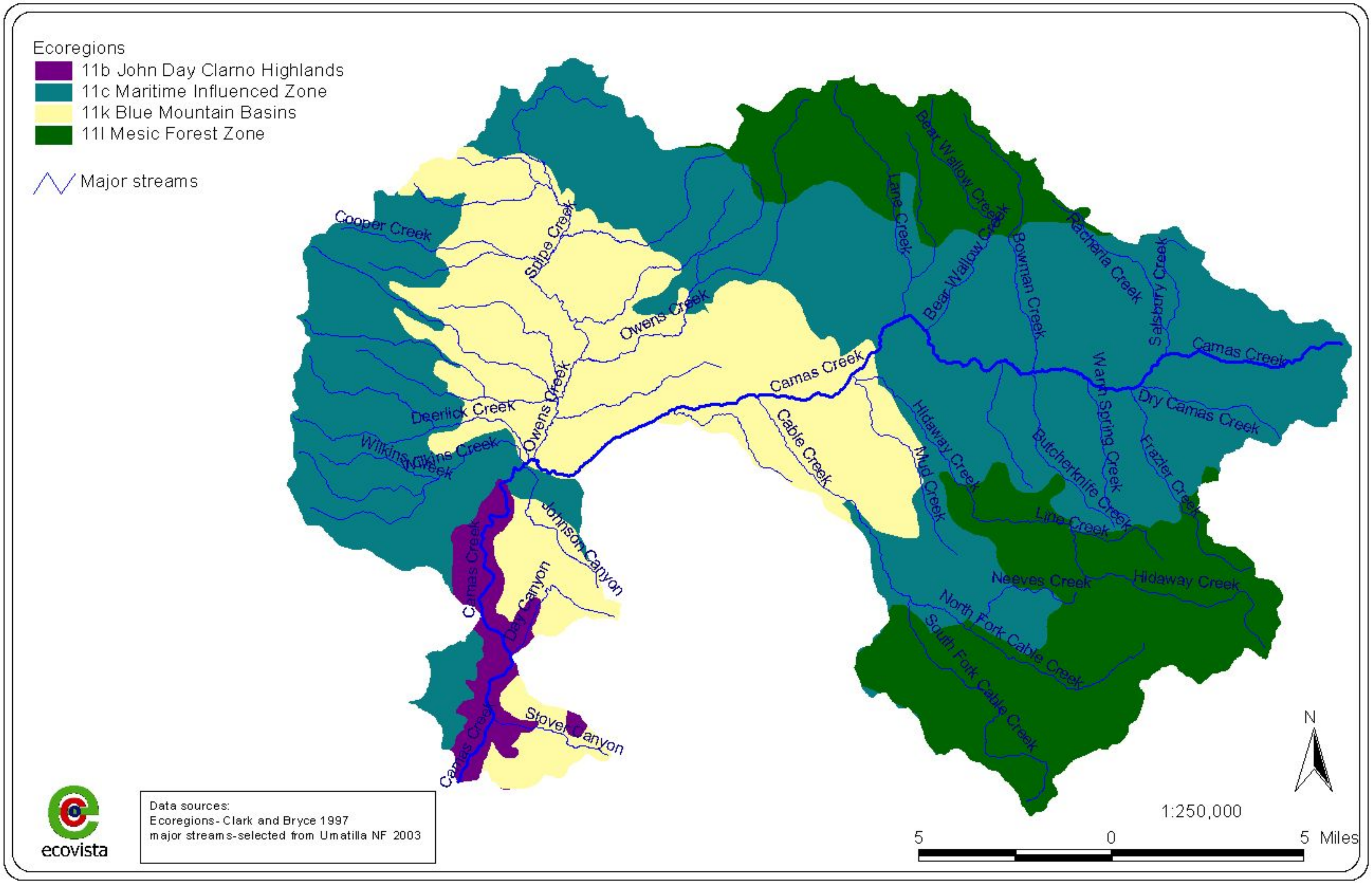

Figure 4. Subregions of the Blue Mountain Ecoregion occurring within the Camas Creek assessment area

2.1.1 Ecoregions

The Camas Creek watershed analysis area occurs within the Blue Mountain Ecoregion (BME). Ecoregions, such as the BME, are defined as areas of general similarity in type, quality, and quantity of environmental resources (Watershed Professionals Network 2001a). Local resources such as climate, geomorphology, geology, and soils influence substrate, discharge, channel morphology and chemical properties of the water. The vegetation type and extent also influence water quantity, as well as quality (i.e. temperature and nutrients). Ecoregions also share a similar response pattern to physical activities (i.e. rainfall, fire, human land use activities, etc.), thereby providing a logical framework upon which ecosystem research, assessment, management and monitoring may be conducted (Watershed Professionals Network 1999).

Pater (et al. 1998) delineated a hierarchical set of ecoregions for Oregon, as have the Environmental Protection Agency (EPA) and the Oregon Natural Heritage Program (ONHP). The EPA definitions, which are used in this document, have recently been summarized in Appendix A of the Oregon Watershed Assessment Manual (Watershed Professionals Network 1999). The EPA delineations incorporate Level III and Level IV descriptions to characterize patterns within a watershed.

There are a total of four sub-ecoregions, or sub-regions in the Camas Creek watershed analysis area (Figure 4). The percentage of area by ecoregion type is shown in Table 2. A textual characterization of the BME and each of the sub-regions has been summarized in (Bryce 2000) and is provided below.

Table 2. Blue Mountain Ecoregion area and percentage of total area in the Camas Creek assessment area

Sub-region Name	Subregion Code	Area (Square Miles)	Percent of Total Area
John Day Clarno Highlands	11b	5,713	3
Maritime-Influenced Zone	11c	97,861	50
Blue Mountain Basins	11k	49,751	25
Mesic Forest Zone	11l	44,225	22

Blue Mountain Ecoregion (Ecoregion 11)

This Ecoregion includes three mountain ranges: the Blue Mountain, Ochoco, and Wallowa mountain ranges. The Blue Mountains (11) ecoregion is mostly volcanic in origin. Only its highest ranges, particularly the Wallowa and Elkhorn Mountains, consist of intrusive rocks that rise above the dissected lava surface of the region. The area has deep canyons, high plateaus, broad river valleys, mountain lakes, forests and meadows. Short dry summers and long cold winters characterize this region. Much of Ecoregion 11 is grazed by cattle.

John Day Clarno Highlands (subregion 11b)

The John Day Clarno Highlands subregion lays in the rain shadow of the Cascade Mountains to the west, a factor that greatly defines this area characterized by little rain and wide annual and daily temperature extremes. The continental climate of this area, however, is moderated by a marine influence that spills south out of the Columbia Gorge. Soils are predominately xeric with a frigid temperature regime and low water-holding capacity. Potential vegetation cover is ponderosa pine, with true fir occurring on north slopes or in areas rich in Mazama ash. Geologic parent materials include the Picture Gorge basalts, and areas of cemented alluvium.

Maritime-Influenced Zone (subregion 11c)
The Maritime-Influenced Zone is that part of the Blue Mountains that directly intercepts the marine weather systems moving east through the break in the Cascade Range and the Columbia River Gorge. Xeric forests compose the lower elevations, while mesic forest occurs at higher elevations. Geologically, the zone is dominated by Columbia River basalts. Mean annual precipitation ranges from 58 cm (23 in) at the grassland-pine margin, to 100 cm (40 in) in the upper elevations. Mount Mazama ash and loess are common soil types; however, on south-facing slopes or grassland areas, much of this material has eroded away. Idaho fescue and mesic shrub associations occur in the subregion, as does Douglas-fir and ponderosa pine.

Blue Mountain Basins (subregion 11k)
The Blue Mountain Basins ecoregion includes the Wallowa, Grande Ronde, and Baker valleys. All three valleys are fault-bounded grabens or depressions; all are well-watered from surrounding mountains. The climate of the Wallowa and Grande Ronde valleys is moderated by a marine influence and receives an average annual precipitation of 13 to 24 inches. The Baker Valley is drier and more continental; it receives 9 to 16 inches per year. Most of the floodplain wetlands have been drained for pasture and hay.

Mesic Forest Zone (subregion 11l)
The Mesic Forest Zone is found between 4,000-7,000 feet in the western Wallowas, the western Seven Devils Mountains, and the higher elevation Blue Mountains. These areas are influenced by marine air coming through the Columbia River Gorge to the west. Much of the ecoregion’s precipitation falls as snow that persists late into the spring. The soil has a significant ash layer that is relatively rock free that helps to retain moisture during the dry season.

2.2 Geology

The geology of the Camas Assessment Area plays an important role in controlling stream-habitat characteristics. Substrate composition, habitat complexity, habitat stability, and water quantity are all affected by the geologic parent materials in a given reach (Clarke et al. 1997).

Tertiary-formed Columbia River basalt (CRB) and, more specifically, basalts from the Grande Ronde formation, comprise the dominant bedrock in the Camas Assessment Area, its occurrence roughly corresponding to the Maritime-Influenced Zone. Grande

Ronde basalts occur on over 150,000 acres in the assessment area, accounting for 76% of all geologic types identified (Table 3).

Dating from 15.5 to 19.5 million years before present, the Grande Ronde flows were the most significant of all CRB formations and are estimated to have accounted for more than 85% of the Columbia River Basalt Group (Bryce and Omernik 1997a). This Miocene lava inundated and subdued previous erosional topography, building a vast plateau that all but covered the tallest peaks in the Blue Mountain range (Orr and Orr 1996). Grande Ronde basalts are generally crystal-poor, silica-rich, and fine-grained (Reidel and Hooper cited in (Clarke et al. 1997). The flow thickness can range from five feet to as much as 150 feet, and collectively is estimated to be hundreds to thousands of feet thick (Newcomb 1965).

Other less dominant lava flows occurring throughout the assessment area include the Picture Gorge basalts and Andesite flows. Picture Gorge basalts occur near the confluence of the mainstem Camas with the North Fork John Day, which is also the area corresponding to the John Day Clarno Uplands sub-region (see Figure 5 and Figure 4). The chemical composition of the Picture Gorge basalt differs somewhat from that of the Grande Ronde basalt due to their higher magnesium content (Clarke et al. 1997). This difference is noteworthy from a geomorphologic standpoint since the Picture Gorge basalts tend to be less resistant to erosion and have a significant exposure in the areas they occur. Andesite deposits occur outside of the study area in the headwater portions of the Fivemile Drainage and due to their platy structure may or may not represent a more erodible material than the surrounding basalt.

Tuff and tuffaceous sedimentary rock occurs in the headwater portions of the Hidaway and Cable subwatersheds, its distribution roughly corresponding to the Mesic Forest Zone sub-region (see Figure 4). Tuff and tuffaceous sedimentary rock accounts for approximately 12% of all geologic types found in the assessment area, and represents the second most common material found (see Table 3). Tuff is a term used to describe relatively soft, porous rock that is usually formed by the compaction and cementation of volcanic ash or dust. The tuff material was likely washed out over the basalt and then subjected to various processes of faulting, as it will often occur in a thin, veneer-like layer. The erosivity and porosity of this material is generally low.

Concurrent with volcanism, tectonism during the Cenozoic Era-Tertiary Period played a major role in the formation and deposits of the basins in the area (Clarke et al. 1997). It is believed that the Ukiah basin was formed by faulting as well as folding in a structural depression (Clarke et al. 1997). This depression served as a depositional area for loess and alluvium that was produced following mountain uplifting and lacustrine formation. The geologic character found in much of the Owens Creek, Cable Creek, Pine Creek (not in study area), and lower mainstem Camas Creek subwatersheds are defined by this alluvium of cemented gravel and interbedded tuffaceous sand and silt, (Clarke et al. 1997) an area that also corresponds to the Blue Mountains Basins sub-region (see Figure 4). The areas underlain by cemented alluvium or fine silt generally have low permeability (Clarke et al. 1997).

The capacity for bedrock to store water differs throughout the assessment area (Figure 6). These differences are due to variations in the type and extent of fracturing, weathering, joint frequencies, bedding, and unique geologic types. Overall, the least porous bedrock is the tuff and tuffaceous sedimentary rock, which underlies streams and upland areas in the Mesic Forest Zone (i.e. subwatersheds, or portions thereof, such as upper Hidaway, and North/South Forks Cable Creek). Areas with greater water storage capacity are associated with Grande Ronde basalt parent materials. It is important to note, however, that bedrock water storage capacities will be similar in areas where ground compaction is high (i.e. infiltration rates are low).

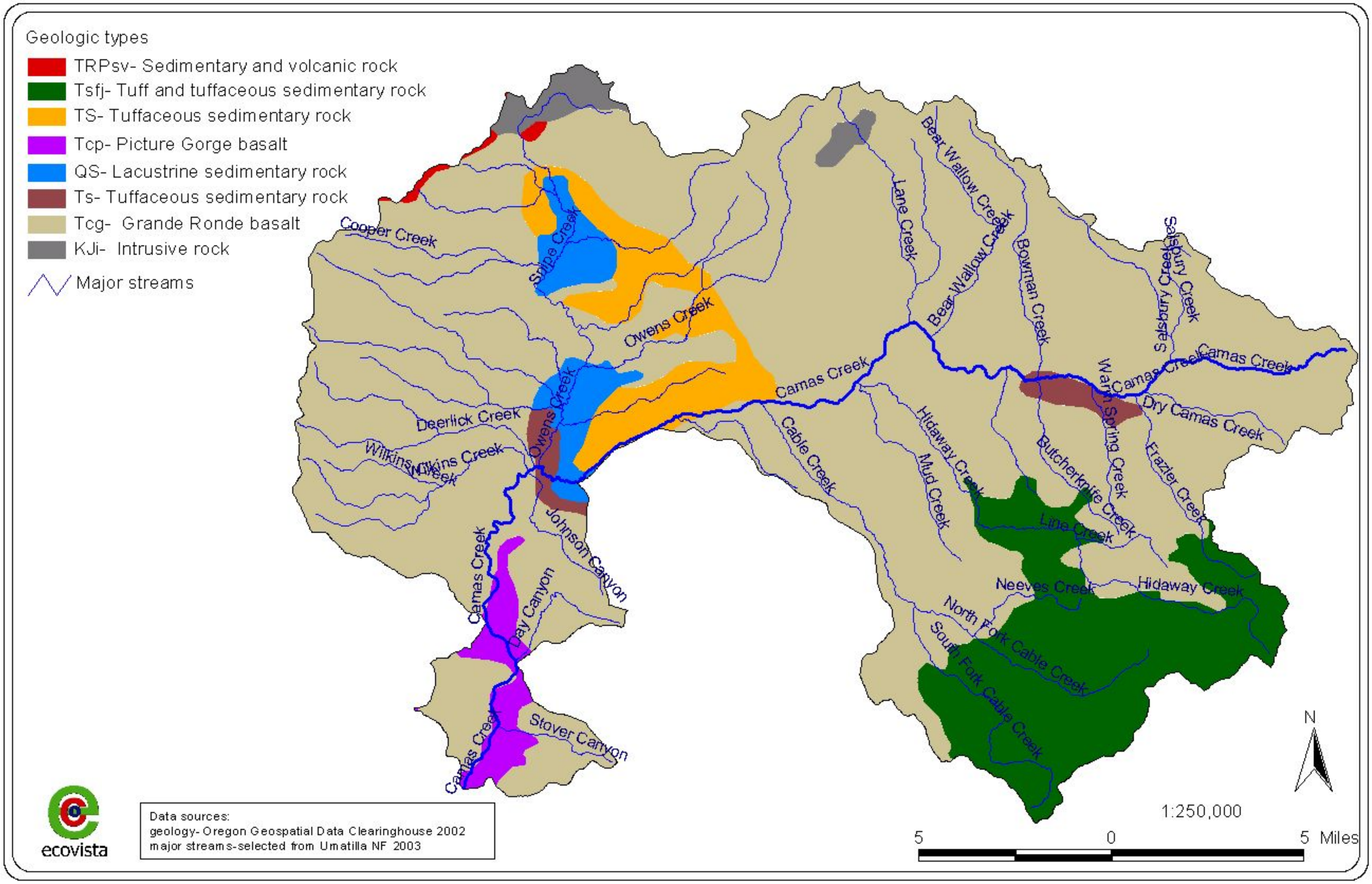

Figure 5. Geology of the Camas Creek assessment area

Table 3. Division of geologic types in the Camas Assessment Area

Subwatershed	Geologic Types (acres)													
	Grand Ronde Basalt	% Total Area	Intrusive Rock	% Total Area	Sedimentary & volcanic rock	% Total Area	Tuffaceous sedimentary rock	% Total Area	Lacustrine sedimentary rock	% Total Area	Tuff and tuffaceous sedimentary rock	% Total Area	Picture Gorge basalt	% Total Area
Lane	15,862	8	671	0	0	0	225	0	0	0	0	0	0	0
Snipe	18,936	10	1,770	1	429	0	4,080	2	2,442	1	0	0	0	0
Bowman	41,790	21	0	0	0	0	1,311	1	0	0	1,478	1	0	0
Upper Owen	12,128	6	47	0	0	0	1,436	1	270	0	0	0	0	0
Lower Owen	12,233	6	0	0	0	0	2,464	1	1,821	1	0	0	0	0
Hidaway Cr	11,009	6	0	0	0	0	0	0	0	0	8,225	4	0	0
Camas/Wilkins	21,302	11	0	0	0	0	2,502	1	520	0	0	0	662	0
Cable	9,860	5	0	0	0	0	0	0	0	0	14,459	7	0	0
Lower Camas	6,908	3	0	0	0	0	0	0	0	0	0	0	2,711	1
Total	**150,028**	**76**	**2,488**	**1**	**429**	**0**	**12,018**	**6**	**5,054**	**3**	**24,162**	**12**	**3,373**	**2**

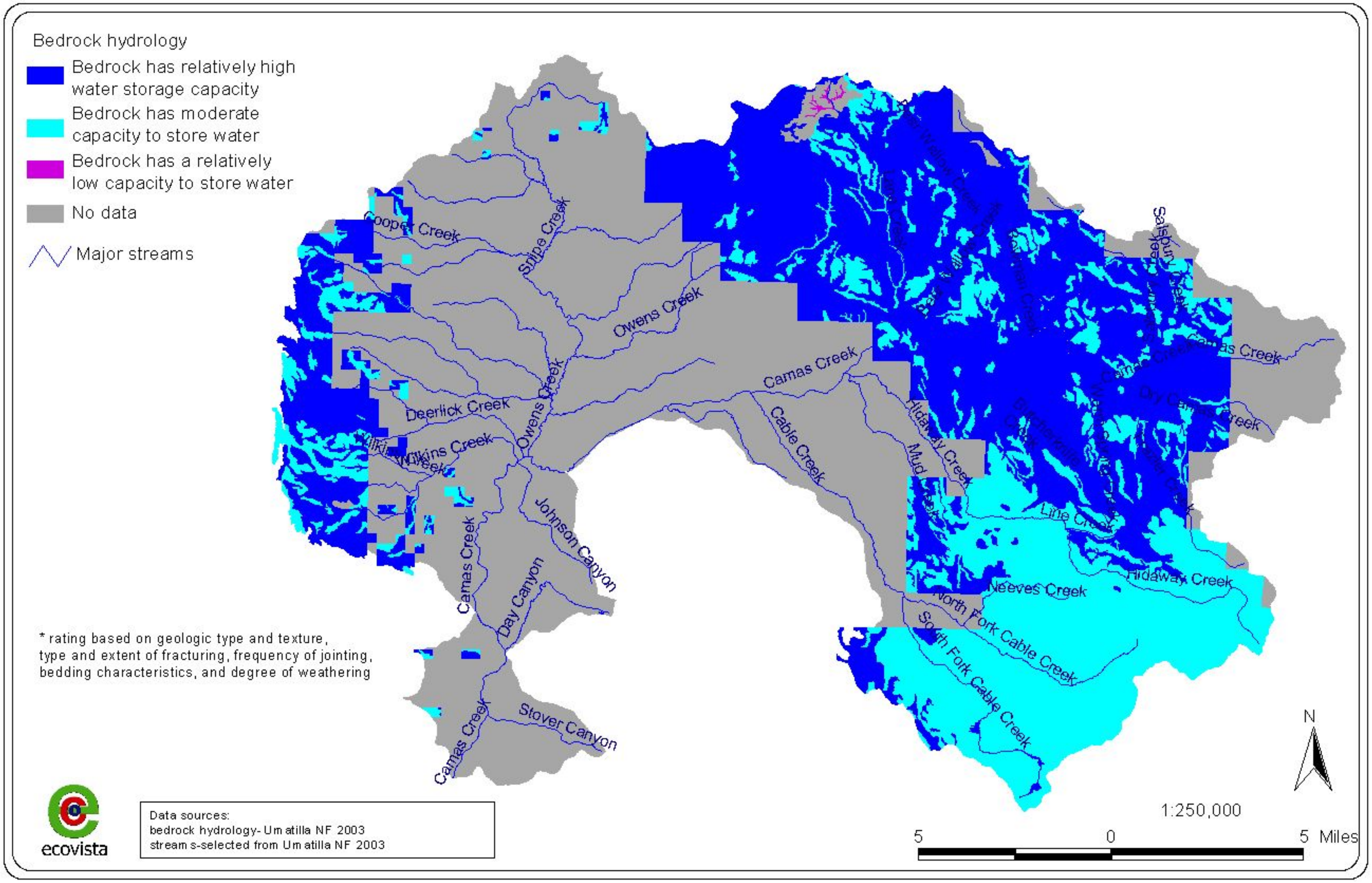

Figure 6. Storage capacity of bedrock occurring on National Forest lands within the Camas Assessment Area (unpublished data, Umatilla National Forest, 2003)

2.3 Soils

The soils occurring throughout the Camas Assessment Area have largely been shaped from volcanic ash and pumice depositions and the associated decomposition of bedrock parent materials. The deposition that most dramatically influenced assessment area soils occurred about 6,600 years ago following the eruption of Mount Mazama, which had an estimated fallout area of 900,000 km^2 (Harvey et al. 1994). Wind and water have redistributed the ash since the original deposition to depths ranging from zero to two feet or more (Umatilla National Forest 1995). The eruption of Mount St. Helens in southwestern Washington in 1980 had comparatively little effect on Camas Creek soils.

Camas Creek soils overlie older, loamy soils buried at depths of about 30 to 150 cm (12-59 in). Soil organic matter tends to be concentrated within the top 15 to 25 cm (6-10 in) of the surface, declining rapidly with depth (Harvey et al. 1994). At lower elevations, soils tend to be xeric or aridic, in that they are dry for at least 60 to 90 days in the summer (Bryce and Omernik 1997b). At elevations greater than 1,525 meters (≥5,000 ft), soils are often udic or moist.

In natural or near-natural conditions, assessment area soils tend to have very high porosities and high water storage capacities (Figure 7) making them relatively unsusceptible to surface erosion, unless they occur on steeper (≥30%), barren slopes (Harvey et al. 1994). The high absorption rates and storage capacities of the soil in subwatersheds such as Cable readily yields a large percentage of the water to plants.

Other materials present in the Blue Mountains Basins sub-region include xeric loess, and/or loess and residuum, both of which occur over cemented alluvium. Sedimentary deposits, or paleosols, may be interspersed between the layers of basalt, as soil genesis and/or deposition occurred between successive flows. The soil of the region, however, is not a direct reflection of the basalt parent material. A thick ashcap, derived from eruptions of Mount Mazama, Mount St. Helens, and Glacier Peak, covers the Blue Mountains and is common in the Maritime-Influenced zone (Bryce and Omernik 1997a). Because of the maritime influence and vigorous growth of vegetation, ashy soils of the Subalpine and Mesic Forest zones have minimal erosion rates. Erosion is higher in the lower elevation loessial soils.

2.4 Topography

Camas Creek topography consists of rolling hills with some steep sided canyons, relatively flat basins, and entrenched to moderately entrenched streams, many of which have been confined to facilitate grazing, hay production, and/or transportation (Figure 8). The highest elevations in the Camas Drainage occur at the summits of Arbuckle Mountain (elevation 5,847 ft.) and Tower Mountain (elevation 6,850 ft.). Although Arbuckle Mountain occurs outside of the study area (in the Fivemile subwatershed), it is pertinent to this document since it represents the only source of SnoTel data in the Camas Drainage. Tower Mountain is adjoined by Pearson Ridge, an uplifted, east-west trending fault that separates Camas Creek from the North Fork John Day River.

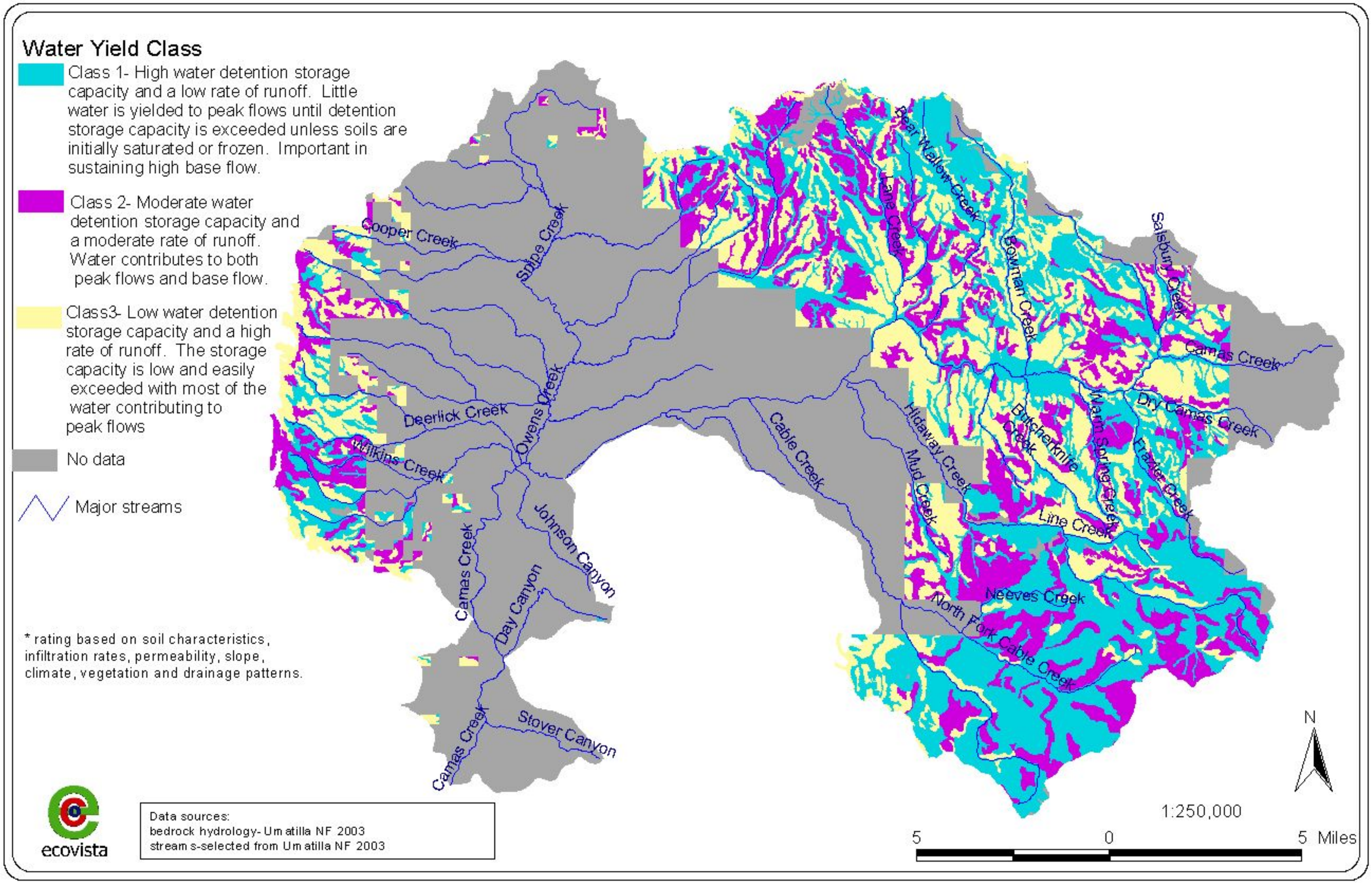

Figure 7. Water storage and detention capacity of soils in the Camas Assessment Area

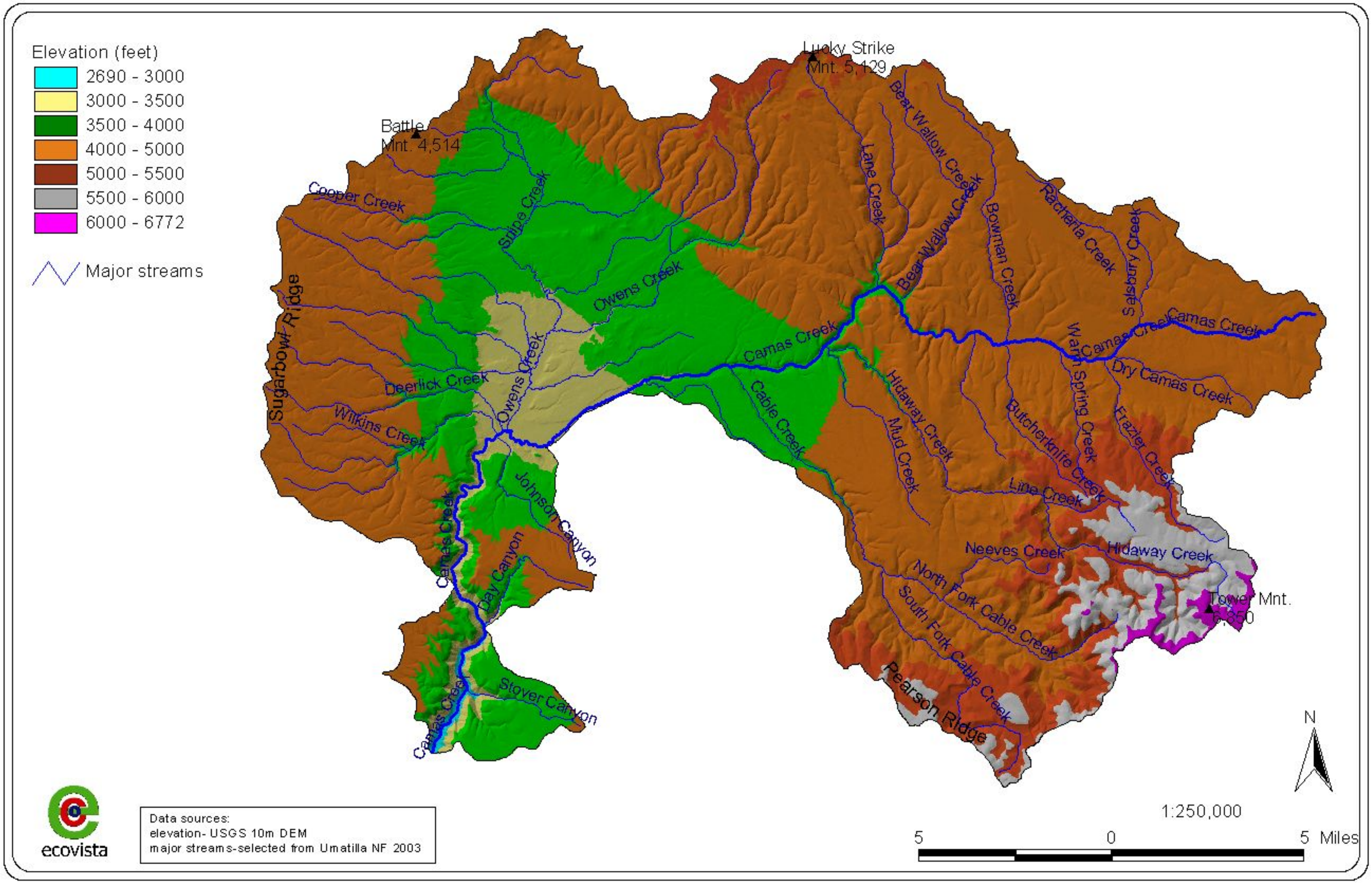

Figure 8. Topography and elevation in the Camas Creek assessment area

Tributaries originating in the southeast lobe of the study area, such as upper Hidaway, and Cable Creeks, have the highest maximum (6,771 ft and 6,286 ft) and mean (4,993 ft and 4,863 ft) elevations of the nine subwatersheds in the study area (Table 4). Bowman Creek, a tributary originating in the northeastern portion of the study area, has the highest minimum elevation (3,874 ft). The higher elevation tributaries are noteworthy, as they represent areas of cool water infusion to lower elevation stream reaches (e.g.) (Umatilla National Forest 1995).

Table 4. Subwatershed elevations in the Camas Creek assessment area

Subwatershed	Minimum Elevation feet (meters)	Maximum Elevation feet (meters)	Mean Elevation feet (meters)
Lower Camas	2,690 (820)	4,330 (1,320)	3,764 (1,147)
Camas/Wilkins	2,929 (893)	4,763 (1,452)	4,025 (1,227)
Lower Owens	3,277 (999)	4,822 (1,470)	3,878 (1,182)
Snipe	3,339 (1,018)	5,068 (1,545)	4,045 (1,233)
Upper Owens	3,339 (1,018)	5,127 (1,563)	4,269 (1,301)
Lane	3,533 (1,077)	5,127 (1,563)	4,400 (1,341)
Cable	3,543 (1,080)	6,286 (1,916)	4,863 (1,482)
Bowman	3,874 (1,181)	5,977 (1,822)	4,671 (1,424)
Hidaway Creek	3,664 (1,117)	6,771 (2,064)	4,993 (1,522)

2.5 Climate

The Camas Creek watershed assessment area occurs in the western portion of the National Oceanic and Atmospheric Administration's (NOAA) Northeast Oregon Zone 8 Climate Division[1]. Climate patterns throughout Zone 8 and throughout the Camas Assessment Area differ by elevation and relative location, although the seasonal distribution is similar.

The climate in the Camas Assessment Area is best defined as being continental with a marine influence. The climate is generally arid, with cold winters and hot summers. Topographic features such as the Rocky Mountains to the east, Cascade Mountains to the west, and Pacific Ocean beyond the Cascades, have direct bearing on prevailing easterly and westerly winds. The Rocky Mountains block the drainage from the westerly-moving continental air masses, while the Cascade Mountain range blocks the majority of the easterly-moving maritime air masses that originate from the Pacific Ocean. The result is a rain shadow effect, which contributes to the general aridity of the subbasin.

In-basin climate data (temperature and precipitation) has been collected at the town of Ukiah (elevation 3,300 feet) since 1931. Precipitation measurements have also been made at Arbuckle Mountain (elevation 5,800 feet), which is the highest point of the Camas Creek watershed assessment area.

[1] Climate Divisions are standardized regions within each state designating areas of similar climate regime. The number of climate divisions in a state varies from one (Rhode Island) to a maximum of ten (many states). Climate Divisions are defined by the National Climate Data Center.

2.5.1 Temperature

Air temperature measurements have been made in Ukiah since 1931. The Ukiah measurements are representative of temperatures occurring throughout mid-elevation portions of the study area. Temperatures occurring at lower elevation stream reaches closely mirror those collected outside the Camas Drainage at the Monument, OR weather station, where they are generally about 7˚F lower than those collected at the Ukiah station (Umatilla National Forest 1995).

July and August are the warmest months in the study area, with maximum temperatures averaging 82.9 ˚F and 82.5˚F respectively (Figure 9). The average annual maximum temperature is 59.1˚F. The highest temperature on record was 110˚F and occurred on August 4, 1961. The coldest months are December and January, during which temperatures average 18˚F and 14.4˚F (respectively). The average annual minimum temperature is 27.8˚F. The record low temperature recorded at Ukiah was negative 54˚F, measured February 9, 1933.

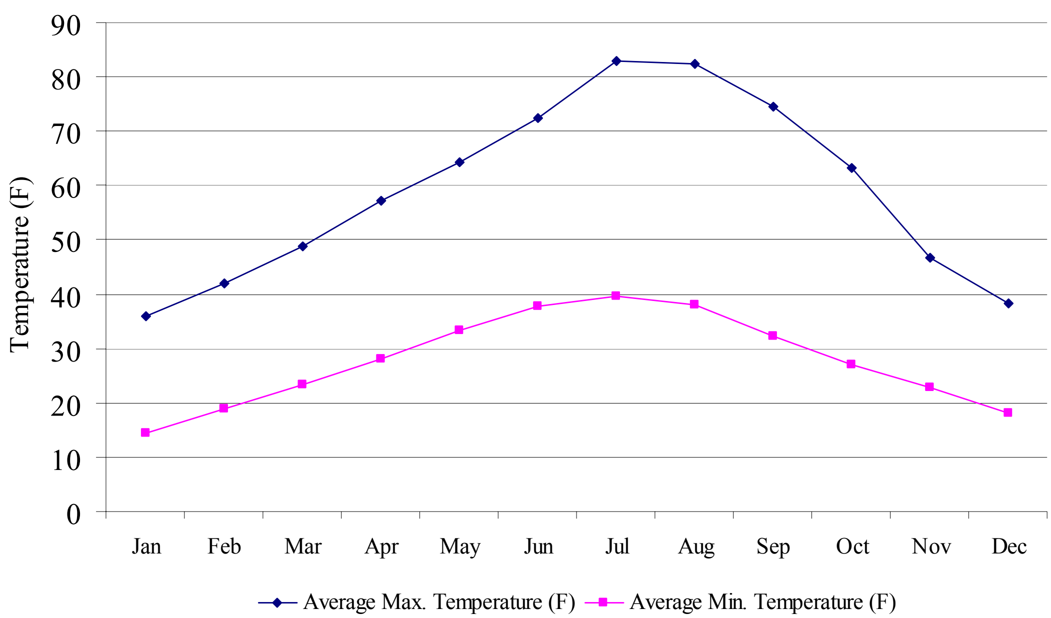

Figure 9. Average monthly air temperatures for Ukiah, Oregon (1931 – 2002). Data accessed from the Western Regional Climate Center Website, July 2003 (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?orukia)

2.5.2 Precipitation

The average annual total precipitation measured at Ukiah, OR is 17.24 inches (Figure 10). Not surprisingly, precipitation is highest during winter and spring months and lowest during the summer. An examination of annual precipitation extremes measured at the Ukiah station, shows that record maximum amounts fell in 1941 (26.09 in), compared to a record minimum of 9.04 inches that was recorded in 1985 (Table 5). Table 6 shows the top-ten monthly precipitation events that have occurred between the months of November – May, as recorded at the Ukiah climate station.

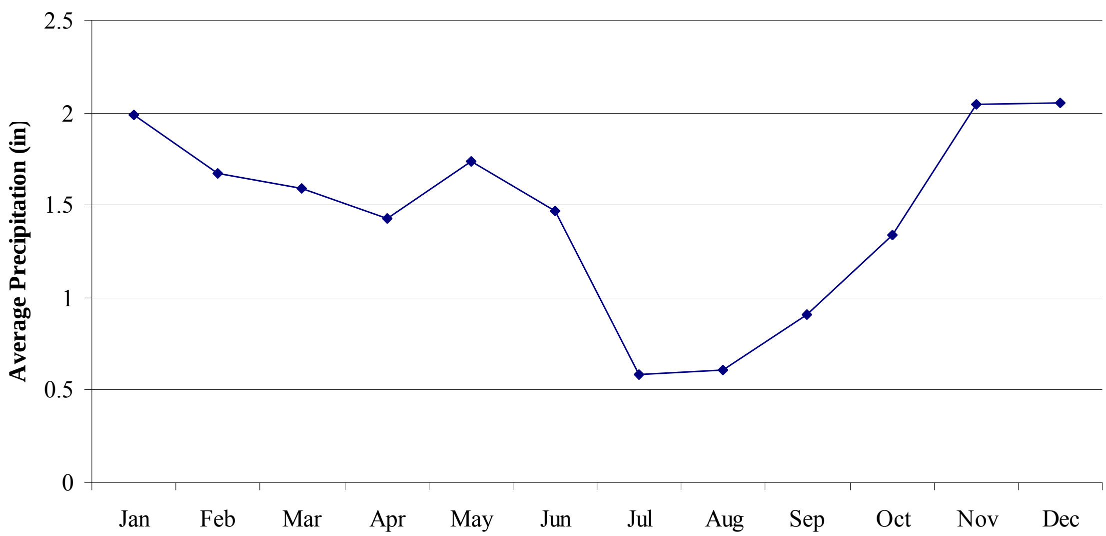

Figure 10. Mean monthly precipitation amounts measured at Ukiah, OR between 1931 and 2003 (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?orukia)

Table 5. Seasonal precipitation summary from Ukiah, OR (1931 – 2002). Data downloaded July, 2003 from Western Regional Climate Center website (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?orukia)

Season	Mean (in)	High (in)	Year	Low (in)	Year (in)	1 Day Max. (in)	yyyymmdd
Annual	17.24	26.09	1941	9.04	1985	2.9	19380622
Winter	5.57	12.78	1965	1.35	1977	2	19490218
Spring	4.69	7.93	1962	1.84	1968	1.53	19890510
Summer	2.88	7.03	1941	0.66	1973	2.9	19380622
Fall	4.1	8.32	1940	0.93	1974	2.01	19951128

Table 6. Ranking, in descending order, of top ten monthly (November – May) precipitation extremes recorded at Ukiah, OR for the period 1931-2003

Year	**Nov**	**P[1] (in)**	**Year**	**Dec**	**P (in)**	**Year**	**Jan**	**P (in)**	**Year**	**Feb**	**P (in)**	**Year**	**Mar**	**P (in)**	**Year**	**Apr**	**P (in)**	**Year**	**May**	**P (in)**
1973	1	5.04	1996	1	5.81	1970	1	4.89	1949	1	4.65	1957	1	3.13	1937	1	3.28	1941	1	5.03
1995	2	3.62	1964	2	5.26	1965	2	4.35	1940	2	3.98	1953	2	3.07	1995	2	3.19	1956	2	4.34
1998	3	3.40	1955	3	4.25	1956	3	3.33	1986	3	3.72	1983	3	3.02	1963	3	3.09	1942	3	4.32
1945	4	3.35	1942	4	4.13	1953	4	3.27	1942	4	3.06	1932	4	2.69	1943	4	2.82	1960	4	3.76
1963	5	3.28	1973	5	4.04	1936	5	2.97	1999	5	2.44	1962	5	2.64	1978	5	2.61	1962	5	3.70
1937	6	3.20	1941	6	3.50	1998	6	2.91	1961	6	2.41	1931	6	2.61	1958	6	2.50	1945	6	3.67
1964	7	3.17	1969	7	3.40	1969	7	2.73	1945	7	2.24	1950	7	2.39	1993	7	2.48	1991	6	3.67
1981	8	3.07	1945	8	3.30	1995	8	2.67	2000	8	2.23	1989	8	2.30	1935	8	2.34	1989	8	3.64
1942	9	3.02	1939	9	3.24	1974	9	2.60	1939	9	2.21	1960	9	2.21	1944	9	2.21	1994	9	3.39
1966	10	3.00	1957	10	3.17	1951	10	2.54	1953	10	2.20	1940	10	2.11	1997	10	2.16	1949	10	2.97

[1]/ P = monthly precipitation extreme in inches

The amount of precipitation a given region or subregion receives over the course of a year varies (Table 7). For example, low elevation stream reaches occurring within the John Day Clarno Highlands subregion, such as Lower Camas Creek, will average around 44 centimeters (17 inches) every year, compared to ecosystems in the Mesic Forest Zone, such as upper Hidaway, which may average over 72 centimeters (28 inches) annually.

Table 7. Mean annual precipitation for watersheds throughout the Camas Assessment Area (Parameter-elevation Regressions on Independent Slopes Model - PRISM data)

Subwatershed	Acreage	Mean Annual Precipitation (in)	Mean Annual Precipitation (cm)
Bowman	44,495	27.2	69.0
Cable	24,273	27.8	70.7
Camas/Wilkins	24,940	21.0	53.4
Hidaway	19,199	28.4	72.2
Lane	16,721	26.9	68.3
Lower Camas	9,600	17.4	44.2
Lower Owens	16,487	21.1	53.5
Snipe	27,606	24.4	62.0
Upper Owens	13,857	25.7	65.3

Precipitation in the Maritime Zone (refer to Figure 4) is comparatively high, and accounts for the majority of flow provided to streams and rivers throughout the year. The climate in the maritime zone is influenced by a unique break in the Cascade Range and Columbia Gorge that allows marine weather to directly funnel through to the Blue Mountains (Bryce and Omernik 1997b). The wet weather is intensified with the orographic lifting produced from the rise of the Blues, delivering rain and snow to the area three out of four seasons. Because it's a snow-dominated area, the Maritime Zone is the region in the study area most likely to experience the effects of flooding brought on by an early spring thaw or rain-on-snow events (see *Peak Flow* discussion below).

Winter precipitation typically falls as snow above 5,000 feet and as rain at lower elevations or on south facing slopes. Spatially, the "zone" of rain-on-snow contributing area varies with elevation, aspect, and latitude. For the Camas Assessment Area, this zone is climatologically at the transition from marine-influence to continental influence (C. Clifton, Forest Hydrologist, UNF, Personal Communication, August 7, 2003) and is therefore less defined than other subbasins.

High elevation snowpack, which for the Camas Drainage is measured at the Arbuckle Mountain SnoTel site (elevation 5,800 feet), begins to accrue sometime in mid- to late October (as measured by snow/water equivalence, or SWE), with the greatest accumulations occurring sometime between the months of December and January (Figure 11). Because the snow tends to melt between storms, a deep snowpack typically isn't common (Umatilla National Forest 1995), especially in lower elevations such as the town of Ukiah, where average annual snow depth is only 1 inch. Spring snowmelt at the Arbuckle SnoTel site commences around the first or second of April and is complete sometime in the first week of June (see Figure 11).

The Camas Assessment Area is subject to both wet and dry periods. A plot of the two year moving precipitation average shows that there were prolonged dry periods from 1947 through 1950, and again from 1986 through 1995 (Figure 12). Conversely, there have been distinct wet periods such as that occurring roughly from 1936 through 1946, and again from 1995 through 1999.

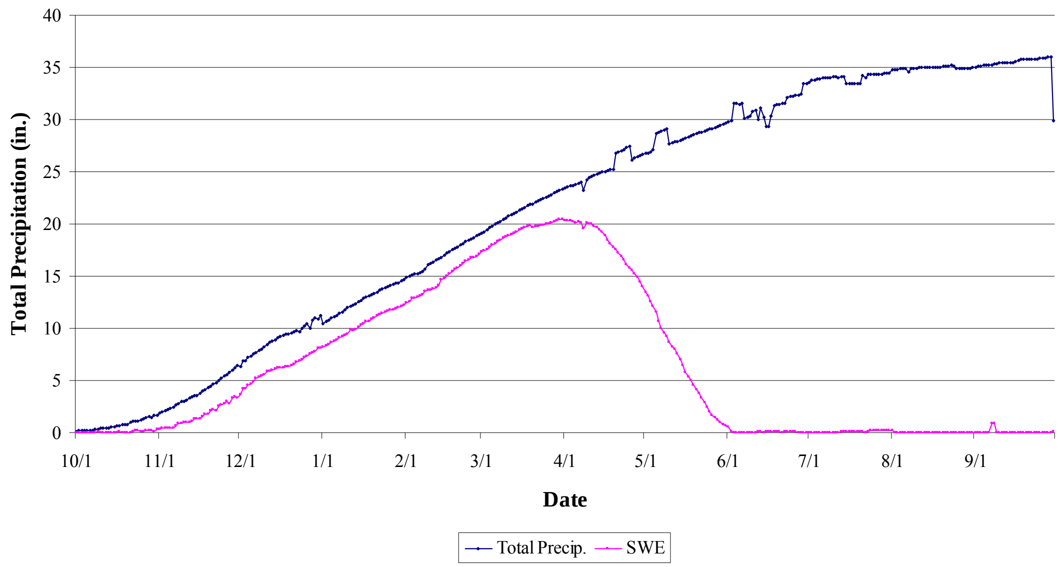

Figure 11. Average annual precipitation accumulation and snow-water-equivalence (SWE), as measured at the Arbuckle Mountain SnoTel site (1978-2003)

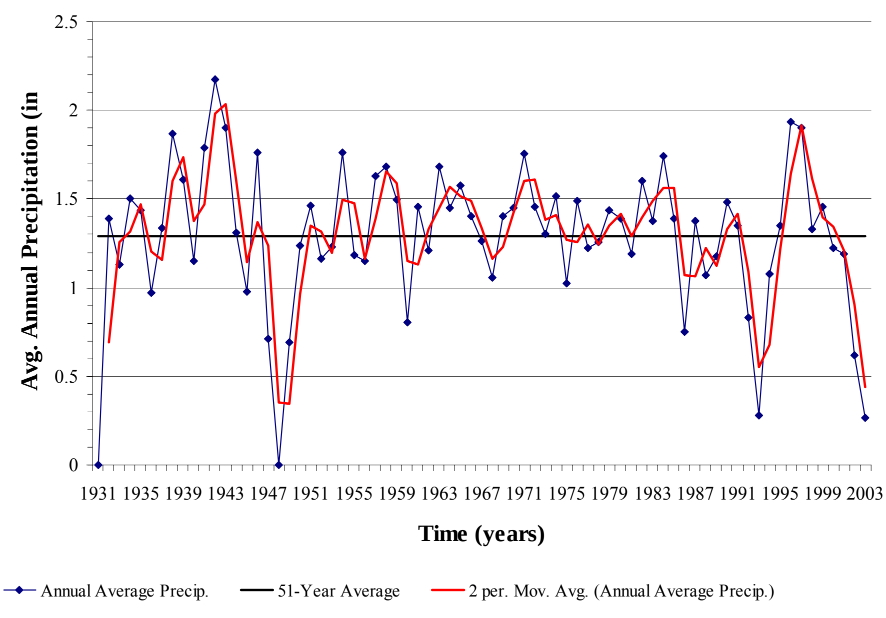

Figure 12. Two year moving average precipitation for Ukiah, Oregon

2.6 Hydrology

The purpose of this chapter is to provide a general characterization of the hydrologic processes in the study area. An introductory overview precedes the various subsections to provide requisite background information. A more in-depth examination of peak and base flows is provided in Section 5.1.

2.6.1 General Hydrologic Characterization

Streamflow data for the Camas Assessment Area has been collected from 1915 until 1998 at the USGS-maintained gage (gage #14042500) located between the Cable and Hidaway tributaries approximately 19 river miles upstream from the confluence with the North Fork John Day River (Table 8). The period of record (May, 1914 to September, 1998) is interrupted in 1918 and 1919, then again between 1924 and 1940 during which only a partial record is maintained. Three other gages were historically active in the assessment area, but are no longer in service.

Table 8. USGS gaging summary, Camas Creek, Oregon

Gage #	Gage Name	Drainage Area (mi^2)	Elev. (ft)	Period of Record
14041900	Line Cr. Nr. Lehman Springs[1]	2.4	4,517	01/30/1965 →05/07/1979
14042000	Camas Cr. Nr. Lehman	60.7	3,969.5	10/01/1950 →09/30/1970
14042500	Camas Cr. Nr. Ukiah	121	3,588.6	05/01/1914 →09/30/1998
14043560	Snipe Cr. Nr. Ukiah	37	3,430	10/01/1967 →09/30/1973

[1]/ Only peak flows were recorded

The annual mean discharge measured at the Ukiah gage is 96.3 cfs (Figure 13), and the average runoff volume is 70,200 acre-feet (10.88 in). Average monthly streamflow is shown in

Figure 14. Typically, the ascending limb of the hydrograph initiates sometime in mid-October with peak flows occurring in April (324 cfs). Flows rapidly drop off in June and July, reaching base levels by early August (5.3 cfs). A maximum discharge of 3,840 cfs occurred on January 30, 1965 compared to the minimum discharge of 1 cfs which occurred between June 24 and July 2, 1940.

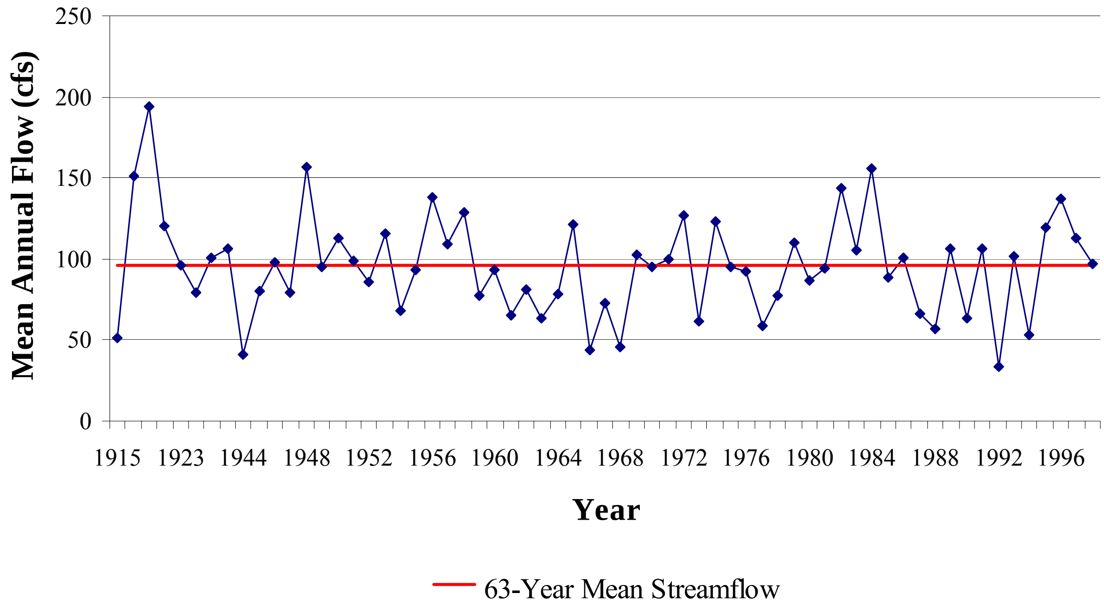

Figure 13. Average annual flows in the Camas Assessment Area (USGS gage #14042500)

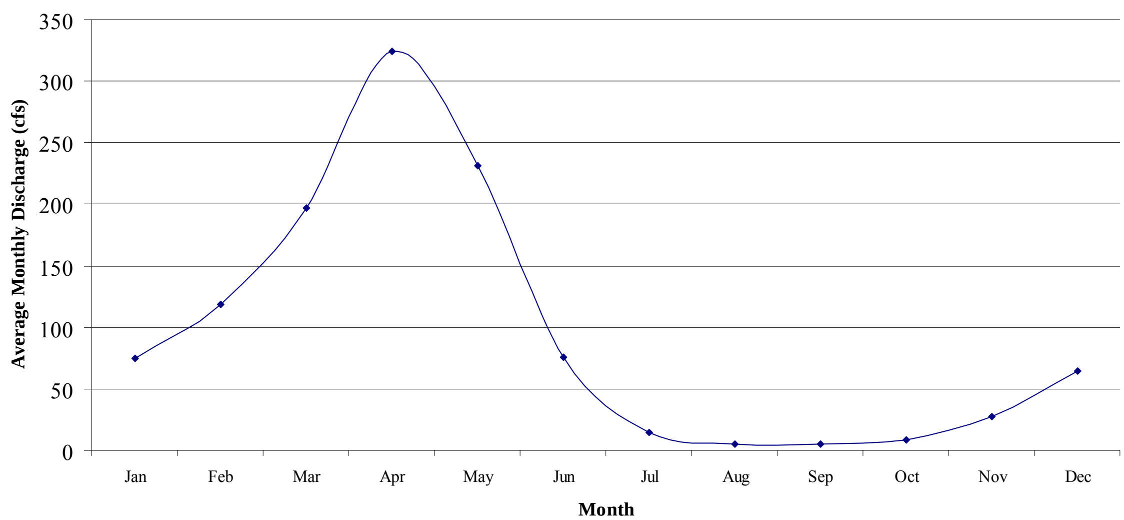

Figure 14. Mean monthly discharge measured at Ukiah, OR, gage #14042500

2.7 Water Quality

Background

The term “water quality” includes the water column and the physical channel required to sustain aquatic life. The goal of the federal Clean Water Act (CWA), “*to protect and maintain the chemical, physical, and biological integrity of the nation’s waters,*” establishes the importance of assessing both water quality and the habitat required for maintaining fish and other aquatic organisms.

Although other water quality issues have been identified in Camas Creek, excessive stream temperatures are the only water quality parameter in violation of state and federal standards and will therefore comprise the following water quality discussion. (Cockle 2001) maintains that localized toxic mine effluents are a concern in some NF John Day tributaries, including Camas Creek. Another water quality concern in Camas Creek involves livestock-related nutrification of streams, especially following storm runoff.

High water temperatures during summer months effectively limit the distribution of obligate cold water species such as bull trout (Rieman and McIntryre 1993) and may reduce life history success of other salmonids (Bjornn and Reiser 1991). Growth and reproduction are adversely affected when water temperature is outside the range to which these organisms were adapted. There is continuous debate about the actual numerical values that should be used for setting the temperature criterion. This is because the temperature cycle varies daily and seasonally, and different life stages and species of fish exhibit different tolerances.

The temperature criteria below and in Table 10 are established in the Oregon Water Quality Standards (Oregon Administrative Rules [OAR] 340-41-[basin][2][b]) for the protection of resident fish and aquatic life, and salmonid spawning and rearing.

> Seven (7) day moving average of the daily maximum shall not exceed the following values unless specifically allowed under a Department-approved basin surface water temperature management plan:

- 64°F (17.8°C)
- 55°F (12.8°C) during times and in waters that support salmon spawning, egg incubation and fry emergence from the egg and from the gravels;
- 50°F (10°C) in waters that support Oregon bull trout’

Temperatures in excess of OAR criteria have been identified as one of the primary factors limiting resident and anadromous production in the Camas Watershed (Umatilla National Forest 1995). And while there are no historical quantitative data against which to compare current water temperatures, the continued persistence of cool (spring chinook) and cold-water (bull trout) species in select portions of the drainage implies that water temperatures were once sufficiently cooler throughout a broader area to provide for population maintenance and propagation (Umatilla National Forest 1995).

303d Listed Streams

Water quality standards are benchmarks established to assess whether river and lake quality is adequate to protect fish and other aquatic life, recreation, drinking, agriculture, industry and other uses. Water quality standards are also regulatory tools used by the Oregon Department of Environmental Quality (ODEQ) and the US Environmental Protection Agency (EPA) to prevent water pollution. States are required to adopt water quality standards by the federal CWA. Standards are subject to EPA approval.

The CWA also requires states to maintain a list of stream segments that do not meet water quality standards. This list is called the 303(d) List because of the section of the CWA that established the requirement. The CWA requires states to develop water quality goals (called Total Maximum Daily Loads or TMDLs) along with an implementation plan and schedule to achieve water quality goals for 303(d) listed water bodies**.**

The US EPA approved Oregon's 2002 303(d) list on March 24, 2003 (http://www.deq.state.or.us/wq/303dlist/303dpage.htm). The 303(d) listed streams within the Camas Assessment Area, which includes the entire mainstem and numerous key tributaries (Table 9; Figure 15), exceed the numeric criteria of the water quality standard for temperature.

Table 9. 303d-listed streams in the Camas Assessment Area (downloaded July, 2003 from ODEQ website (http://www.deq.state.or.us/wq/WQLData/)

Record ID	Waterbody/Subwatershed Name	River Mile	Parameter	Season	List Date	Listing Status
1411	Camas/Lower Camas; Camas Wilkins/Lane; Bowman	0-36.7	Temperature	Summer	1998	303(d) List
9139	Camas/Lower Camas; Camas Wilkins/Lane; Bowman	0-36.7	Temperature	03/01-07/05	2002	303(d) List
1404	Bear Wallow/Bowman	0-7.4	Temperature	Summer	1998	303(d) List
1407	Bowman/Bowman	0-6.9	Temperature	Summer	1998	303(d) List
1410	Cable /Cable	0-7.1	Temperature	Summer	1998	303(d) List
1426	Frazier/Bowman	0-6.2	Temperature	Summer	1998	303(d) List
1429	Hidaway/Hidaway	0-16.2	Temperature	Summer	1998	303(d) List
1435	Lane/Lane	0-7.1	Temperature	Summer	1998	303(d) List
9132	NF Cable/Cable	0-7.5	Temperature	Summer	2002	303(d) List
9133	NF Cable/Cable	0-7.5	Temperature	03/01-07/05	2002	303(d) List
1443	Rancheria/Bowman	0-5.1	Temperature	Summer	1998	303(d) List
9148	SF Cable/Cable	0-8.4	Temperature	Summer	2002	303(d) List
9149	SF Cable/Cable	0-8.4	Temperature	03/01-07/05	2002	303(d) List

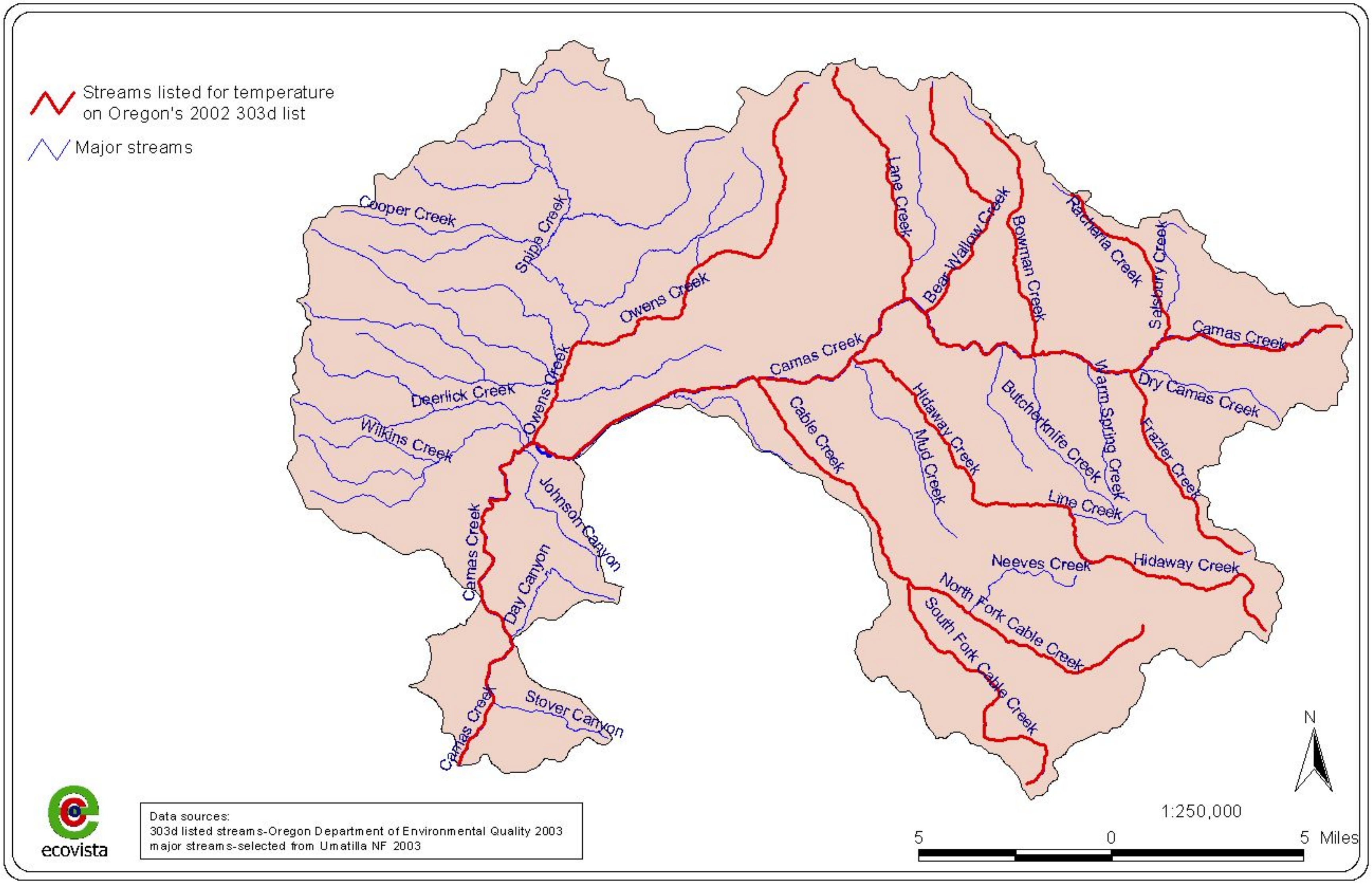

Figure 15. 303d-listed streams in the Camas Assessment Area

Table 10. ODEQ criterion used to define water temperature exceedance in the North Fork John Day. Criteria are based on the 55.0˚F (12.8˚C) thermal requirement of focal salmonids during spawning and incubation through fry emergence. Criteria are applicable to streams above Camas confluence. Data accessed 07-03 (http://www.deq.state.or.us/wq/standards/WQStdsnfjohndaySpawn.pdf)

NF John Day Basin Segments	Application	Dates
NF John Day River above Camas Creek[1]	***Overall Application***	**8/15 – 7/15**
(Check individual species[2] distribution maps for	Summer Steelhead	3/15 – 7/15
specific locations)	Spring Chinook	8/15 – 4/30
	Redband Trout (fluvial)	3/15 – 7/15

1/ Because Camas Creek (proper) was not included in the temperature criteria rating protocol,

2/ The bull trout temperature criterion (50.0˚F/10.0˚C) applies year round to bull trout spawning, rearing, and adult presence in areas identified in Status of Oregon's Bull Trout (Buchanan et al. 1997).

Seven-Day Moving Averages

Water temperature monitoring has occurred in earnest at various locations throughout the assessment area since 1992. Monitoring efforts have been conducted by the UNF, Ukiah RD and include annual summaries of seven-day moving average of the daily maximum. Stream temperature data specific to the assessment area was available for eight of the nine subwatersheds. Continuous (1992 – 2002) monitoring data was not available for each subwatershed due to access issues, sample site changes, or other problems. Hourly water temperatures were collected during summer months using electronic temperature data loggers.

Bear Wallow Creek

The seven-day moving average of maximum daily temperatures for the various monitoring sites throughout the Bear Wallow subwatershed is shown in Table 11. The data clearly illustrates that maximum stream temperatures are in excess of state standards, and not likely conducive to the life history success of cool or cold-water biota.

Table 11. Seven-day moving average of maximum daily temperatures measured in the Bear Wallow subwatershed (1992 – 2002). Data provided by E. Farren, UNF, Ukiah Ranger District

Sample Site	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02
Bear Wallow Creek @ mouth/below campground		**67**	**72**		**69**	**67**	**69**	**66**	**68**	**67**	**72**
Bear Wallow Creek below Rd 54									**69**	**71**	
Bear Wallow Creek below springs				**60**	**66**	**66**	**67**	**65**	**63**	**63**	**69**
Bear Wallow Creek above private		**72**									
Bear Wallow Creek below private	**70**	**69**									

Bowman Creek

The seven-day moving average of maximum daily temperatures for Bowman Creek near its confluence with Camas Creek is shown in Table 12. Like Bear Wallow, maximum stream temperatures recorded at the mouth of Bowman are in excess of state standards, yet they are considerably higher, especially when comparing the years for which there are data.

Table 12. Seven-day moving average of maximum daily temperatures measured in the Bowman Creek subwatershed (1992 – 2002). Data provided by E. Farren, UNF, Ukiah Ranger District

Sample Site	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02
Bowman Creek near mouth	83	78								73	75

Cable Creek

The seven-day moving average of maximum daily temperatures for the various monitoring sites throughout the Cable Creek subwatershed is shown in Table 13. The lowest elevation monitoring site in the subwatershed contributes excessively warm temperatures to the mainstem Camas on an annual basis (average = 76.4° F). The North and South Forks of Cable Creek do not appear to be an ameliorating influence on downstream temperatures, as both are well above the state standard.

Table 13. Seven-day moving average of maximum daily temperatures measured in the Cable Creek subwatershed (1992 – 2002). Data provided by E. Farren, UNF, Ukiah Ranger District

Sample Site	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02
Cable Cr @ mouth	77	73	78	74		75	77	76	76	78	80
NF Cable Cr @ Mouth				66	68	71		68	70		
NF Cable Cr @ ATV Trail										70	72
NF Cable Cr @ Whoopdeedo Trail						75					
SF Cable Cr @ mouth		66		66	68	72	73	70	73	73	

Camas Creek (Camas/Wilkins and lower Camas)

The seven-day moving average of maximum daily temperatures for the various monitoring sites throughout the mainstem Camas subwatershed (Camas/Wilkins and lower Camas subwatersheds) is shown in Table 14. The temperature data clearly illustrate that the mainstem Camas provides less than hospitable salmonid habitat during summer months. There are no instances during the years 1992-2002 for which the mean seven day moving average of maximum daily temperatures was less than 71° F for any of the 12 monitoring sites that recorded data. Because temperatures throughout the mainstem are so warm, the lack of, or limited abundance of spring chinook that rely on mainstem habitat should not be surprising. Steelhead rearing habitat is similarly compromised by temperatures of this magnitude.

The occurrence of summer temperatures that range in the mid- to upper-seventies in the upper Camas (i.e. those recorded above and below the Rancheria Creek confluence) indicates that thermal refugia for species relying upon mainstem habitat is problematic, if not altogether absent. Granted, the highly reduced summer baseflows throughout the mainstem, and especially in the upper portions of the watershed, contribute to the temperature problem, as do other factors including limited amounts of stream shading, channel morphology and aspect, geothermal inputs, and ground water interception (Umatilla National Forest 1995).

Table 14. Seven-day moving average of maximum daily temperatures measured throughout the mainstem Camas subwatersheds (1992 – 2002). Data provided by E. Farren, UNF, Ukiah Ranger District

Sample Site	‘92	‘93	‘94	‘95	‘96	‘97	‘98	‘99	‘00	‘01	‘02
Camas Creek @ mouth		**74**		**77**	**78**	**78**	**78**	**76**		**79**	**82**
Camas Creek below Bear Wallow Creek	**76**										
Camas Creek below Bowman Creek	**80**										
Camas Creek below Cable Creek	**78**										
Camas Creek below Five Mile Creek	**76**										
Camas Creek below Frazier Creek	**76**										
Camas Creek below Hidaway Creek	**78**										
Camas Creek above Lane Creek					**72**	**76**	**78**	**76**	**76**	**78**	**81**
Camas Creek below Lane Creek	**76**	**71**	**74**			**72**	**78**				
Camas Creek below Owens Creek	**78**	**75**									
Camas Creek above Rancheria Creek			**77**		**73**	**72**	**77**	**74**	**74**	**75**	**77**
Camas Creek below Rancheria Creek	**80**	**73**	**78**	**74**		**76**	**77**				

Frazier Creek

The seven-day moving average of maximum daily temperatures for Frazier Creek, near its confluence with Camas Creek, is shown in Table 15. Although the mean seven day moving average of maximum daily temperatures exceeds state standards, values are somewhat lower in Frazier Creek than those recorded in comparably sized subwatersheds. This may be attributed to the northerly aspect of the drainage, which is supported by findings presented in (Umatilla National Forest 1995).

Table 15. Seven-day moving average of maximum daily temperatures measured in Frazier Creek (1992 – 2002). Data provided by E. Farren, UNF, Ukiah Ranger District

Sample Site	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02
Frazier Cr @ mouth	**74**	**67**	**71**	**71**	**71**	**68**	**71**	**69**	**72**	**71**	**74**

Hidaway

The seven-day moving average of maximum daily temperatures for Hidaway Creek is shown in Table 16. Temperatures recorded at the monitoring station located near Chimney Trail are the lowest recorded throughout the assessment area. Temperatures recorded at the National Forest boundary are considerably warmer than those measured at the Chimney Trail site, while those measured at the Hidaway confluence are even warmer. The considerable increase in temperatures over the length of the stream is notable, especially when considering that Hidaway Creek was ranked highest by the UNF (Umatilla National Forest 1995) in terms of its potential to produce cold streamflow to the mainstem Camas Creek.

Table 16. Seven-day moving average of maximum daily temperatures measured throughout the Hidaway Creek subwatershed (1992 – 2002). Data provided by E. Farren, UNF, Ukiah Ranger District

Sample Site	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02
Hidaway Cr near Chimney Trail				**59**	**60**	**66**	**64**	**63**	**63**	**63**	**65**
Hidaway Cr @ FS Bdy / middle				**83**	**69**	**71**	**71**				
Hidaway Cr @ mouth	**76**	**72**	**70**	**78**	**75**	**77**	**78**	**75**	**77**		
Hidaway Cr above Hot Springs										**71**	**74**

Owens Creek (Upper and Lower)

The seven-day moving average of maximum daily temperatures for monitoring sites throughout the Owens Creek subwatersheds (Upper and Lower Owens Creek subwatersheds) is shown in Table 17. The lowest elevation monitoring site in the subwatershed contributes excessively warm temperatures to the mainstem Camas on an annual basis. Upper reaches of Owens Creek do not appear to be an ameliorating influence on downstream temperatures, as both are well above the state standard.

Table 17. Seven-day moving average of maximum daily temperatures measured throughout the Owens Creek subwatersheds (1992 – 2002). Data provided by E. Farren, UNF, Ukiah Ranger District

Sample Site	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02
Owens Cr below FS Bdy / private					72		74				
Owens Cr @ FS Bdy				65		72		72	72	72	74
Owens Cr @ mouth	77	77									

Water Quality – Summary

Temperature is the primary water quality problem in the Camas Assessment Area. The seven-day moving average of maximum daily temperatures throughout the entire mainstem and the majority of key subwatersheds have been in exceedance of state standards for cool and/or cold-water biota for the eleven years during which temperatures have been monitored.

The temperature problem is a primary limiting factor to resident and anadromous fish that occur in the area. Mainstem Camas temperatures likely contribute to the lack of spring chinook that rely upon habitat for spawning and rearing. Summer steelhead rearing is similarly influenced.

The UNF (Umatilla National Forest 1995) suggests that low baseflows, limited amounts of stream shading, channel morphology and aspect, geothermal inputs, and ground water interception are contributing factors to the temperature problems.

The fact that dissolved oxygen levels are not identified as a 303d parameter is unusual. It is unlikely that dissolved oxygen levels would be at sufficient levels to sustain cool and/or cold-water biota, given the high temperatures. Further monitoring of dissolved oxygen levels is warranted.

3 Aquatic Focal Species Status, Distribution, & Trends

3.1 General Species Assemblage

A number of endemic and non-endemic anadromous and resident fish species occur in the Camas Assessment Area. The UNF (Umatilla National Forest 1995) provides a spatially detailed list of species identified from stream surveys. Focal species for this document include summer steelhead and spring chinook.

The current management policy is designed to maintain native, wild stocks of salmon and steelhead, and to preserve the genetic diversity of these native stocks for maximum habitat use and fish production (ODFW et al. 1990).

Threatened and Endangered Species

Naturally occurring, federally listed, threatened and endangered anadromous species in the Camas Assessment Area include spring chinook salmon (*Oncorhynchus tshawytscha*), and summer steelhead (*Oncorhynchus mykiss*). Naturally reproducing chinook populations were listed by the National Marine Fisheries Service (NMFS) as threatened on May 22, 1992 (Federal Register, Vol. 57, 14653) (National Marine Fisheries Service 1997). The state of Oregon also lists chinook as threatened. In March 1999, NMFS listed the John Day River summer steelhead as a threatened species as part of the Middle Columbia Evolutionarily Significant Unit (ESU) under the ESA (National Marine Fisheries Service 1999). Mid-Columbia River summer steelhead are not listed in the state of Oregon.

3.2 Summer Steelhead

Mid-Columbia River summer steelhead are the most ubiquitous, naturally occurring salmonid found in the assessment area. Naturally occurring populations are not viable in all areas however, and fluctuate widely due to natural and anthropogenic pressures.

3.2.1 Population Data and Status

Historical Status

Little information exists relating the historical status of summer steelhead in the Camas Assessment Area. Prior to the arrival of white man it is assumed that Mid-Columbia summer steelhead were similarly distributed throughout the subbasin as they are currently, but at higher levels of abundance. Table 18 shows the usual and accustomed fishing sites of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). The fishing sites shown were established for the purposes of harvesting "trout, salmon and whitefish", and therefore did not specifically identify summer steelhead as a game species. In Camas Creek, however, it may be assumed that "trout" could be in reference to rainbow, *steelhead*, or possibly bull trout.

Table 18. Usual and accustomed fishing sites of the Confederated Tribes of the Umatilla Indian Reservation in the Camas Assessment Area (modified from Buchanan et al. 1997)

Stream	Location	Indian Name	Species	Fishing Method	Active Site
Camas Cr.	Nr. Mouth Wm. Spr. Cr	Tucg-kupin-was	Trout	Hooks	No
Camas Cr.	5 km below Cable Cr.	Couse-shets-pa	Trout, Whitefish	Water Diversion	No
NF Cable	Near mouth of Neeves	Tipas	Trout	Water Diversion	Yes
NF Cable	Headwaters	Kolk-tie	Trout	Hooks	Yes
Camas Cr.	Near Ukiah, OR	Tack-en-pala	Trout	Hooks	Yes
Camas Cr.	Camas Gorge	Wy-na-nets-pa	Trout, Whitefish	Hooks	Yes
Owens Cr.	4 km north of Ukiah	Ukiahs	Trout	Hook & Spear	No
Snipe Cr.	Near mouth	Wrap-neet-pa	Trout	Hook & Spear	No

Current Population Data and Status

Life History

Low, warm water in the lower John Day River during summer months precludes adult summer steelhead from entering the John Day River until mid- to late September. Upon entrance in the mainstem John Day, adults will require approximately three months (October through December) to migrate upriver to access spawning habitat in North Fork John Day tributaries (Table 19).

Adults initiate spawning throughout the Camas Assessment Area in mid-March, the majority of which conclude by the end of May. Depending upon conditions and spawning location, a minority of the fish may prolong reproduction activities through mid-June (Table 19).

Egg incubation typically commences early in May and extends through mid-July, at which point fry emergence occurs. The incubation period is a function of spawn timing, streamflow, and temperatures, and may therefore initiate in early April.

Juveniles will rear in North Fork John Day tributaries year-round prior to outmigration. Most John Day summer steelhead smolt at age two (62%), although some (38%) will reside in freshwater habitat for three years (Howell et al. cited in Busby et al. 1996). Regardless of age at smolt, outmigration from the Camas generally coincides with spring runoff flows (February through June).

Table 19. Life history stages, timing, and activity for summer steelhead and spring chinook in the Camas Assessment Area[1]. Reproduced from (Oregon Department of Environmental Quality 2001)

Life Stage/Activity/Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upstream Adult Migration												
Summer Steelhead	X X	X X	X X	X X	X X							
Spring Chinook salmon					X X							
Adult Holding												
Summer Steelhead					Not applicable							
Spring Chinook salmon						X X	X X	X X				
Adult Spawning												
Summer Steelhead			X	X X	X X	X						
Spring Chinook salmon												
Egg Incubation through Fry Emergence												
Summer Steelhead					X X	X X	X					
Spring Chinook salmon	X X	X X	X X	X X					X X	X X	X X	X X
Juvenile Rearing												
Summer Steelhead	X X	X X	X X	X X	X X	X X	X X	X X	X X	X X	X X	X X
Spring Chinook salmon	X X	X X	X X	X X	X X	X X	X X	X X	X X	X X	X X	X X
Downstream Juvenile Migration												
Summer Steelhead				X X	X X	X X						
Spring Chinook salmon				X X	X X	X X						

- Represents periods of peak use based on professional opinion.
- Represents lesser level of use based on professional opinion.
- Represents periods of presence - no level of use indicated
- X Represents periods of use based on reported observation

1/ Data reflects species timing and life history stages for 'areas above the confluence of Camas and the North Fork John Day'. Based on communication with ODFW (T. Unterwegner, ODFW, Personal Communication, August, 2003) these data also pertain to Camas Creek fish. Incidental use by steelhead and chinook juveniles occurs in the mainstem Camas from Pine to 5-mile Creek during summer months, but varies water year to water year. Habitat from Pine Creek to just below Cable Creek may be non-existent during some water years as flows become intermittent on occasion.

Carrying Capacity & Productivity Estimates

Quantitative steelhead carrying capacity and productivity data for the Camas Assessment Area is limited. There is no existing information on smolt production in the Camas Watershed (Umatilla National Forest 1995). A somewhat dated attempt at modeling carrying capacity (and productivity) does exist, however, following subbasin planning efforts in 1990.

Steelhead smolt carrying capacity for 31 subbasins throughout the Columbia River Basin was estimated by the Monitoring and Evaluation Group (MEG) and the System Planning Group (SPG) in response to subbasin planning needs in 1990. The following discussion is taken from (Northwest Power Planning Council 1990).

Based upon a review of available techniques and information, the MEG and SPG developed the Smolt Density Model (SDM). The SPG used several criteria in selecting a standard method for estimating current production capacity levels. The method employs a habitat-based, smolt-density approach. Requisite data for the approach are smolt density estimates (number of smolts per unit of usable habitat area) and estimates of the availability of usable smolt spawning and rearing habitat.

Generic estimates of smolt density for species, races, and key stocks of salmon and steelhead were selected by the SPG. Modelers reviewed and corrected (if necessary) the percentage of the reach shown to be accessible to fish (i.e. no physical barriers) and the low flow reach width from an EPA database. For steelhead, the usable area was defined as equivalent to accessible area for all stream reaches regardless of width.

Upon the definition of usable area, a use type was defined for each reach. The 3 types included 1) spawning and rearing, 2) Rearing only, and 3) Migration or no use. Habitat quality was then assigned. Qualitative ratings of excellent, good, fair, and poor were assigned to address fish production potential. Further discussions of the techniques used are available from the Streamnet website (downloaded June, 2003) (ftp://ftp.streamnet.org/pub/streamnet/projman_files/sdmdoc.pdf).

Table 20. Standard smolt density estimates (smolts/m^2) used in the SDM

Stock	**Spawning & Rearing Habitat Quality**				**Rearing Only Habitat Quality**			
	EX (1)	**GO (2)**	**FA (3)**	**PO(4)**	**EX (1)**	**GO (2)**	**FA (3)**	**PO(4)**
Steelhead	.10	.07	.05	.03	.04	.03	.02	.01
Chinook	.90	.64	.37	.10	.40	.27	.15	.03

Based on these data and the set of density values for each stock in each production category (Table 20), the model calculated a smolt production estimate for the reach. For example, if a reach was 2 miles long and 35 feet wide, with a presence/absence value of 0.75 for spring chinook, a habitat quality rating of 2, and a use type value of 1 (Spawning and Rearing), the calculation of potential smolt production would be:

$$(0.75 * 2 \text{ mi} * 5{,}280 \text{ ft/mi} * 35 \text{ ft}) / 10.764 \text{ ft/m}^2 = 34{,}336 \text{ m}^2$$

The density value for spawning and rearing habitat of quality value 2 for spring chinook is 0.64, therefore:

$$34{,}336\ m^2 * 0.64\ smolts/m^2 = 21{,}975\ smolts$$

Mainstem Camas Carrying Capacity

Estimated summer steelhead smolt carrying capacity was summarized for the mainstem Camas Creek (Lower Camas, Camas/Wilkins, and Bowman Creek subwatersheds) using methods described above. The reach with the highest estimated carrying capacity for summer steelhead occurs between the Bear Wallow and Bowman Creek confluences (RM 24.0 – 28.3) (Figure 16). Habitat quality in this reach was rated fair while habitat use determined to be for spawning and rearing.

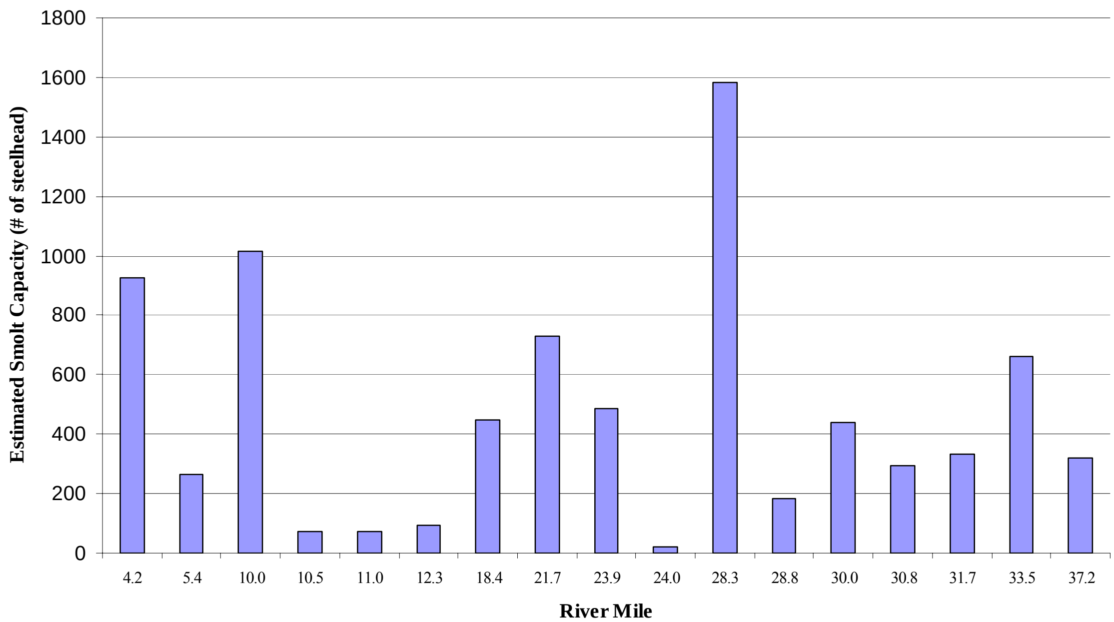

Figure 16. Estimated summer steelhead smolt carrying capacity for the mainstem Camas Creek. Estimates based on the SDM model developed in 1990 for the NPPC (1990)

Cable Creek Carrying Capacity

The estimated summer steelhead smolt carrying capacity for Cable Creek is shown in Figure 17. Smolt capacity is highest between the confluence of Cable Creek and North Fork Cable Creek.

Steelhead Carrying Capacity for Remainder of Streams

Because the remainder of streams in the assessment area was defined by 2 or fewer reaches, steelhead carrying capacity estimates are presented in tabular format (Table 21).

Carrying capacity in lower Hidaway Creek has an estimated potential to support 1,339 steelhead smolts, which is by and large the highest of all streams in the assessment area. Habitat quality in all streams was rated as fair.

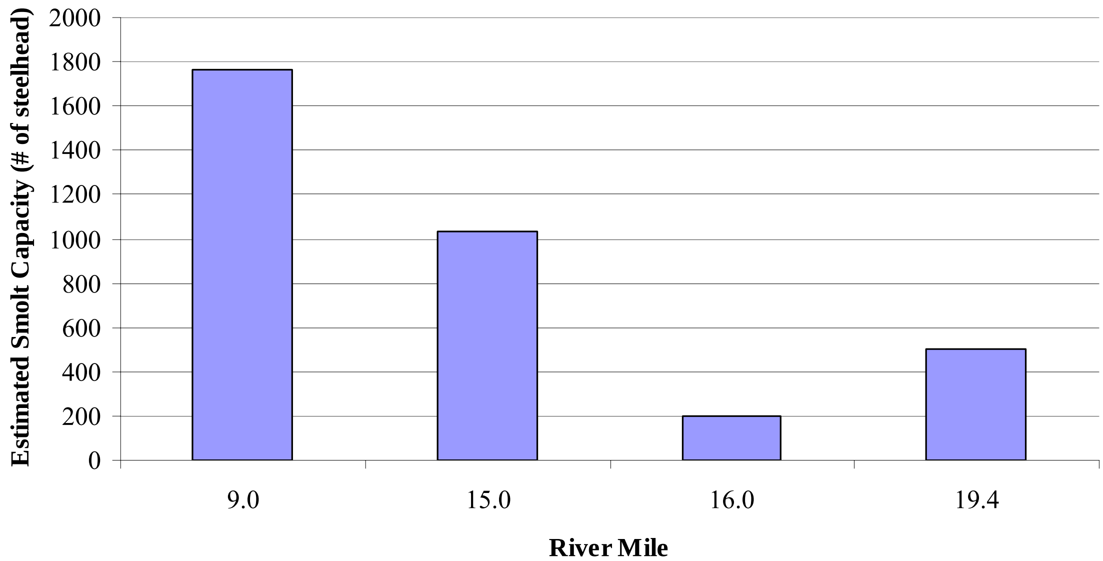

Figure 17. Estimated summer steelhead smolt carrying capacity for Cable Creek. Estimates based on the SDM model developed in 1990 for the NPPC (1990)

Carrying Capacity – Summary

Using the model developed by the Northwest Power Planning Council, it is possible to arrive at a rough estimate of summer steelhead carrying capacity in streams throughout the Camas Assessment Area. Overall, carrying capacity does not appear to be a limiting factor to production.

Results from the model indicate that habitat capacity for steelhead smolts is greatest in portions of the mainstem Camas (between the Bear Wallow and Bowman Creek confluences; RM 24.0 – 28.3), lower Cable Creek (between the confluence of Cable Creek and North Fork Cable Creek), and in lower Hidaway Creek (from the mouth to Line Creek). Relative habitat quality was rated “fair” in most of the stream reaches assessed. The only “good” habitat was defined as occurring in the lower ten miles of the mainstem Camas. “Poor” habitat was defined between RM 11.0 and 24.0 (from the confluence of Owens Creek to the confluence of Bear Wallow Creek).

Table 21. Estimated summer steelhead smolt carrying capacity for various streams within the Camas Assessment Area for which SDM derivations were made. Estimates are based on the SDM model developed in 1990 for the NWPPC (Northwest Power Planning Council 1990)

Stream Name	Tributary To	From	To	Present	Length (mi)	Width (ft)	Use Type	Habitat Quality	Smolt Capacity
Hidaway Cr	Camas Cr	Mouth	Line Cr	100	9.1	6	spawning and rearing	Fair	1339
Hidaway Cr	Camas Cr	Line Cr	Headwaters	34	6	4	spawning and rearing	Fair	206
Lane Cr	Camas Cr	Mouth	Headwaters	80	5.5	3	spawning and rearing	Fair	323
Bear Wallow Cr	Camas Cr	Mouth	Headwaters	94	7.4	3	spawning and rearing	Fair	517
Bowman Cr	Camas Cr	Mouth	Headwaters	60	6.5	4	spawning and rearing	Fair	382
Warm Spring Cr	Camas Cr	Mouth	Headwaters	80	3	4	spawning and rearing	Fair	235
Frazier Cr	Camas Cr	Mouth	Headwaters	50	6.3	4	spawning and rearing	Fair	309
Rancheria Cr	Camas Cr	Mouth	Salsbury Cr	100	0.5	3	spawning and rearing	Fair	36
Salsbury Cr	Rancheria Cr	Mouth	Headwaters	80	2.4	2	spawning and rearing	Fair	94
Rancheria Cr	Camas Cr	Salsbury	Headwaters	100	4.4	3	spawning and rearing	Fair	323
Dry Camas Cr	Camas Cr	Mouth	Headwaters	64	4	2	spawning and rearing	Fair	127

Population Trends

Escapement

Spawning escapement data has been collected for various years from index reaches by the ODFW. Redd count data has been collected during low flow years in the mainstem Camas, Lane Creek, Owens Creek, Rancheria Creek, and Cable Creek.

Mainstem Camas Redd Counts

Summer steelhead redd counts in the mainstem Camas have been conducted for various years between 1963 and 1992 (Figure 18). The average number of redds observed is 18.9 while the average number of redds per mile is 5.7. The highest number of redds observed occurred during the 1985 survey. Because the considerable variability in year-to-year redd surveys may be due to years during which no surveys occurred, it is impossible to establish, with any accuracy, the existence of trends in the data ($R^2 = \leq 0.001$). Nonetheless, redd counts from 1967 to 1969 were consistently above the average.

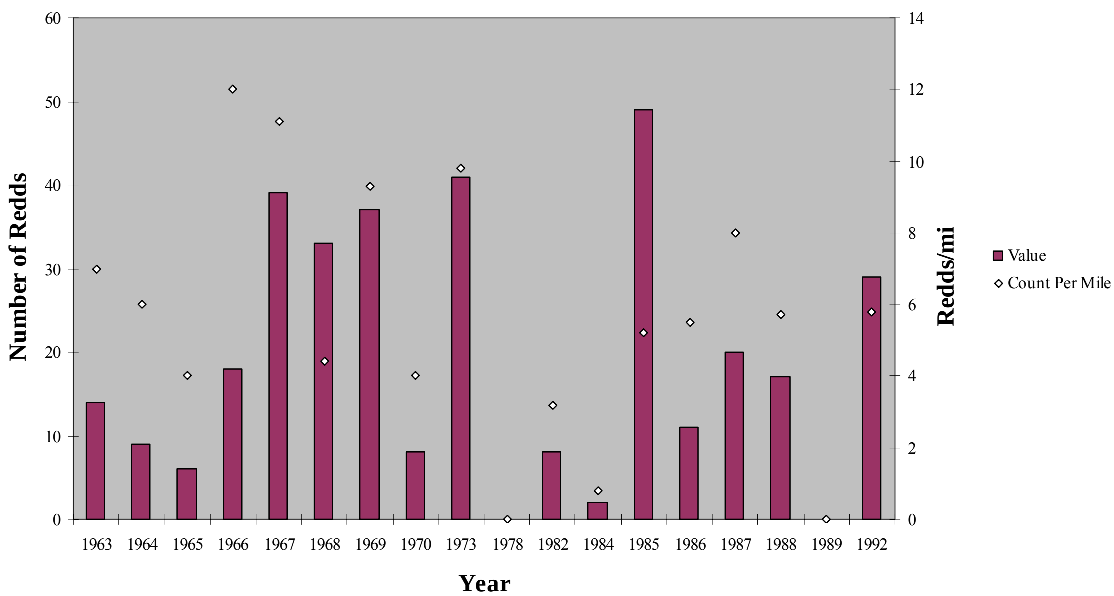

Figure 18. Summer steelhead redd counts for the mainstem Camas Creek, for various years between 1963 – 1992. Streamnet data downloaded July, 2003

Lane Creek Redd Counts

Redd counts in Lane Creek were conducted only once in 1981. A total of two redds were observed over the one-mile length of channel surveyed. Surveys were concluded for unknown reasons.

Owens Creek Redd Counts

Summer steelhead redd counts in Owens Creek have been conducted for various years between 1965 and 1992 (Figure 19). The average number of redds observed is 18.9 while the average number of redds per mile is 5.7. The number of redds observed in the late 1960s was among the highest recorded for the 22 years of survey.

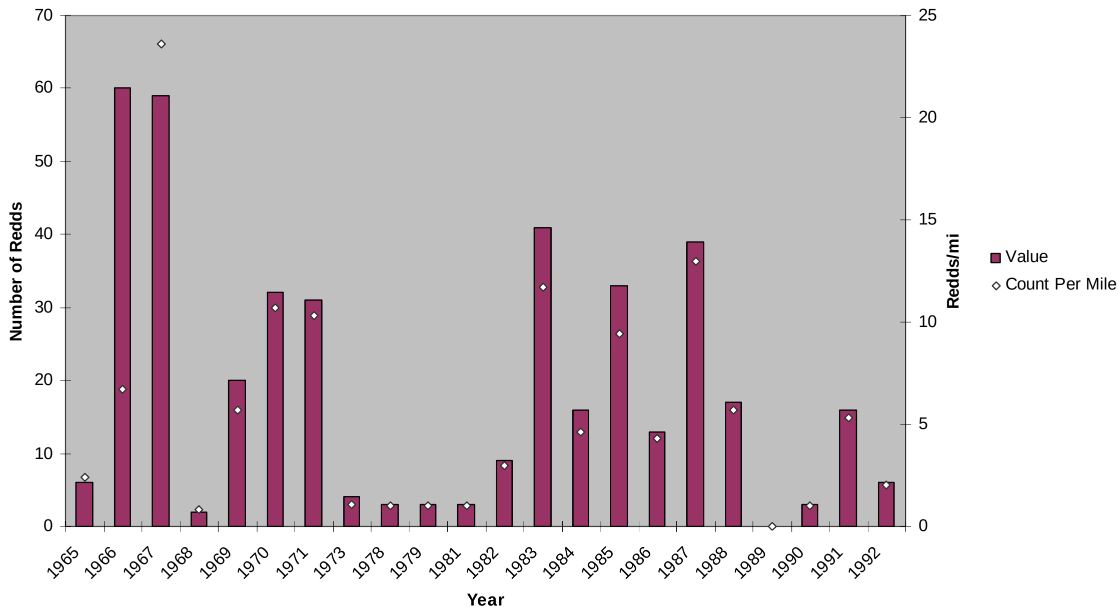

Figure 19. Summer steelhead redd counts for Owens Creek, for various years between 1965 – 1992. Streamnet data downloaded July, 2003

Rancheria Creek Redd Counts

Summer steelhead redd counts in Rancheria Creek have been conducted for various years between 1966 and 1986 (Figure 20). The average number of redds observed for the nine years of survey is 5.1 while the average number of redds per mile is 3.9. The year-to-year variability and lack of consistent survey precludes the establishment of increasing or decreasing trends, however, redd counts were well above the average in 1966 and 1967, and again in 1985.

Cable Creek Redd Counts

Summer steelhead redd counts in Cable Creek have been conducted for various years between 1963 and 1996 (Figure 21). The average number of redds observed for the nineteen years of survey is 17.3, while the average number of redds per mile is 4.13. The highest number of redds observed (61) occurred in 1970. Because the considerable variability in year-to-year redd surveys may be due to years during which no surveys occurred, it is impossible to establish, with any accuracy, the existence of trends in the data. Nonetheless, redd counts do appear to be on the decrease for the years for which there have been surveys ($R^2 = 0.23$).

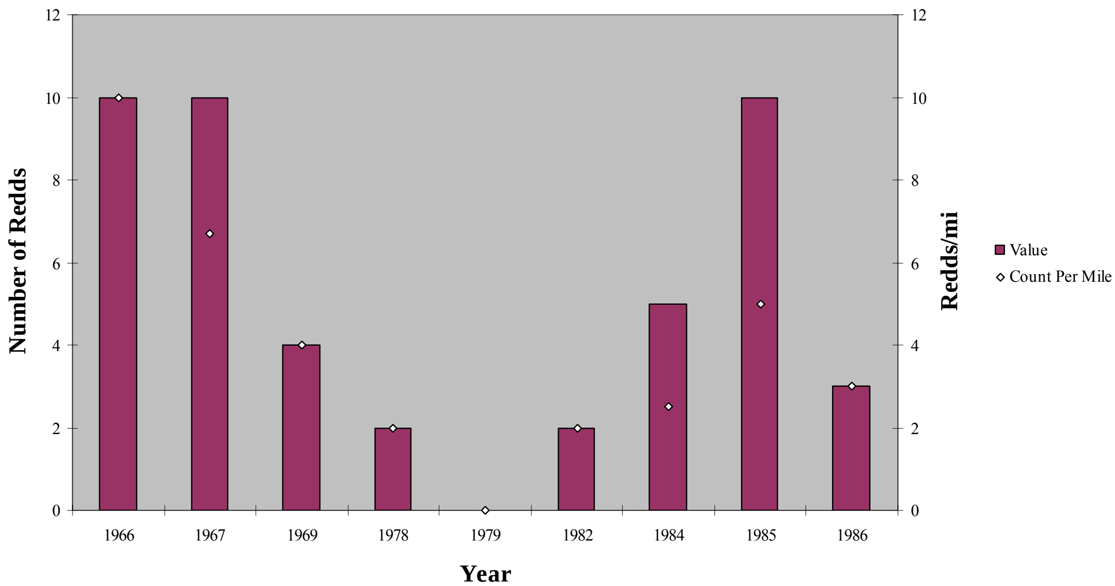

Figure 20. Summer steelhead redd counts for Rancheria Creek, for various years between 1966 – 1986. Streamnet data downloaded July, 2003

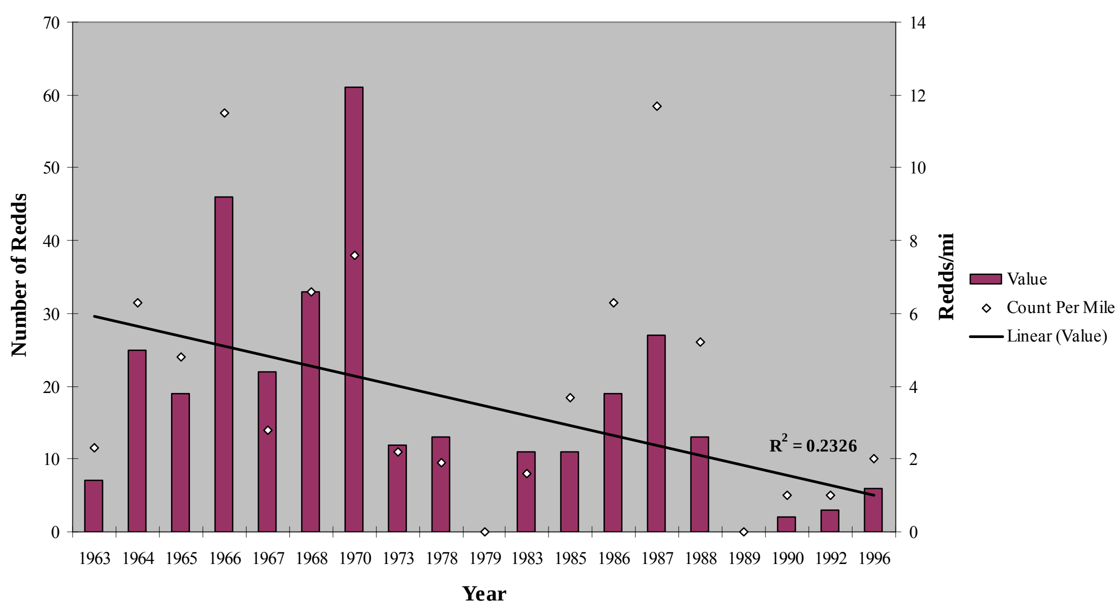

Figure 21. Summer steelhead redd counts for Cable Creek, for various years between 1963 – 1996. Streamnet data downloaded July, 2003

Population Trends – Summary

Due to the lack of consistent redd survey data across all years, it is problematic to establish, with any degree of accuracy, the presence of increasing or decreasing trends in summer steelhead escapement to the Camas Assessment Area. Comparisons of redd counts across all streams suggest that the most successful period for redd construction occurred during the late 1960s and then again in the mid-1980s (Figure 22). Between-stream comparisons show that the number of redds observed in mainstem and Cable Creek habitats were consistently higher than in other streams surveyed.

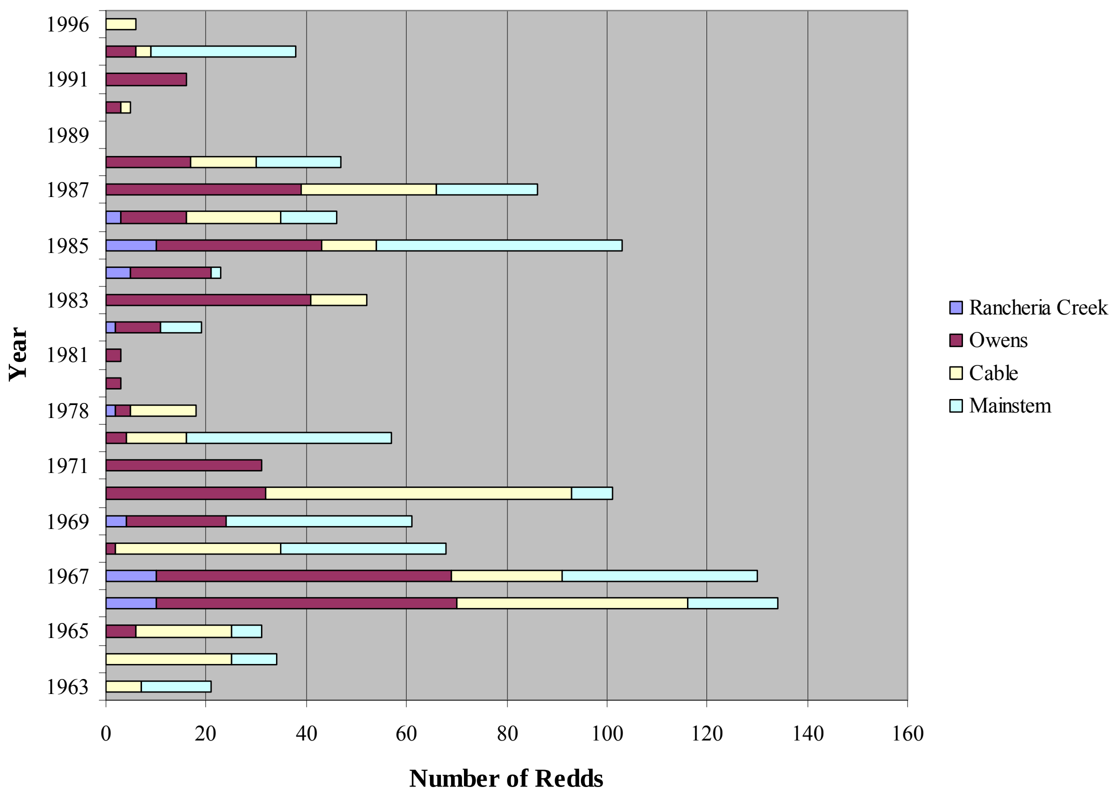

Figure 22. Summer steelhead redd counts for all streams surveyed in the Camas Assessment Area (1963 – 1996). Streamnet data downloaded July, 2003

3.2.2 Distribution

Current Distribution

As mentioned previously, summer steelhead are the most ubiquitous salmonid occurring in the Camas Assessment Area, and are present in all accessible habitats. Because fish distribution surveys are conducted during periods of low flow, actual distribution may be more widespread during periods of higher flows when more reaches are accessible (Umatilla National Forest 1995).

When considered at the subwatershed scale, summer steelhead occupy an estimated 95.2% of usable habitat (161.4 linear stream miles) in the Camas Assessment Area (Table 22).

Table 22. Steelhead distribution and habitat utilization at the subwatershed scale for the Camas Assessment Area (adapted from (Umatilla National Forest 1995)

Subwatershed	Habitat Available (mi)	Habitat Used (mi)	Percentage Occupied
Lane	18.4	17.7	96.2%
Snipe	9.7	9.7	100.0%
Bowman	41.6	35.7	85.8%
Upper Owens	11.1	11.1	100.0%
Lower Owens	7.9	7.9	100.0%
Hidaway Creek	28.6	28.6	100.0%
Camas/Wilkins	13	13	100.0%
Cable	33.8	32.2	95.3%
Lower Camas	5.5	5.5	100.0%
TOTAL	**169.6**	**161.4**	**95.2%**

Historic Distribution

Historic summer steelhead distribution was likely very similar to current distribution. The occurrence of resident redband trout in isolation from stream reaches currently occupied by anadromous summer steelhead (i.e. Frazier Creek; Umatilla National Forest 1995) suggests there may have been a more widespread historic distribution of the anadromous form, however, the difficulty of distinguishing the redband from other forms in the absence of genetic profiles precludes the validity of this assumption. Genetics work is therefore warranted.

Identification of differences in distribution due to human disturbance

Because of the lack of genetics work in distinguishing resident redband rainbow forms from other rainbow, it is not possible to tell if anadromous summer steelhead were more widely distributed historically than they are currently. One may assume that anthropogenic modification of steelhead habitat has reduced year-round accessibility (especially for summer rearing forms) from what likely existed historically, however, in the absence of historic data, this assumption may be remiss.

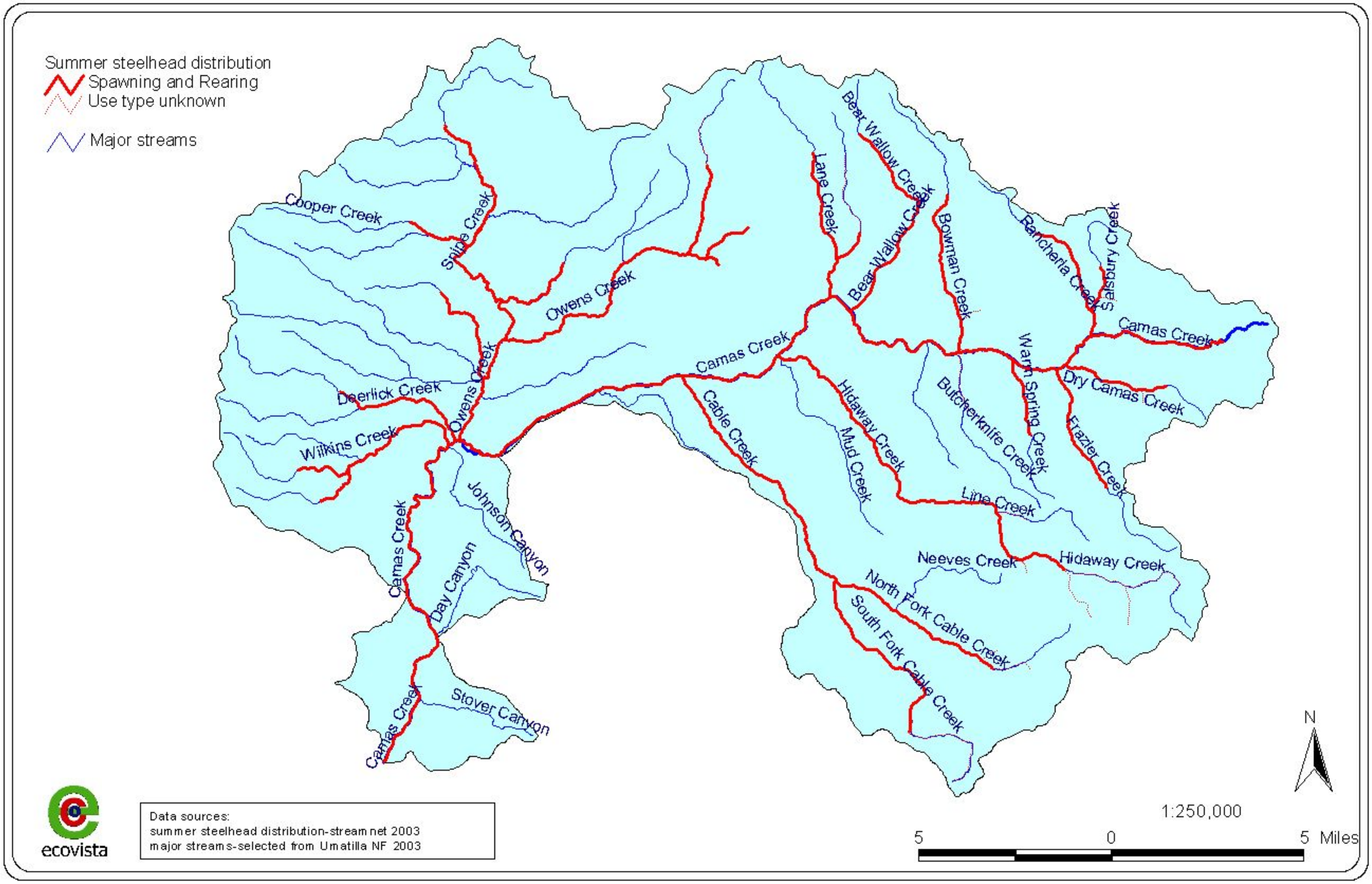

Figure 23. Summer steelhead distribution in the Camas Assessment Area (data downloaded from Streamnet, July 2003)

3.2.3 Artificial production and captive breeding programs

Artificial Production: Current

No hatchery steelhead have been released in the John Day River Subbasin [Camas Creek] since the late 1960's, and those releases were from a stock that had very little probability of survival (Knapp 2001).

Artificial Production: Historic

Historic releases of hatchery summer steelhead into the John Day Subbasin were limited. Approximately 37,495 hatchery summer steelhead were released into the John Day in 1947 and 1969. The hatchery fish were bred from a non- John Day stock.

Ecologic Consequences of Artificial Production

Because of the limited degree of hatchery influence, the Camas Assessment Area has not suffered ecologically from the influx of non-endemic steelhead.

3.2.4 Harvest

Current in-basin harvest levels

Camas-specific, in-basin harvest levels are not available. The UNF (Umatilla National Forest 1995) states that "angling effort in the watershed is low, and is primarily targeted for resident trout". Harvest data is available, however, for the North Fork John Day and its tributaries (Figure 24).

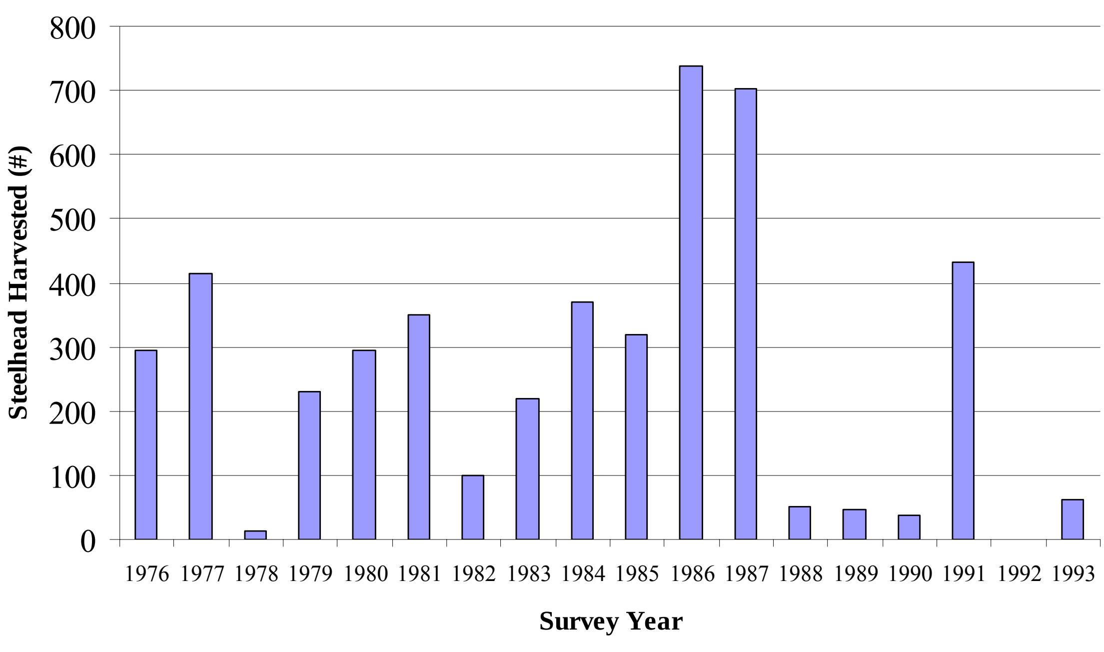

Figure 24. Steelhead harvest for the North Fork John Day and its tributaries (1976-1993). Data downloaded from Streamnet, July, 2003

3.3 Spring Chinook

The Camas Assessment Area provides habitat for spring-run chinook salmon that exhibit a stream-type life history. Camas chinook belong to the Mid-Columbia River Spring-Run ESU (Myers et al. 1998). The North Fork John Day (and associated tributaries) accounts for as much as 70 percent of all spring chinook production in the John Day Subbasin, although the Camas Drainage accounts for only a small percentage of this production. Naturally-produced spring chinook populations in the John Day Subbasin are among some of the healthiest in the mid-Columbia basin (Jonasson 1998-1999).

3.3.1 Population Data and Status

Historical Status

Little information exists relating the historic status of spring chinook in the Camas Assessment Area. The CRITFC (1996) reports that the John Day River was historically one of the most significant anadromous fish producing rivers in the Columbia River Basin. Whether or not Camas Creek contributed more fish to the subbasin than it does currently is unknown. Based on the fact that the CTUIR had usual and accustomed fishing sites in the area, and that among the species sought were chinook, it is reasonable to assume that fish were in sufficient harvestable numbers.

Current Population Data and Status

Life History

Most John Day spring chinook return as 4-year-olds (76 percent), while 22 percent return as five year-olds and 3 percent return as 3 year-olds (Myers et al. 1998). Both of the two carcasses sampled in Camas Creek by ODFW in 2000 were determined to be age-4 fish.

As shown in Table 19, spring chinook salmon adult migration occurs during the month of May, (may extend into June) after which the fish will 'hold' from June - August. However, since stream temperatures throughout the mainstem Camas become excessively warm (mid- to upper-70s) during the subsequent 'holding' period, it is reasonable to assume that spring chinook will hold in the larger, cooler, North Fork John Day until the actual time of spawning during mid-August through late September (and occasionally into October). Spring chinook may hold in the mainstem during unseasonably cool years, or in habitats with suitable temperature ranges.

Egg incubation usually initiates in early September and extends through late April. Emergence of fry commences in April or May following high water. Juveniles reside in rearing areas for approximately 12 months before migrating downstream the following spring, with migration peaking past Spray, OR (RM 170) on the mainstem during the second week in April (Lindsay et al. cited in Myers et al. 1998). Because of their use of smaller tributaries such as Camas Creek for spawning and extended juvenile rearing, stream-type chinook increase their potential for adaptation to local ecosystems, unlike fall chinook which spawn in mainstem areas and migrate more quickly to the marine environment (Myers et al. 1998).

Mid-Columbia spring chinook typically undertake extensive off-shore ocean migrations, as very few CWT-marked fish appear in appreciable numbers in any coastal or off-shore fisheries (Myers et al. 1998).

Carrying Capacity and Productivity Estimates

The only carrying capacity estimates made for spring chinook in Camas Creek were those derived from the 1990 subbasin planning efforts. Please refer to the previous steelhead discussion for information on methods used in model derivations.

Mainstem Camas Carrying Capacity

Estimated spring chinook smolt carrying capacity was summarized for the mainstem Camas Creek (Lower Camas and Camas/Wilkins subwatersheds) using methods described in (Northwest Power Planning Council 1990). The lower Camas and Camas/Wilkins subwatersheds (first ten river miles of the mainstem Camas) were the only in the assessment area that were considered to contain spring chinook habitat. Habitat quality in the three reaches was considered to be “Good”, used primarily for rearing and migration. The uppermost reach (RM 5.4 – 10.0) was determined adequate to support as many as 9,138 fish, compared to the lower reach (RM 0.0 – 4.2) that had a smolt density capacity of 8,343 chinook (Figure 25).

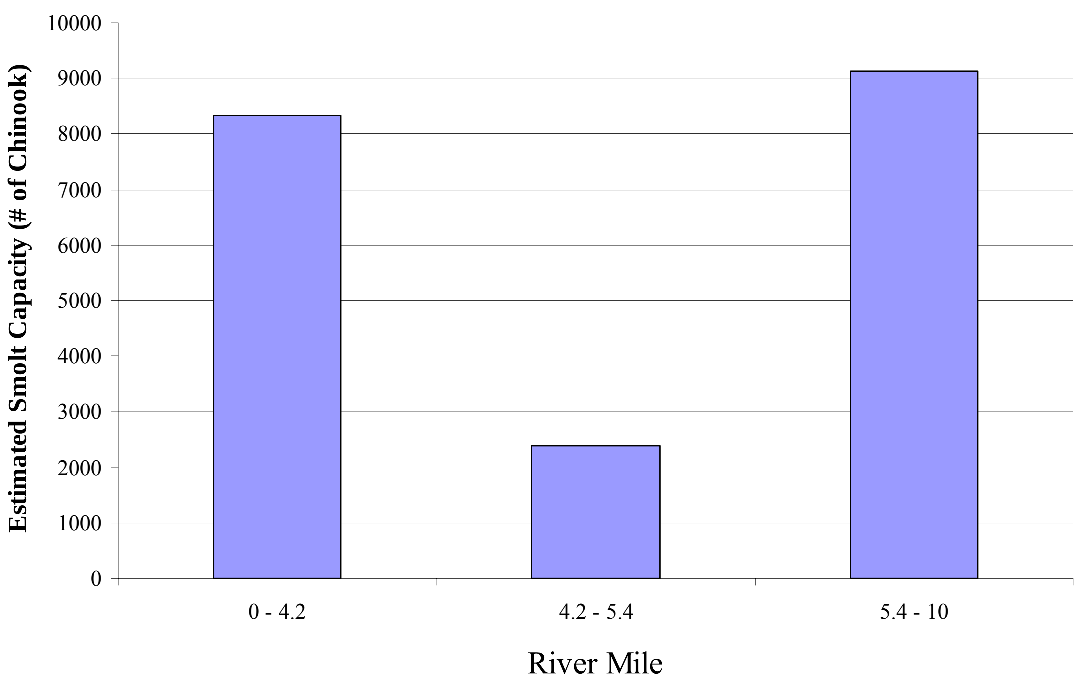

Figure 25. Estimated spring chinook smolt carrying capacity for the mainstem Camas Creek. Estimates based on the SDM model developed in 1990 for the NWPPC (Northwest Power Planning Council 1990)

Population Trends

Escapement

Spring chinook escapement data in the Camas Assessment Area is insufficient to establish, with any degree of certainty, increasing or decreasing population trends. Part of the reason for the lack of long-term data is that the Camas Creek watershed represents a "minor" spawning area for John Day Subbasin spring chinook (Carmichael 2000-2001). ODFW conducts annual spawning surveys in specific index streams, at established spawning periods. When spawning is believed to occur outside of the index areas, ODFW will conduct "exploratory" surveys of watersheds that historically have contained redds (i.e. Camas Creek, Desolation Creek, and the South Fork John Day). Available redd count information is therefore based on surveys conducted by the Forest Service (Umatilla National Forest 1995) and by exploratory surveys conducted by ODFW (Carmichael 2000-2001).

Spawning surveys conducted on the mainstem by the UNF identified one redd in 1989, while in 1990 three redds were observed. No redds were found in 1992 and three redds and one carcass were observed in 1993 (Umatilla National Forest 1995). Kristi Groves, a USFS fish biologist for the Ukiah District, reported that spring chinook were observed in 2003 downstream of the Ukiah-Dale Wayside Park (K. Groves, USFS, Personal Communication, September, 2003).

Camas Creek was surveyed by ODFW in September and October of 2000 (Carmichael 2000-2001) and again in 2001 (Jim Ruzycki, ODFW, unpublished data). The exploratory surveys in 2000 were partially in response to the 6,947 adult chinook that returned to spawn in the John Day Subbasin, which represented the highest number of fish ever recorded in the John Day. A total of 3 redds were identified following the 2000 surveys (Table 23), while no redds were observed in 2001 (Jim Ruzycki, ODFW, unpublished data). All three redds were observed in one reach on October 3rd (between the Bridge Creek confluence (RM 4.2) and 3 miles below the Ukiah/Dale state Campground (RM 8.2). This ODFW reach occurs in the lower Camas and Camas/Wilkins subwatersheds. A total of seven adult chinook were observed off redds in 2000 (4 in the Lane and Bowman subwatersheds and three in the Camas/Wilkins subwatershed). ODFW (Carmichael 2000-2001) estimates that there were eleven spawners in 2000, and that the percentage of spawning fish from Camas Creek represented only 0.2 percent of the total for the John Day Subbasin.

Abundance

Not surprisingly, Camas-specific, spring chinook abundance data is lacking. (Myers et al. 1998) provides a discussion of spring chinook abundance estimates for the Columbia basin, and includes a brief examination of short- and long-term trends at the fourth-field HUC scale. The following discussion is taken from (Myers et al. 1998), unless otherwise noted.

Table 23. Exploratory spring chinook redd surveys in Camas Creek (Carmichael 2000-2001)

Stream Reach	Date	Miles	New Redds		On Dig		Off Dig		Dead Fish, Unmarked			
			Occupied	Unoccupied	A	J	A	J	M	F	J	U
Lehman Springs Rd. to Rd. 54 Bridge	1-Sep	3.3	0	0	0	0	0	0	0	0	0	0
Rd. 54 Bridge to FS Boundary	1-Sep	2.3	0	0	0	0	4	0	0	0	0	0
Ukiah-Dale Park down 3 miles	1-Sep	3.0	0	0	0	0	3	0	0	0	0	0
Cable Creek Forks to 4-T Ranch	1-Sep	5.0	0	0	0	0	0	0	0	0	0	0
Cable Creek 4-T Ranch Property	7-Sep	1.0	0	0	0	0	0	0	0	0	0	0
Rd. 54 Bridge to FS Boundary	3-Oct	2.3	0	0	0	0	0	0	3	0	0	0
Ukiah-Dale Park down 3 miles	3-Oct	3.0	0	0	0	0	0	0	0	0	0	0
3 miles below park to Bridge Creek	3-Oct	4.0	0	3	0	0	0	0	0	0	0	0
TOTAL			**0**	**3**	**0**	**0**	**7**	**0**	**3**	**0**	**0**	**0**

The relationship between present carrying capacity and present abundance is important for evaluating the health of local spring chinook populations and provides an indication of relative extinction risk. In the mid-1990s, a biological review team (BRT) evaluated, among other population factors, extinction risk for spring chinook throughout all ESUs in the Columbia Basin. Specific methods used in the evaluation are lengthy, but were largely based on previous assessments and data regarding individual elements of population status, such as abundance, trend, hatchery influence, and habitat conditions. The reader is referred to (Myers et al. 1998) for a complete description of methods used.

The BRT estimated the recent (article published in 1998) 5-year geometric mean spawning escapement for spring chinook in the John Day Subbasin to be in excess of 10,000 fish (Myers et al. 1998). The trend (percent annual change) in abundance of John Day chinook was estimated to be decreasing from -1 to -5%. When considered at the fourth-field HUC scale (i.e. North Fork John Day), for the years 1964-1996 the long-term trend of natural production (i.e. all data collected after 1950) was in decline (-0.2), as was the short-term trend (-8.9).

3.3.2 Distribution

Current Distribution

As reported by the UNF (Umatilla National Forest 1995), spring chinook currently occur in the lower two-thirds of the mainstem Camas Creek, albeit sporadically. The lower ten miles of the mainstem is used primarily as a migration corridor, while the next six miles is defined as migration and/or rearing habitat. The final eight to ten miles may be used by spawning and rearing life history stages (Figure 26).

Reports of spring chinook in Hidaway Creek suggest that distribution may be more widespread than what is presented in Figure 26. In 1990, two adult chinook were observed in the stream, and a carcass was found in 1992 (Umatilla National Forest 1995). Juveniles were also noted during a 1992 survey of Hidaway, although no redds were counted during a subsequent survey in 1993 (Umatilla National Forest 1995). It is likely, that similar to summer steelhead movement and distribution, spring chinook will access available habitat in the assessment area given the appropriate streamflow and water quality conditions, and thereby escape detection during baseflow surveys.

When considered at the subwatershed scale, spring chinook currently occupy an estimated 88.9% of usable habitat (29.6 linear stream miles) in the Camas Assessment Area (Table 24).

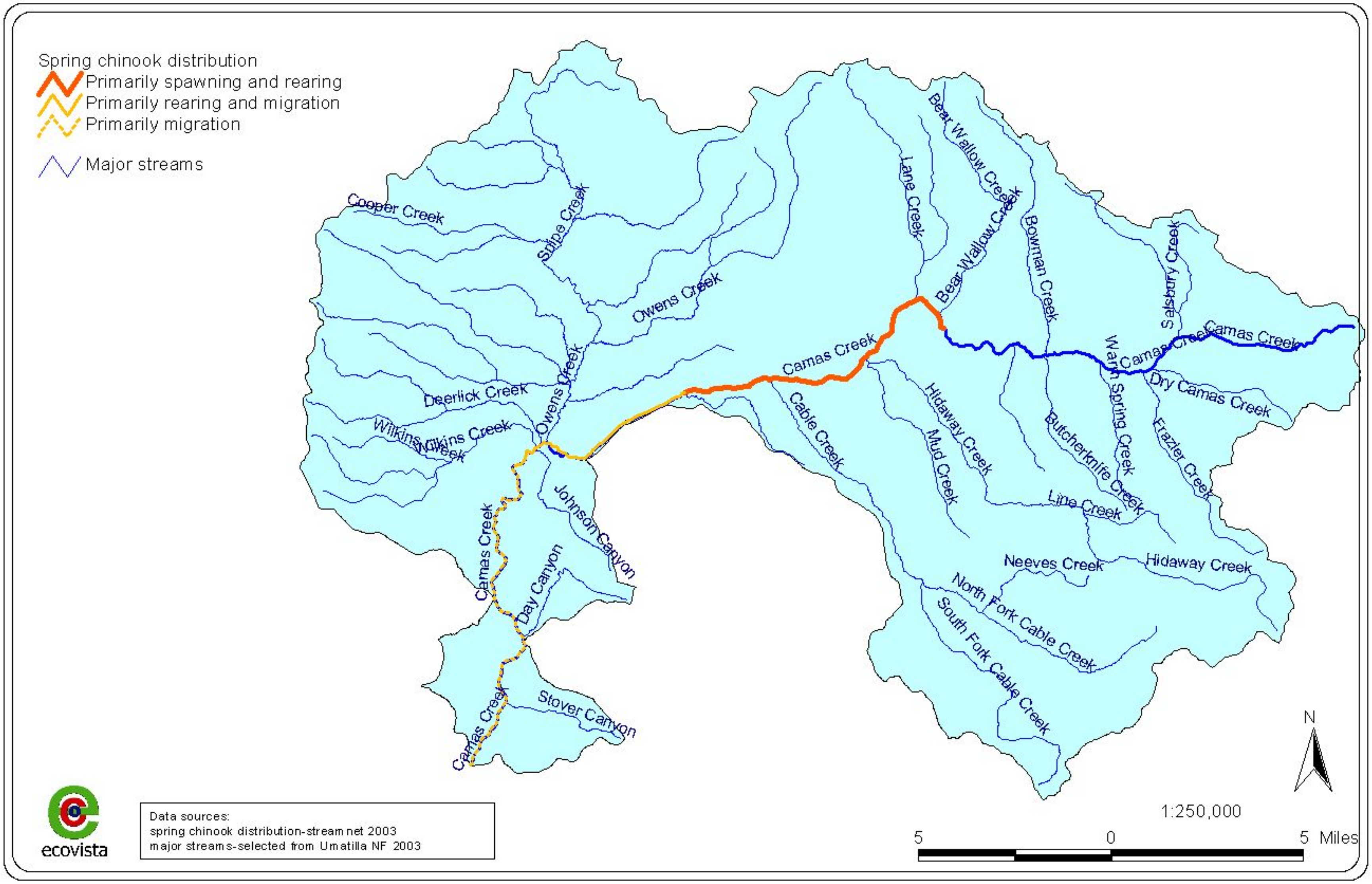

Figure 26. Current spring chinook distribution in the Camas Assessment Area

Table 24. Spring chinook distribution and habitat utilization at the subwatershed scale for the Camas Assessment Area (adapted from (Umatilla National Forest 1995)

Subwatershed	Habitat Available (mi)	Habitat Used (mi)	Percentage Occupied
Lane	6.1	6.1	100.0%
Hidaway Creek	8.7	5.0	57.4%
Camas/Wilkins	13.0	13.0	100.0%
Lower Camas	5.5	5.5	100.0%
TOTAL	**33.3**	**29.6**	**88.9**

Historic Distribution

Only implied or empirical information exists in relation to historic spring chinook distribution throughout the Camas Assessment Area.

Since stream-type juvenile chinook are adapted to watersheds, or portions thereof, that are more consistently productive and less susceptible to stochastic disturbance pressures (i.e. dramatic changes in water flow), it is reasonable to assume that historic distribution of juvenile chinook in mainstem Camas rearing areas has not changed significantly from current rearing distributions. Differences in historic and. current water quality and flow volumes are likely however, and may have provided juvenile chinook with a wider range of habitat availability and distribution.

Based on the locations of the usual and accustomed fishing sites of the CTUIR (*refer to* Table 18), adult spring chinook distribution was somewhat wider than current distribution. The farthest upstream fishing site, the mainstem Camas near the mouth of Warm Springs Creek (≈ RM 30), is approximately four miles above the uppermost reach of current chinook distribution. Assuming a portion of the CTUIR harvest was comprised of chinook, it is reasonable to assume that spawning adults had a more widespread distribution pattern than currently.

Identification of differences in distribution due to human disturbance

One may assume that anthropogenic modification of spring chinook habitat has reduced habitat accessibility and availability from what likely existed historically, however, in the absence of quantitative historic data, this assumption would be unsubstantiated. The presence of aboriginal [salmon] fishing sites further upstream than current adult spring chinook distribution provides argument that human disturbance has reduced current available habitat from what existed historically.

3.3.3 Artificial production and captive breeding programs

Artificial Production: Current

Hatchery production of spring chinook salmon currently does not occur in the John Day Subbasin. Artificial production has not occurred anywhere in the subbasin since 1982 (Myers et al. 1998). The current fish management policy is designed to maintain native, wild stocks of salmon and steelhead, and to preserve the genetic diversity of these native stocks for maximum habitat use and fish production (Oregon Department of Fish and Wildlife et al. 1990). (Carmichael 2000-2001) reports that of the 1,530 carcasses examined following 2000 spawning surveys, only sixteen (1.0%) were of hatchery origin.

Artificial Production: Historic

The John Day Subbasin has historically been stocked with comparatively fewer fish than similar- sized, or adjacent subbasins. In 1952, 19,957 spring chinook from the Sandy River hatchery were stocked in the John Day Subbasin (Myers et al. 1998). Twenty-six years later, hatchery stocking resumed. A total of 89,094 hatchery spring chinook of John Day origin were stocked from 1978-1982.

Ecologic Consequences of Artificial Production

Because artificial production currently does not occur in the Camas Assessment Area (or anywhere else in the subbasin), the ecologic consequences of hatchery x wild[2] fish interactions are negligible.

3.3.4 Harvest

Current in-basin harvest levels

Camas-specific, in-basin harvest levels are negligible. There has not been a spring chinook sport fishery in the John Day Subbasin since 1978, although the CTUIR have a limited subsistence fishery on the North Fork John Day River (Carmichael 2000-2001). In 2000, Umatilla tribal members harvested 49 of their allotted 50 adult spring chinook from the Granite Creek System in the North Fork Drainage (Carmichael 2000-2001).

The escapement target that would allow a sport fishery to resume in the John Day Subbasin is 7,000 spawners for three to four consecutive years, but this target has not yet been met (Carmichael 2000-2001). Given an average annual return of 7,000+ fish, 1,050 fish would be available for tribal and sport harvest, leaving 5,950 fish for natural production. Tribal, Oregon state Police (OSP), and ODFW closely monitor the quota for this fishery and the fishery itself.

Historic in-basin harvest levels

Historic, in-basin harvest levels are not available. Based on the usual and accustomed fishing sites of the CTUIR (Buchanan et al. 1997), the Camas once supported anadromous [salmon & steelhead] and resident species at harvestable levels (*refer to* Table 18).

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[2] There has been considerable concern that hatchery-reared salmon and steelhead have reduced the prevalence of wild anandromous salmonids through competitive interaction, genetic introgression, and disease transmission. The fact that more than 70 percent of Oregon's salmon start life in a fish hatchery (http://www.oregonvos.net/salmon) lends credence to this concern. Also, the mixed stock fishery that has been created through the introduction of hatchery fish has resulted in increased harvest rates of wild/natural fish.

4 Summary of Aquatic Habitat Quality

4.1 Evaluation of Habitat Unit Quality

The quality of instream habitat for anadromous species in the Camas Assessment Area varies. Like most subbasins, habitat quality in the Camas Assessment Area generally follows an elevational gradient – it is highest in headwater areas and lowest in lower elevation or depositional reaches. The following discussion presents a general assessment of the quality of key habitat components.

Methods Used to Assess Habitat Quality

The most recent (1998 – 2003) stream survey data available for analysis was collected by the North Fork John Day Ranger District, UNF, which included information from a total of six distinct drainages that occur within the Camas Assessment Area (Table 25). Data collection methods were consistent with Region 6 inventory protocol. Survey data collected prior to 1995 was considered inadequate for in-depth analysis due to lack of uniformity in data collection and interpretation methods.

Table 25. Stream reaches within the Camas Assessment Area that were recently (1998 - 2003) surveyed by the UNF

Subwatershed(s)	Reach Name	Year Surveyed	From (RM)	To (RM)
Lower Camas	Main. R1	Not Surveyed	0.0	6.77
Lower Camas	Main. R2	2000	6.77	10.75
Camas/Wilkins	Main. R3	Not Surveyed	10.75	21.8
Camas/Wilkins	Main. R4	2000	21.8	22.8
Lane; Bowman	Main. R5	2000	22.8	23.9
Bowman	Main. R6	2000	23.9	26.6
Bowman	Main. R7	Not Surveyed	26.6	30.4
Bowman	Main. R8	2000	30.4	31.5
Lane	Lane R1	2000	0.0	0.68
Lane	Lane R2	2000	0.68	1.25
Lane	Lane R3	2000	1.25	3.07
Lane	Lane R4	2000	3.07	3.92
Lane	Lane R5	2000	3.92	4.42
Lane	Lane R6	2000	4.42	4.99
Hidaway	HidawayR1	2003	0.0	0.65
Hidaway	HidawayR2	2003	0.65	2.63
Hidaway	HidawayR3	2003	2.63	4.78
Hidaway	HidawayR4	2003	4.78	6.06
Hidaway	HidawayR5	2003	6.06	9.39
Bowman	DryCamas R1	1998	0.0	0.86
Bowman	Dry Camas R2	1998	0.86	3.73
Bowman	RancheriaR1	Not Surveyed	0.0	0.50
Bowman	RancheriaR2	1998	0.50	1.61
Bowman	RancheriaR3	1998	1.61	4.69
Bowman	Salsbury R1	1998	0.0	1.56
Bowman	Salsbury Trib	1998	0.0	0.81

It is important to note that while stream survey data plays an integral role in the assessment of habitat quality, it must be interpreted carefully since it only represents a "snapshot" of conditions. In the case of the Camas Assessment Area, information presented should be assumed to reflect conditions measured during baseflow periods for the respective year, as the data did not lend itself to trend interpretation.

Habitat quality evaluations for streams in the Camas assessment were based upon a combination of methods described in the Oregon Watershed Assessment Manual (Umatilla National Forest 1995) and upon an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat (commonly referred to as PACFISH) criteria. Based on survey and empirical data, the ODFW has established a number of habitat benchmarks that are designed to provide an initial context for evaluating measures of habitat quality (Watershed Professionals Network 1999). The benchmarks rate key habitat attributes qualitatively, as they pertain to a survey units' ability to support salmonids (Appendix 1). The ODFW ratings were used to assess pool habitat quality (% pool area, pool frequency, and residual pool depth), and riffle habitat quality (width:depth ratio, percent sand, and percent gravel).

Modifications to OWAM Habitat Assessment Protocol

Because of data limitations, portions of the OWAM habitat assessment protocol were omitted, modified, and/or enhanced. Riparian assessment, as called for in the OWAM, requires data describing conifer diameter at breast height (dbh), which was omitted due to a lack of data. Furthermore, the OWAM requires a fish passage evaluation, which was not conducted due to a lack of data. The "pool complexity" rating, as defined in the OWAM, was not clear. Upon conversations with ODFW and the Oregon Watershed Enhancement Board (OWEB), we agreed upon a definition of a complex pool as one containing $\geq$3 pieces of LWD (>12" diameter, >35' length), and rated their frequency of occurrence per mile as either undesirable (<1.0 complex pool/mi) or desirable (>2.5 complex pools/mi).

The protocol used in the OWAM to assess habitat quality rates habitat attributes as either "desirable", "undesirable", "between", or "no data". A disproportionate number of the Camas Creek ratings fell in the "between" category, which did not provide for an effective measure of condition. The "between" ratings were subsequently weighted based on where they fell relative to the median of the ranges defining "desirable" or "undesirable" habitat conditions. For instance, the OWAM rates percent pool area as "undesirable" (<10), or desirable (>35). A computed value of 28 would therefore be considered "between/desirable" (B/D) since it fell between the "undesirable" and "desirable" categories, but on the "desirable" end of the median (25). Scores were assigned to each rating category to provide a relative picture of habitat condition between-streams and/or between reaches (Table 26). A final positive rating was considered "desirable", a negative rating "undesirable", and a rating of zero "between".

Table 26. Codes and values used to score habitat attributes in the Camas Assessment Area

OWAM Codes	Desirable (D)	Undesirable (U)	Between-Desirable (B/D)	Between-Undesirable (B/U)
PACFISH Codes	Properly Functioning (PF)	Not Properly Functioning (NPF)	Functioning at Risk – Properly (FAR/P)	Functioning at Risk – Not Properly (FAR/N)
Rating Value	+1	-1	+0.5	-0.5

In an effort to increase the sample size and reduce the occurrence of "between" ratings, we use PACFISH criteria in conjunction with the OWAM rating system. The PACFISH criteria, which is presented in the matrix of pathways and indicators (refer to Appendix 2) is an established and regionally accepted protocol for evaluating the effects of human activities on ESA-listed species and the habitats within which they reside (National Marine Fisheries Service 1996). Similar to the OWAM rating system, the PACFISH criteria is based on empirical data applicable to anadromous salmonids, and rates a given set of key habitat attributes qualitatively. The ratings of "Properly Functioning", "At Risk", and "Not Properly Functioning" are assumed to correspond to the "desirable", "between", and "undesirable" ratings used in the OWAM, and are scored similarly (*refer to* Table 26). Attributes that are rated in conjunction with the OWAM system are shown in Table 27.

We found the use of the PACFISH criteria in combination with OWAM criteria to also be helpful in situations where attribute data may have been missing or otherwise unrated. For example, the OWAM doesn't include a rating for bank stability whereas PACFISH does. Similarly, in the situation where we lacked the necessary information required by the OWAM to assess pool frequency (i.e. the average number of channel widths between pools), we were able to assess pool frequency based on PACFISH criteria (pools/mile).

Table 27. Common habitat attributes rated using OWAM and PACFISH criteria.

Riffle Attributes (OWAM)	**Riffle Attributes (PACFISH)**	**Pool Attributes (OWAM)**	**Pool Attributes (PACFISH)**	**LWD Attributes (OWAM)**	**LWD Attributes (PACFISH)**
Wetted W:D Ratio	Bankfull W:D Ratio	Pool Frequency (chan. widths between pools)	Pool Frequency (pools/mi)	LWD/100 meters	LWD/Mile

An additional modification to the OWAM habitat assessment protocol was the inclusion of Wollman substrate data. In its riffle quality assessment, the OWAM calls for the percentage of riffle area comprised of gravel and fine substrate. While this information was for the most part available, the USFS stream survey data was based on ocular estimates only. And because Wollman pebble count data was available, its inclusion was assumed to be beneficial to the final riffle quality rating. Ratings of average percent gravel and sand (respectively) along *n* transects per reach followed OWAM criteria for the percent gravel/sand per area.

4.1.1 Assessment of Habitat Components

Pool Habitat – Between Stream Comparisons

Recent (post-1995) pool habitat data was available for a total of six drainages occurring within the Camas Assessment Area. By all indications, pool habitat appears to be a limiting factor to anadromous salmonid productivity (i.e. juvenile rearing and overwintering life history stages), as only three stream reaches are considered to maintain functionally desirable pool habitat (Table 28).

Overall, pool habitat quality in the Hidaway subwatershed is higher than in the other five drainages examined. Based on a summation of reach scores, the Hidaway subwatershed rates highest, the Mainstem second highest, and Lane Creek lowest.

Residual pool depth was at or above desirable levels for all streams analyzed whereas the frequency of pools containing ≥3 pieces of LWD was not desirable for most streams. On average, pools are most frequent in the Hidaway and Mainstem subwatersheds (approximately one pool per 15 channel widths) and least frequent in the Rancheria and Lane Creek Drainages (37 and 30 channel widths between primary pools).

Stream reaches with pools containing ≥3 pieces of LWD were uncommon. Only the Lane and Hidaway subwatersheds have "complex" pool habitats, albeit at a less than desirable frequency.

Table 28. Pool habitat quality ratings for stream reaches occurring within the Camas Assessment Area. Refer to Appendix 1 for rating criteria (D=desirable, B=between, U=undesirable)

Site	Surv. Year	Gradient	Mean Width	"OWAM" Stream Size	Pool Area		Pool Frequency		Residual Pool Depth		Complex Pools/mi	
			(ft/m)		% Pool	Bench mark	Freq	Bench mark	Resid pd (ft)	Bench mark	ComPool1	Bench mark
Main. R2	2000	1.1	35.2/10.7	Medium	47.4	D	10.6	B/D	2.6	D	0	U
Main. R4	2000	1.6	21.3/6.5	Small	18.1	B/U	9.2	B/D	1.3	D	0	U
Main. R5	2000	2	22.2/6.7	Small	17.9	B/U	13.9	B/D	2.7	D	0	U
Main. R6	2000	1	19.8/6.0	Small	24.3	B/U	16.5	B/U	1.7	D	0	U
Main. R8	2000	1.3	12.8/3.9	Small	27.8	B/D	24.8	U	1.6	D	0	U
Lane R1	2000	1	12.3/3.7	Small	6.3	U	20.7	U	1.5	D	0	U
Lane R2	2000	4	11.9/3.6	Small	3.7	U	30.6	U	1.6	D	0	U
Lane R3	2000	3	8.9/2.7	Small	7.8	U	36.8	U	0.9	D	0	U
Lane R4	2000	3	6.7/2.0	Small	9.5	U	32.4	U	0.9	D	0.98	U
Lane R5	2000	4	7.3/2.2	Small	15	B/U	20.7	U	0.8	D	0	U
Lane R6	2000	3	6.2/1.9	Small	9.2	U	41.3	U	0.8	D	0	U
HidawayR1	2003	2.3	12.5/3.8	Small	20.1	B/U	11.4	B/D	1.4	D	1.3	B/U
HidawayR2	2003	1.9	12.5/3.8	Small	41.3	D	10.2	B/D	1.6	D	0.4	U
HidawayR3	2003	4.7	15.2/4.6	Small	20.2	B/U	16.9	B/U	1.9	D	1.3	B/U
HidawayR4	2003	4.4	15.9/4.8	Small	19.7	B/U	8.5	D	1.8	D	0.9	U
HidawayR5	2003	2.5	9.8/3.0	Small	18.5	B/U	30.7	U	1.5	D	0.2	U
DryCamas R1	1998	2.3	5.0/1.5	Small	18.6	B/U	23	NPF	1.27	D	0	U
Dry Camas R2	1998	1.4	4.5/1.4	Small	17	B/U	16	NPF	1.29	D	0	U
RancheriaR2	1998	1.5	4.8/1.5	Small	23.2	B/U	29	NPF	1.5	D	0	U
RancheriaR3	1998	1.5	2.5/0.7	Small	41.5	D	46	NPF	1.7	D	0	U
Salsbury R1	1998	1.9	4.0/1.2	Small	22	B/U	27	NPF	1.3	D	0	U
Salsbury Trib	1998	1.9	3.0/1.0	Small	22	B/U	27	NPF	1.3	D	0	U

___: Rated according to PACFISH criteria (pools/mile)

Table 29 Pool habitat quality scoring summary for stream reaches in the Camas Assessment Area. Positive scores reflect desirable conditions (D), negative scores undesirable conditions (U), and zero scores a "between" condition (B)

Site	B/U (FAR/N)	B/D (FAR/P)	U (NPF)	D (PF)	Reach Score	Final Pool Rating
	-0.5	**+0.5**	**-1.0**	**+1.0**		
Main. R2	0	1	1	2	1.5	**D**
Main. R4	1	1	1	1	0	**B**
Main. R5	1	1	1	1	0	**B**
Main. R6	2	0	1	1	-1	**U**
Main. R8	0	1	2	1	-0.5	**U**
Lane R1	0	0	3	1	-2	**U**
Lane R2	0	0	3	1	-2	**U**
Lane R3	0	0	3	1	-2	**U**
Lane R4	0	0	3	1	-2	**U**
Lane R5	1	0	2	1	-1.5	**U**
Lane R6	0	0	3	1	-2	**U**
HidawayR1	2	1	0	1	0.5	**D**
HidawayR2	0	1	1	2	1.5	**D**
HidawayR3	3	0	0	1	-0.5	**U**
HidawayR4	1	0	1	2	0.5	**D**
HidawayR5	1	0	2	1	-1.5	**U**
DryCamas R1	1	0	2	1	-1.5	**U**
Dry Camas R2	1	0	2	1	-1.5	**U**
RancheriaR2	1	0	2	1	-1.5	**U**
RancheriaR3	0	0	2	2	0	**B**
Salsbury R1	1	0	2	1	-1.5	**U**
Salsbury Trib	1	0	2	1	-1.5	**U**

Pool Habitat – Drainage-Specific Reach Comparisons

Mainstem

The lowermost mainstem reach surveyed (RM 6.77 – RM 10.75) contains the highest quality pool habitat of all reaches surveyed. Pools throughout this reach are generally larger, more frequent and deeper than those found elsewhere. The lack of complex pool habitat is a common problem throughout all mainstem reaches, but should be considered more of a problem in the upper, forested reaches rather than in the lower elevation reaches that are dominated by grass-forb communities.

Lane

Pool habitat quality in the Lane subwatershed is for the most part, undesirable. Pools are infrequent, small, lack complexity, and are comparatively shallow. The fifth reach has a slightly greater percentage of its total area comprised of pools than the other five reaches surveyed, which affords it a somewhat higher rating than the other reaches. Only 3.7% of the total habitat area in the second reach of Lane Creek is comprised of pools.

Hidaway Creek

The percentage of the total habitat area comprised of pools in Reach 2 of Hidaway Creek is at least twice as high (41.3%) as pool area percentages in the four other surveyed reaches. The frequency of pool habitat types in Reach 2 is also comparatively high (1 pool per 10.2 channel widths), lending to the difference in pool area percentages. Pools occurring in Reach 3 of Hidaway Creek contain a relatively high amount of large woody debris, are the deepest of all reaches surveyed, but occur rather infrequently. Pools are least frequent in Reach 5, comprise the least percentage of habitat surface area, and are among the shallowest surveyed, which is not uncommon in a headwater reach.

Dry Camas Creek

Pool habitat quality in the two surveyed reaches of Dry Camas Creek is similar. Overall, habitat quality is undesirable due to a lack of wood and infrequence of pools. When pools do occur, they are surprisingly deep (mean residual depth = 1.2 ft), especially for a stream the size of Dry Camas Creek. The low score assigned to pool habitat quality in Dry Camas Creek may be a result of the low flow conditions encountered during the survey. Surveyors reported that the estimated discharge in Dry Camas Creek in late August 1998 was $\leq$0.1 cfs., and was largely a result of the underlying alluvium and shallow subsoil (Schloss 1999a). Lateral and/or cutbank pools were the most common pool type in Reach 1 of Rancheria Creek. The highly reduced flows allowed for aquatic vegetation to serve as pool-forming hydraulic controls.

Rancheria

Pool habitat quality in Rancheria Creek differs between the two surveyed reaches. Pools in Reach 2 (Reach 1 was not surveyed due to access limitations) were determined to be more frequent than those occurring in Reach 3, but comprised almost half as much of the total habitat area. Man-made structures account for the majority of the pool habitat observed throughout both reaches (Schloss 1999b), and are likely responsible for the surprisingly high residual pool depths. Similar to Dry Camas Creek, low summer flows in Rancheria Creek were likely a contributing factor to the occurrence and overall quality of pool habitat. Pool occurrence and percentage of total area may actually be higher than reported, as many of the habitat units surveyed did not meet the “pool-defining” criteria (Schloss 1999b).

Salsbury

Pool habitat quality in Salsbury Creek and a surveyed tributary to Salsbury Creek is not desirable. Only 22% of the total area is comprised of pool habitat (both reaches). Pools occur on average, once every 22 channel widths (both reaches). Lateral scour pools were common in Reach 1 and in the tributary, many of which were afforded cover by overhanging banks (Schloss 1999c). Pool occurrence and percentage of total area may actually be higher than reported, as many (10) of the habitat units surveyed did not meet the “pool-defining” criteria (Schloss 1999c). Recent changes in survey methodology would likely revise the 1998 survey observations and result in higher percentages of slow-water habitat area and frequency.

Riffle Habitat – Between Stream Comparisons

Riffle habitat in most of the surveyed reaches was rated to be of sufficient quality to support anadromous species (Table 31). Riffle habitat quality in the fourth reach of Hidaway and in the third reach of Rancheria Creek was rated as undesirable. Riffle quality in the surveyed tributary of Salsbury Creek received a neutral (“between”) rating.

The bankfull width to depth ratio for all assessed reaches was determined to be excessive. Reach 2 of the Mainstem Camas Creek has the highest bankfull width:depth ratio (71.3) while Reach 3 of Hidaway Creek has the highest wetted bankfull width:depth ratio (43.2). Riffle habitats in the Hidaway subwatershed are, on average, shallower and wider than other surveyed reaches. The low percentage of fines (avg. 5.4% total area) and comparatively high percentage of gravels (avg. 44.5% total area) in Hidaway riffles is surprising given the wide and shallow channel profile.

The percentage of stable (non-eroding) stream banks is functioning properly in most of the surveyed areas. Exceptions occur in the fourth reach of the mainstem, where only 62% of the banks are considered stable. Bank stability is considered to be functioning at risk in the upper portion of the drainage, as Reach 8 of the Mainstem, both Rancheria reaches and the Salsbury tributary reach have less than 90% stable banks and undesirable percentages of fines.

Most of the riffles in the surveyed reaches are dominated by gravel-sized substrate. Reaches with riffle habitats that aren’t dominated by gravel, such as the Salsbury tributary and the third reach in Rancheria Creek, contain a disproportionately high percentage of fine sediment. Riffle habitats in the second reach of the mainstem have low percentages of gravel and fine substrate and are dominated primarily by cobble-sized material.

Riffle Habitat – Drainage-Specific Reach Comparisons

Mainstem

Riffle habitat for all surveyed reaches in the mainstem Camas Creek is rated desirable, and is among the highest quality for all reaches assessed. Of the five reaches assessed in October, 2000, riffle habitats in reach eight (RM 30.4 – 31.5) scored the highest. Reach eight has the lowest wetted width:depth ratio, high percentages of gravel, and low amounts of fines, all of which contribute to the high rating. The percentage of stable banks is somewhat lower in Reach eight than compared to reaches 2, 5, and 6.

Table 30. Riffle habitat quality ratings for stream reaches occurring within the Camas Assessment Area. Refer to Appendix 1 and Appendix 2 for rating criteria (D=desirable, B=between, U=undesirable)

Site	Wetted W:D Ratio		Bankfull W:D Ratio[1]		Gravel (% Area[2])		Gravel (% Transect[3])		Fines (% Area[2])		Fines (% Transect[3])		% Bank Stability[4]	
	W:D	Bench mark	W:D	Bench mark	% Gravel	Bench mark	% Gravel	Bench mark	% Fine	Bench mark	% Fine	Bench mark	% Stab.	Bench mark
Main. R2	18.4	B/D	29.1	NPF	28	B/D	20.2	B/D	10	D	4.8	D	100	PF
Main. R4	25.4	B/U	71.3	NPF	36.3	D	32.5	B/D	10	D	1.3	D	62	NPF
Main. R5	20.5	B/U	18.5	NPF	44	D	40.1	D	10	B/D	7.4	D	98.3	PF
Main. R6	22.6	B/U	34.5	NPF	43.5	D	36	D	10.2	D	1.6	D	90.5	PF
Main. R8	16.4	B/D	21.5	NPF	37.6	D	41.1	D	10	D	9.5	D	88	FAR/P
Lane R1	13.7	B/D	19.6	NPF	32	B/D	46.8	D	10	D	3	D	100	PF
Lane R2	11.9	B/D	22.6	NPF	26.7	B/D	38	D	10	B/D	11.1	B/D	94.1	PF
Lane R3	13.2	B/D	17.6	NPF	38.2	D	37.9	D	10.7	B/D	8.1	B/D	98.2	PF
Lane R4	10.7	B/D	32.6	NPF	38.9	D	42.4	D	14.5	B/U	11.8	B/U	100	PF
Lane R5	10.8	B/D	27.1	NPF	31	B/D	33.8	B/D	11.2	B/D	9.4	B/D	100	PF
Lane R6	10.8	B/D	15.3	NPF	41.6	D	42	D	16	U	15.2	U	100	PF
HidawayR1	29.6	B/U	37.8	NPF	25	B/D	49.5	D	6.5	D	20.1	U	98.7	PF
HidawayR2	30.8	U	28.2	NPF	51.8	D	47.2	D	7	D	15.2	U	98.3	PF
HidawayR3	43.2	U	28.8	NPF	36.9	D	52.1	D	1.3	D	4.9	D	99.4	PF
HidawayR4	41.4	U	19.8	NPF	33.5	B/D	41	D	2	D	9.3	B/D	100	PF
HidawayR5	26.8	B/U	23.7	NPF	75.1	D	63.7	D	10.4	B/D	18.7	U	96	PF
DryCam.R1	11	B/D	15.8	NPF	49.5	D	64.62	D	15.8	U	13.7	B/U	100	PF
Dry CamR2	10.8	B/D	15.8	NPF	46.4	D	62.3	D	31.8	U	29.6	U	94.9	PF
Ranch.R2	8.3	D	N/A	N/A	N/A	N/A	48.8	D	N/A	N/A	30.2	U	87.3	FAR/P
Ranch.R3	4.9	D	N/A	N/A	N/A	N/A	14.2	U	N/A	N/A	83.6	U	85.3	FAR/P
SalsburyR1	7.9	D	N/A	N/A	N/A	N/A	50	D	N/A	N/A	41.8	U	95.6	PF
SalsburyT1	6.1	D	N/A	N/A	N/A	N/A	25	B/D	N/A	N/A	57.1	U	82.5	FAR/N

1/ Bankfull W:D ratio based on bankfull width / average bankfull depth taken at measured riffle habitat units. Rating based on PACFISH standards
2/ Rating based on an average of ocular estimates recorded at each habitat unit. Rating based on OWAM criteria.
3/ Value represents an average of data collected from (2) Wolman Pebble Count transects within the respective reach. Rating based on OWAM criteria
4/ Value represents the percentage of stable banks recorded per reach. Rating based on PACFISH standards

Table 31. Riffle habitat quality scoring summary for stream reaches in the Camas Assessment Area. Positive scores reflect desirable conditions (D), negative scores undesirable conditions (U), and zero scores a "between" condition (B)

Site	B/U (FAR/N)	B/D (FAR/P)	U (NPF)	D (PF)	Reach Score	Final Riffle Rating
	-0.5	**+0.5**	**-1.0**	**+1.0**		
Main. R2	0	3	1	3	3.5	D
Main. R4	1	1	2	3	1	D
Main. R5	1	1	1	4	3	D
Main. R6	1	0	1	5	3.5	D
Main. R8	0	2	1	4	4	D
Lane R1	0	2	1	4	4	D
Lane R2	0	4	1	2	3	D
Lane R3	0	3	1	3	3.5	D
Lane R4	2	1	1	3	1.5	D
Lane R5	0	5	1	1	2.5	D
Lane R6	0	1	3	3	0.5	D
HidawayR1	1	1	2	3	1	D
HidawayR2	0	0	3	4	1	D
HidawayR3	0	0	2	5	3	D
HidawayR4	0	2	2	3	2	D
HidawayR5	1	1	2	3	1	D
DryCamas R1	1	1	2	3	1	D
Dry Camas R2	0	1	3	3	0.5	D
RancheriaR2	0	1	1	2	1.5	D
RancheriaR3	0	1	2	1	-0.5	U
Salsbury R1	0	0	1	3	2	D
Salsbury Trib	1	1	1	1	0	B

Lane

Riffle habitat for all surveyed reaches in the Lane Creek subwatershed is rated desirable, and is among the highest quality for all reaches assessed. Of the six reaches assessed in July, 2000, riffle habitats in reach one (RM 0.0 – 0.68) scored the highest. Since all of the surveyed reaches in Lane Creek are "B" channels, it is not surprising that riffles are the dominant habitat type and that fine sediment storage does not appear to be a significant problem.

Hidaway

Erosional habitats in the Hidaway subwatershed are, on average, excessively wide and shallow. Wetted width:depth ratios of riffles are as high as 43.2 (Reach 3) and average 34.4 for all reaches surveyed. The wide, shallow nature of riffle habitats in Hidaway is uncharacteristic of an "A" channel stream (Rosgen definition), which are typically defined by gradients from 4 to 10% and are more entrenched and confined (Rosgen 1994). Excessive fine sediment, as measured by its percentage of occurrence along a transect, is problematic in the first two reaches and in reach five. Lack of gravels does not appear to be a problem in Hidaway, nor does bank stability. The frequency of LWD in Hidaway riffles and other fast-water habitat types is desirable (average 20 pieces per mile).

Dry Camas

The quality of fast-water habitat in Dry Camas Creek is limited by flow and fine sediment. Although both reaches received a final "desirable" rating, the estimated percentage of fine sediment by area, and measured fine sediment are both undesirable. Stream survey reports state that although the substrate is primarily gravel, every habitat unit contains fines (Schloss 1999a). Streambank erosion was not determined to be a contributor to fine sediment.

Rancheria

Bank stability and excessive fine sediment limits the quality of riffle habitats in Rancheria Creek. Reach 3 of the two reaches surveyed, received a final rating of "undesirable", which in large part was a function of the low percentage of gravel, high percentage of fines (83.6%), and unstable banks. Channel sloughing is a problem in Rancheria Creek, as is channel confinement due to a historic railroad grade that borders much of the channel (Schloss 1999b).

Salsbury

Similar to Rancheria Creek, erosional habitats in Salsbury Creek suffer from excessive amounts of fine sediment. Although riffles in reach one of Salsbury Creek were rated as functioning at a desirable level, the high levels of fines are a concern and may be limiting the potential for salmonid use. Reach 2, which is a tributary to Salsbury Creek, has undesirable levels of fine sediment (57.1%), some of which may be a function of bank failure (mean bank stability = 82.5%).

Large Woody Debris – Between Stream Comparisons

The frequency of large (>12" diam., 35 ft. long) woody debris for streams recently surveyed in the Camas Watershed is at undesirable levels. LWD is most abundant in the Hidaway and Lane Creek subwatersheds and least abundant in the mainstem. The frequency of "Key" pieces of LWD is at undesirable levels for all reaches surveyed, except Reach 4 of Hidaway Creek, which had 2.1 pieces per 100 meters. Unlike other surveyed drainages, the frequency of LWD pieces per mile in Hidaway Creek is consistent in all five surveyed reaches and is considered to be properly functioning based on PACFISH standards.

Large Woody Debris – Drainage-Specific Reach Comparisons

Mainstem

The frequency of large woody debris in the mainstem Camas is low. The highest amount of woody debris in the five surveyed reaches occurs in Reach 5, albeit at levels considered to be undesirable (OWAM standards) or not properly functioning (PACFISH standards). The infrequency of wood in the lower portion of the mainstem should not be surprising, as the majority of Reach 2 and Reach 4 occur in non-wooded areas.

Table 32. Large woody debris ratings for stream reaches occurring within the Camas Assessment Area. Refer to Appendix 1 and Appendix 2 for rating criteria (D=desirable, B=between, U=undesirable)

Site	LWD PIECES/100m[1]		LWD PIECES/mi[2]		"Key" LWD/100m[3]	
	LWDpiece1	Benchmark	LWDpiece1	Benchmark	KeyLWD1	Benchmark
Main. R2	0.03	U	0.5	NPF	0.01	U
Main. R4	0.12	U	1.9	NPF	0.06	U
Main. R5	0.4	U	6.3	NPF	0.3	U
Main. R6	0.2	U	2.7	NPF	0.05	U
Main. R8	0.15	U	2.4	NPF	0	U
Lane R1	1.4	U	22.1	PF	0.5	U
Lane R2	0.7	U	10.7	NPF	0	U
Lane R3	0.8	U	13.6	NPF	0.2	U
Lane R4	2	U	31.5	PF	0.8	U
Lane R5	0.3	U	4.7	NPF	0	U
Lane R6	0.7	U	12	NPF	0	U
HidawayR1	1.7	U	28.9	PF	0.5	U
HidawayR2	1.5	U	29.9	PF	0.4	U
HidawayR3	1.3	U	20.5	PF	0.7	U
HidawayR4	3.2	U	51.8	PF	2.1	B/D
HidawayR5	1.3	U	21.9	PF	0.2	U
DryCam.R1	1	U	14	NPF	0	U
Dry CamR2	0.3	U	15	NPF	0.1	U
Ranch.R2	1.2	U	22	PF	0.4	U
Ranch.R3	0.08	U	4	NPF	0.1	U
SalsburyR1	0.7	U	19	NPF	0.3	U
SalsburyT1	1.6	U	21	PF	0.3	U

1/ LWD/100m reflects the frequency of pieces of wood per 100-m in the USFS "medium" and "large" size categories (minimum size is >12" diam., 35 ft. long); values are rated according to OWAM criteria

2/ Used PACFISH standards for LWD Frequency; "MED" & "LARGE" LWD surveyed by USFS meets PACFISH criteria for LWD (>12" diam., 35 ft. long)

3/ "Key" LWD refers to pieces of wood in the "Large" size class (>20" diam., >35' length); diameter measured at small end

Table 33. Large woody debris habitat quality scoring summary for stream reaches in the Camas Assessment Area. Positive scores reflect desirable conditions (D), negative scores undesirable conditions (U), and zero scores a "between" condition (B)

Site	B/U (FAR/N)	B/D (FAR/P)	U (NPF)	D (PF)	Reach Score	Final LWD Rating
	-0.5	**+0.5**	**-1.0**	**+1.0**		
Main. R2	0	0	3	0	-3	**U**
Main. R4	0	0	3	0	-3	**U**
Main. R5	0	0	3	0	-3	**U**
Main. R6	0	0	3	0	-3	**U**
Main. R8	0	0	3	0	-3	**U**
Lane R1	0	0	2	1	-1	**U**
Lane R2	0	0	3	0	-3	**U**
Lane R3	0	0	3	0	-3	**U**
Lane R4	0	0	2	1	-1	**U**
Lane R5	0	0	3	0	-3	**U**
Lane R6	0	0	3	0	-3	**U**
HidawayR1	0	0	2	1	-1	**U**
HidawayR2	0	0	2	1	-1	**U**
HidawayR3	0	0	2	1	-1	**U**
HidawayR4	0	1	1	1	0.5	**D**
HidawayR5	0	0	2	1	-1	**U**
DryCamas R1	0	0	3	0	-3	**U**
Dry Camas R2	0	0	3	0	-3	**U**
RancheriaR2	0	0	2	1	-1	**U**
RancheriaR3	0	0	3	0	-3	**U**
Salsbury R1	0	0	3	0	-3	**U**
Salsbury Trib	0	0	2	1	-1	**U**

Lane

All surveyed reaches in Lane Creek are rated "undesirable" with respect to LWD occurrence/frequency. Only Reach 1 and Reach 4 have LWD frequencies (pieces/mile) that are considered properly functioning, however based on combined metrics, even these reaches receive a final "undesirable" rating. Key pieces of LWD are lacking altogether in Reaches 2, 5, and 6.

Hidaway

Reach 4 of Hidaway Creek is the only reach that receives a "desirable" rating. Based on OWAM standards, Reach 4 is deficient in wood frequency per 100 meters, however it does contain enough debris to satisfy PACFISH requirements/mile, and has enough key pieces of wood per 100 meters to receive a "between/desirable" rating.

Dry Camas

The number of natural pieces of LWD in Dry Camas Creek is insufficient. Man-made structures account for the majority of wood in Dry Camas Creek, some of which are functioning and some which are not. Future LWD recruitment to the channel is limited (Schloss 1999a).

Rancheria

Man-made structures account for the majority of LWD observed in Rancheria Creek. Reach 2 of Rancheria Creek has at least 12 log structures, some of which are functioning and some which aren't (Table 34). The number and frequency of structures (22/mile) in Reach 2 satisfies PACFISH criteria, while those in Reach 3 are deficient.

Table 34. Instream structures surveyed in Reach 2 and 3 of Rancheria Creek, 08/07/1998 – 08/11/1998 (reproduced from (Schloss 1999b).

Reach	Natural Sequence Order	Structure Type	Structure Condition
2	2	Log	Functioning
2	8	Boulder	Blown Out
2	9	Log	Functioning
2	13	Log	Functioning
2	16	Log	Functioning
2	21	Log	Non-functioning
2	22	Log	Functioning
2	24	Log	Functioning
2	26	Boulder	Functioning
2	28	Boulder	Blown Out
2	30	Log	Functioning
2	33	Boulder	Functioning
2	39	Log	Functioning
2	40	Boulder	Functioning
2	42	Log	Functioning
2	54	Log	Functioning
2	63	Log	Functioning
2	64	Boulder	Non-functioning
3	71	Log	Functioning
3	75	Boulder	Functioning

Salsbury

Similar to Rancheria and Dry Camas Creeks, Salsbury Creek contains several man-made structures, which surveyors noted in their LWD counts. Naturally occurring wood in the first reach of Salsbury Creek was slightly deficient in relation to PACFISH standards, and did not satisfy OWAM criteria for either metric. Wood in Reach 2 (tributary) was slightly higher (21 pieces/mile) than the minimum 20 pieces per mile set forth by PACFISH, but was deficient in relation to OWAM standards. Debris jams and root wads were noted in both reaches, as was a good amount of potentially recruitable wood (Schloss 1999c).

4.1.2 Evaluation of Anadromous Salmonid Habitat Quality

The condition of aquatic habitat in the Camas Assessment Area as it relates to anadromous salmonid life history stages is presented below. Life history stages discussed include 1) adult passage, 2) spawning and incubation, 3) colonization and summer rearing, 4) fall redistribution and overwintering, and 5) smolt migration. Assessment of habitat quality is based on stream survey data, unless otherwise specified. Because of the overlap in steelhead and chinook habitat requirements, life stage-specific analyses of habitat quality are shared unless otherwise indicated.

Adult Passage - Steelhead

Based on literature review, Camas steelhead will generally not move into their natal habitats until shortly before spawning, and will use the North Fork John Day River for holding. The peak period of adult passage in the Camas Assessment Area is during winter and spring months (February through the first week in May), which coincides with increased flows and reduced stream temperatures, both of which provide for favorable habitat conditions. Extremely low water temperatures and icing may limit steelhead migration into the Camas during some winters however, this problem does not appear to be commonplace. Migration barriers do not appear to pose a problem in the Camas Assessment Area.

Adult Passage – Chinook

Spring chinook salmon adults migrate into and throughout the Camas Assessment Area in May (*refer to* Table 19), which coincides with the descending limb of the hydrograph. Based on mean monthly flows at the town of Ukiah, chinook upriver migration into the Camas system is not, on average, impeded by streamflow.

As discussed above (*refer to* page 26), stream temperatures in the mainstem Camas are excessive, and are likely the primary factor limiting holding area habitat quality for adult spring chinook.

Spawning and incubation - Steelhead

When adult steelhead begin spawning forays in mid-March, they are actively seeking areas with suitable substrate, water depth, and velocity (Bjornn and Reiser 1991). The substrate must be free of fines (particles $\leq$6 mm) to allow for adequate intergravel flow and alevin emergence. Habitats exhibiting these qualities are typically associated with deep riffles or pool tails, or transitional areas between pools and riffles (Bjornn and Reiser 1991).

Based on these considerations, we assessed the quality of spawning and incubation habitat as those areas exhibiting desirable substrate ($\geq$35 % gravel, $\leq$10% fines), suitable pool frequencies (5-8 channel widths between pools), and sufficient depth (mean residual depths $\geq$ 0.5 m) (Table 35). Although we did not have stream velocity data for the surveyed reaches, we assume that areas surveyed during baseflow conditions with sufficient depth will have sufficient minimum velocities during spawning and incubation periods. It is important to stress that the following analysis should be considered to be a rough estimation in light of a limited dataset from which to base conclusions, and that actual habitat quality varies from year to year. The following discussion is therefore a relative picture of conditions, as they occurred during the year of the stream survey.

Mainstem

In the mainstem, the highest quality steelhead spawning and incubation habitats occur in Reach 5 (RM 22.8 – 23.9) and Reach 6 (RM 23.9 – 26.6). The lower 10 miles of Camas Creek (Reach 2, including the lower 6.7 miles of unsurveyed channel) should also be considered an area of importance for spawning and incubation, as should habitat in Reach 4 (RM 21.8 to 22.8).

Lane

Instream habitat quality for steelhead spawning and incubation life history stages is highest in Reach 1 of Lane Creek (RM 0.0 – 0.68). Overall, Lane Creek does not appear to have an abundance of 'transitional' habitat due to the infrequency of pools and dominance of erosional features. The least favorable spawning and incubation habitat occurs in Reach 6, where pool frequencies are low and the percentage of fine substrate is high.

Hidaway

Reach 3 (RM 2.63 – 4.78) and Reach 4 (RM 4.78 – 6.06) of Hidaway Creek rate the highest when considering spawning and incubation habitat quality for summer steelhead. Reach 5 (RM 6.06 – 9.39) has the lowest pool frequency of the five reaches assessed, and contains a higher percentage of fines than other reaches, thereby making it the least habitable reach for steelhead spawning and incubation life history stages. The amount of transitional habitat in the Hidaway system, especially Reach 4, is higher than all other subwatersheds that were surveyed between 1998-2003, making it one of the more important reaches for steelhead spawning and incubation.

Dry Camas

Steelhead spawning and incubation habitat is most abundant in the first surveyed reach of Dry Camas Creek (RM 0.0 – 0.86). The first reach is characterized by a 2.3% gradient which, depending on flow, may actually be less desirable for spawning than the second reach, which is less precipitous (mean gradient = 1.4%). Both reaches suffer from a high percentage of fine substrate and infrequency of transitional habitat.

Table 35. Steelhead spawning and incubation habitat quality ratings for stream reaches occurring within the Camas Assessment Area. Refer to Appendix 1 and Appendix 2 for rating criteria (D=desirable, B=between, U=undesirable)

Site	GRAVEL[1] (% Transect)		SILT-SAND-ORGANICS[1] (% Transect)		Pool Frequency		Residual Pool Depth		Habitat Quality
	%Gravel	Benchmark	%Sand	Benchmark	Pool Freq.	Benchmark	Residpd (ft)	Benchmark	SCORE
Main. R2	20.2	B/D	4.8	D	10.6	D	2.6	D	3
Main. R4	32.5	B/D	1.3	D	9.2	D	1.3	D	3
Main. R5	40.1	D	7.4	D	13.9	D	2.7	D	3.5
Main. R6	36	D	1.6	D	16.5	D	1.7	D	2.5
Main. R8	41.1	D	9.5	D	24.8	D	1.6	D	2
Lane R1	46.8	D	3	D	20.7	D	1.5	D	2
Lane R2	38	D	11.1	B/D	30.6	D	1.6	D	1.5
Lane R3	37.9	D	8.1	B/D	36.8	D	0.9	D	1.5
Lane R4	42.4	D	11.8	B/U	32.4	D	0.9	D	0.5
Lane R5	33.8	B/D	9.4	B/D	20.7	D	0.8	D	1
Lane R6	42	D	15.2	U	41.3	D	0.8	D	0
HidawayR1	49.5	D	20.1	U	11.4	B/D	1.4	D	1.5
HidawayR2	47.2	D	15.2	U	10.2	B/D	1.6	D	1.5
HidawayR3	52.1	D	4.9	D	16.9	B/U	1.9	D	2.5
HidawayR4	41	D	9.3	B/D	8.5	D	1.8	D	3.5
HidawayR5	63.7	D	18.7	U	30.7	U	1.5	D	0
DryCam.R1	64.62	D	13.7	B/U	23	D	1.27	D	0.5
Dry CamR2	62.3	D	29.6	U	16	D	1.29	D	0
Ranch.R2	48.8	D	30.2	U	29	D	1.5	D	0
Ranch.R3	14.2	U	83.6	U	46	D	1.7	D	-2
SalsburyR1	50	D	41.8	U	27	D	1.3	D	0
SalsburyT1	25	B/D	57.1	U	27	D	1.3	D	-0.5

1/ Value represents an average of data collected from (2) Wolman Pebble Count transects within the respective reach. Rating based on OWAM criteria

Rancheria

Spawning and incubation habitat quality in Rancheria Creek is poor. The presence of an old railroad bed along the majority of Reach 2 (RM 0.5 – 1.1) limits stream channel/floodplain interaction, which in turn reduces sinuosity, and subsequently reduces habitat complexity and the number of transitional areas used for spawning and egg incubation. The high percentage of fine substrate and low percentage of gravels in Reach 3 limits the overall utility of the habitat in this section for most steelhead life history forms, including spawning and incubation.

Salsbury

Similar to Rancheria Creek, steelhead spawning and incubation habitat quality in Salsbury Creek is poor. High percentages of fines and low pool frequencies make Salsbury Creek less than desirable for this particular life history stage of steelhead. Rainbow trout do occur in Salsbury Creek, although it is not known whether the fish are anadromous or residents.

Spawning and Incubation - Chinook

Substrate composition, cover, water quality, space, and water quantity are key habitat elements for spring chinook before and during spawning. Substrate sizes for chinook should range from 10.3 – 100.2 mm (medium gravel to small cobble), and be relatively free ($\leq$10% total area) of fine (<6.3 mm) sediment (Bjornn and Reiser 1991). Cover may be provided through overhanging vegetation, undercut banks, submerged vegetation, logs, rocks, deep water, or turbulence. The initiation of spawning is inextricably linked to stream temperatures, and, on average, will commence when the water is between 5.6 – 13.9° C (42.1 – 57.0° F) (Bjornn and Reiser 1991). Similar to steelhead, spring chinook tend to prefer transitional areas (habitats between riffles and pools) for redd construction and require, on average, an area $\geq$3.3 m^2 (10.8 ft^2).

Habitat requirements for spring chinook incubation differ from those of adult spawning life history stages. The incubation habitat must have a sufficient current to oxygenate the redd and remove metabolic waste, sufficient porosity (i.e. low percentage of fines) to allow for intragravel flow and emergence of alevins, and be near cover for colonization of newly emerged fry.

We use similar metrics to assess spring chinook spawning and incubation habitat quality as used in the assessment of steelhead spawning and incubation. Because the size of material needed for a chinook redd is larger than that required by a steelhead, we use percent cobble (desirable = $\geq$35% [32 – 256 mm], $\leq$10% fines) instead of gravel to determine our ‘desired’ substrate composition. The maximum seven day moving average stream temperatures are assessed to evaluate the suitability of holding and staging conditions. We use pool frequency data (desirable = 5-8 channel widths between pools) as a surrogate for the frequency of transition habitat and residual pool depth (desirable depths = $\geq$ 0.5 m) to assess pool quality. Cover is assessed using LWD frequency (# of pieces/mile).

Mainstem

Spawning and incubation habitat for spring chinook is in fair to good condition in all but the upper reach of the mainstem Camas Creek (Table 36). The overall quality of habitat gradually declines with an upstream progression, primarily due to a decline in pool frequency. Substrate composition, including a low percentage of fines, is desirable in all reaches, as is residual pool depth. A lack of cover and high stream temperatures are common problems in all reaches. The seven-day moving average of maximum daily temperatures throughout the mainstem during the 1990s exceeded 70° F, which resulted in its 303d-listing (RM 0 – RM 36.7) in 2002 for high stream temperatures during spawning life history stages.

Colonization and summer rearing

Habitat quality for colonization and early rearing forms of summer steelhead and spring chinook is strongly related to the capacity of the habitat to provide for feeding and cover (Bjornn and Reiser 1991). In summer, juvenile fish are primarily concerned with feeding and will select sites in streams that optimize the opportunity to obtain food, yet provide acceptable security from predation. Given that the Camas Watershed has a low seeding level (the number of young fish emplaced in a stream by adult fish), the environmental conditions that set the carrying capacity of Camas streams for a particular age group of fish will place little constraint on the abundance of juveniles and/or older fish (Bjornn and Reiser 1991).

Temperature, productivity, suitable space, and water quality are examples of variables that regulate the general distribution and abundance of fish within a stream or drainage (Bjornn and Reiser 1991). Specific habitat factors to which fish will exhibit immediate response include velocity, depth, substrate, cover, predators, and competitors.

We use temperature, residual pool depth, percentage fine substrate, percentage gravel substrate, and LWD frequency (surrogate for cover) to assign ratings to surveyed reaches to assess habitat quality for colonization and summer rearing forms of steelhead and chinook in the Camas Assessment Area (Table 38) . In our assessment of temperature suitability, we rely upon PACFISH standards (*refer to* Appendix 2) to arrive at a final rating of desirable, undesirable, or between. We rely upon Wollman Pebble Count data to determine the relative percentages of substrate particles (Wentworth Scale), and rate substrate quality using the OWAM criteria. A final score is assigned to each reach using the convention described above (*refer to* Table 26). Habitat quality analysis for spring chinook colonization and summer rearing life history forms is pertinent only in the mainstem.

Table 36. Mainstem habitat quality for spring chinook spawning and incubation life history phases. Refer to Appendix 1 and Appendix 2 for rating criteria (D=desirable, B=between, U=undesirable)

Site	Fines (% Transect) [1]		Cobble (%Transect) [1,2]		LWD (Pieces/mi)[3]		Temperature (avg. 7-day Max)		Pool Frequency (avg.#chan.widths/pool)		Residual Pool Depth		Final Score
	% Fine	Bench mark	% Cob.	Bench mark	LWD/ mi	Bench mark	7-day Max.	Bench mark	Cwpool	Benchmark	Resid.d	Bench mark	
Main. R2	4.8	D	61.5	D	0.5	NPF	77	NPF	10.6	B/D	2.6	D	1.5
Main. R4	1.3	D	73.6	D	1.9	NPF	78	NPF	9.2	B/D	1.3	D	1.5
Main. R5	7.4	D	46.9	D	6.3	NPF	75.7	NPF	13.9	B/D	2.7	D	1.5
Main. R6	1.6	D	65.7	D	2.7	NPF	80	NPF	16.5	B/U	1.7	D	0.5
Main. R8	9.5	D	53.4	D	2.4	NPF	75.3	NPF	24.8	U	1.6	D	0

Table 37. Fry colonization and rearing habitat quality ratings for stream reaches occurring within the Camas Assessment Area. Refer to Appendix 1 and Appendix 2 for rating criteria (D=desirable, B=between, U=undesirable)

Site	GRAVEL[1] (% Transect)		SILT-SAND-ORGANICS[1] (% Transect)		Temperature[2] (°F)		Residual Pool Depth (ft)		LWD PIECES/mi		Habitat Quality Score
	%Gravel	Bench mark	%Sand	Bench mark	7-day Max.	Bench mark	Residpd (ft)	Bench mark	LWD piece1	Bench mark	
Main. R2	20.2	B/D	4.8	D	77	NPF	2.6	D	0.5	NPF	0.5
Main. R4	32.5	B/D	1.3	D	78	NPF	1.3	D	1.9	NPF	0.5
Main. R5	40.1	D	7.4	D	75.7	NPF	2.7	D	6.3	NPF	1
Main. R6	36	D	1.6	D	80	NPF	1.7	D	2.7	NPF	1
Main. R8	41.1	D	9.5	D	75.3	NPF	1.6	D	2.4	NPF	1
Lane R1	46.8	D	3	D	64.4	NPF	1.5	D	22.1	PF	3
Lane R2	38	D	11.1	B/D	N/A	N/A	1.6	D	10.7	NPF	1.5
Lane R3	37.9	D	8.1	B/D	N/A	N/A	0.9	D	13.6	NPF	1.5
Lane R4	42.4	D	11.8	B/U	N/A	N/A	0.9	D	31.5	PF	2.5
Lane R5	33.8	B/D	9.4	B/D	N/A	N/A	0.8	D	4.7	NPF	1
Lane R6	42	D	15.2	U	N/A	N/A	0.8	D	12	NPF	0
HidawayR1	49.5	D	20.1	U	75.3	NPF	1.4	D	28.9	PF	1
HidawayR2	47.2	D	15.2	U	72.5	NPF	1.6	D	29.9	PF	1
HidawayR3	52.1	D	4.9	D	73.5	NPF	1.9	D	20.5	PF	3
HidawayR4	41	D	9.3	B/D	63.7	PF	1.8	D	51.8	PF	4.5
HidawayR5	63.7	D	18.7	U	N/A	N/A	1.5	D	21.9	PF	2
DryCam.R1	64.62	D	13.7	B/U	N/A	N/A	1.27	D	14	NPF	0.5
Dry CamR2	62.3	D	29.6	U	N/A	N/A	1.29	D	15	NPF	0
Ranch.R2	48.8	D	30.2	U	75.2	NPF	1.5	D	22	PF	1
Ranch.R3	14.2	U	83.6	U	N/A	N/A	1.7	D	4	NPF	-2
SalsburyR1	50	D	41.8	U	N/A	N/A	1.3	D	19	NPF	0
SalsburyT1	25	B/D	57.1	U	N/A	N/A	1.3	D	21	PF	1.5

1/ Value represents an average of data collected from (2) Wolman Pebble Count transects within the respective reach. Rating based on OWAM criteria

2/ Value represents an average of maximum stream temperatures recorded over a seven-day period

Mainstem

Fry colonization and rearing habitat in the mainstem is fair. Factors limiting the quality of habitat for age 0+ fish include cover (LWD frequency) and temperature. The seven day average maximum stream temperature in all surveyed mainstem reaches was in excess of 75° F, which is more than 18° F warmer than the desired 57° F (Bjornn and Reiser 1991) for salmonid rearing. Temperatures in this range may reduce feeding efficiency due to metabolic constraints. Although the percentage of fine substrate does not appear to be a problem in the mainstem, Reaches 2 and 4 have less substrate comprised of gravel than other reaches.

Lane

Reach 1 of Lane Creek provides the best habitat for age 0+ steelhead. There is a high percentage of gravel, low fines, sufficiently deep pools, and a desirable amount of cover. The 7-day moving average of maximum stream temperatures is 64.4° F, which is among the lowest mean temperatures of all reaches assessed. Reach 4 of Lane Creek also appears to be suitable for rearing and fry colonization, and contains considerably more LWD than other reaches in the Lane subwatershed.

Hidaway

The quality of steelhead fry colonization and summer rearing habitat in Hidaway Creek is, for the most part, desirable. Unlike other reaches surveyed, all reaches in the Hidaway subwatershed are rated as “properly functioning” for LWD. Reach 4 offers the best rearing habitat in the subwatershed, as it is characterized by a low percentage of fine substrate, a high percentage of gravel substrate, suitable stream temperatures, and a high amount of instream cover. Other reaches in Hidaway have desirable physical habitat, however, maximum stream temperatures and percentages of fine substrate are in excess of PACFISH and benchmark standards.

Dry Camas

The quality of steelhead fry colonization and summer rearing habitat in the Dry Camas subwatershed is marginal. It is unknown whether maximum stream temperatures in the subwatershed are conducive or detrimental to this particular life history stage. Instantaneous temperatures taken during the latter part of July, 1998, ranged between 59 - 74° F (Schloss 1999a). High percentages of fine sediment and low amounts of instream cover (LWD) likely limit the quality of rearing habitat in the drainage. Reduced flow is also a concern, as indicated in stream survey reports that document sections of dry channel and isolated pool habitats (Schloss 1999a).

Rancheria

Rancheria Creek does not provide ideal colonization/rearing habitat for summer steelhead. It has limited flow, unsuitable temperatures, high amounts of fine sediment, and in the uppermost reach, limited amounts of instream cover. Anadromous salmonids that do occupy Rancheria Creek may become isolated in pool habitats during baseflow periods, and unless supplemented with cool groundwater inflow, may succumb to lethal temperatures.

Salsbury

Similar to Rancheria Creek, Salsbury Creek does not provide optimal habitat for summer steelhead colonization or rearing. It, like Rancheria Creek, is limited by high amounts of fine sediment and low flow. Instream cover does not appear to be a limiting factor, especially in the surveyed tributary. Instantaneous temperatures ranged from 53 - 62° F (Schloss 1999c).

Fall redistribution and overwintering

Unlike summer rearing, overwintering juvenile steelhead and chinook are primarily concerned with security and less concerned with feeding. Overwintering juvenile salmon and steelhead will actively seek complex habitat types, including those created by in-channel organic debris, deep pools, off-channel refugia, and undercut banks (Bjornn and Reiser 1991). Populations of overwintering salmonids are also reliant upon the interstitial spaces in cobble and boulder-sized substrates, and will exhibit marked declines in productivity when fine sediments fill the voids (Bjornn and Reiser 1991).

We use the percentage of fines and percentage of cobble/boulder substrate measured at multiple transects in each reach to define interstitial habitat availability. Given an age 0+ steelhead or chinook averages <80 mm, and an age 1+ fish averages around 150 mm, the size of substrate needed to form a space large enough to accommodate the respective age class of fish would have to be at least as large as the youngest fish, while large enough to accommodate the older age class. This substrate roughly corresponds to cobble/boulder-sized material (based on the Wentworth scale). Neither the OWAM nor PACFISH assigns a rating to overwintering substrate (i.e. cobble/boulder) percentages. We assume that, based on OWAM and PACFISH criteria, the desirable substrate composition for overwintering habitat should be comprised of less than or equal to 10 percent fines, less than or equal to 10 percent bedrock, less than or equal to 40 percent gravel, and greater than or equal to 40 percent cobble/boulder material. We therefore rate overwintering substrate using the following scale:

≥40% cobble/boulder=Desirable	≤35% cobble/boulder=Undesirable
≤10% fines=Desirable	≥15% fines=Undesirable

To address off-channel refugia, we rely upon stream survey data measurements of side channels, braids, and/or tributary habitat. The process used to gauge the quality of these habitat types is similar to that applied in the assessment of pool habitat quality. Off-channel habitat (OCH) comprising greater than 10% of the total area is considered desirable, and less than or equal to 5% undesirable.

Other habitat metrics used to assess habitat quality for fall distribution and overwintering life history stages of steelhead and chinook include LWD frequency (pieces per mile), pool frequency (number of pools per channel width), and residual pool depth. These metrics are rated and scored using similar criteria and procedures as discussed previously. Habitat quality analysis for spring chinook fall redistribution and overwintering life history forms is pertinent only in the mainstem Camas Creek.

Mainstem

Steelhead and chinook fall redistribution and overwintering habitat in the mainstem Camas is relatively uniform throughout the surveyed reaches (Table 38). Cobble and boulder habitat is in adequate amounts in all but Reach 8, and is relatively free of fines. Off-channel wintering habitat and LWD frequency is poor in all reaches. The frequency of pool habitat is slightly less than desirable, but sufficiently deep. The uppermost reach of the mainstem (RM 30.4 – 31.5) represents the least favorable habitat, as it is has the least desirable substrate and lowest frequency of pools.

Lane

The percent contribution of adequately-sized overwintering substrate in Lane Creek is sufficient in all but Reach 6, which also has the highest amounts of its total area comprised of fine sediment (*refer to* Table 38). Reach 1 has the lowest amount of fines which is notable due to its location in the subwatershed. The percent total area defined by off-channel habitat is low throughout the first three miles of channel but improves over the next two. Pools are infrequent but sufficiently deep. Overwintering steelhead are afforded a desirable frequency of woody debris habitat in Reaches 1 and 4, which isn’t the case in the remainder of the drainage.

Hidaway

The highest quality overwintering habitat in Hidaway Creek occurs between RM 2.63 and RM 6.06 (Reaches 3 and 4). Both the first and last reach are undesirable due to undersized substrate and lack of off channel habitat. The lack of off channel habitat is a problem in all reaches. Overwintering refugia provided by LWD is consistent throughout the entire drainage.

Dry Camas

Dry Camas Creek has the least desirable steelhead overwintering habitat off all reaches assessed. The substrate is prohibitively small and filled with fine sediment. Off-channel habitat is non-existent and the frequency of pools and LWD is not desirable.

Table 38. Fall redistribution and overwintering habitat quality ratings for stream reaches occurring within the Camas Assessment Area. Refer to Appendix 1 and Appendix 2 for rating criteria (D=desirable, B=between, U=undesirable)

Site	COBBLE/ BOULDER[1] (% Transect)		SILT-SAND-ORGANICS[1] (% Transect)		OFF-CHANNEL HABITAT[4] (%TOT.AREA)		Residual Pool Depth (ft)		Pool Frequency (avg.#Chan.Widths / pool)		LWD PIECES/mi		Habitat Quality Score
	%COBB./ BOLDR	Bench mark	%Sand	Bench mark	%OCH	Bench mark	Residpd (ft)	Bench mark	PoolFq	Benchm ark	LWD piece1	Bench mark	
Main. R2	75	PF	4.8	D	0	NPF	2.6	D	10.6	B/D	0.5	NPF	1.5
Main. R4	66.2	PF	1.3	D	0.8	NPF	1.3	D	9.2	B/D	1.9	NPF	1.5
Main. R5	52.4	PF	7.4	D	1	NPF	2.7	D	13.9	B/D	6.3	NPF	1.5
Main. R6	62.5	PF	1.6	D	0.7	NPF	1.7	D	16.5	B/U	2.7	NPF	0.5
Main. R8	39.4	FAR/P	9.5	D	0	NPF	1.6	D	24.8	U	2.4	NPF	-0.5
Lane R1	50.3	PF	3	D	2.5	NPF	1.5	D	20.7	U	22.1	PF	2
Lane R2	50.9	PF	11.1	B/D	0.2	NPF	1.6	D	30.6	U	10.7	NPF	-0.5
Lane R3	54	PF	8.1	B/D	2.7	NPF	0.9	D	36.8	U	13.6	NPF	-0.5
Lane R4	45.8	PF	11.8	B/U	7.4	FAR/N	0.9	D	32.4	U	31.5	PF	1
Lane R5	50.7	PF	9.4	B/D	4.4	NPF	0.8	D	20.7	U	4.7	NPF	-0.5
Lane R6	34.3	NPF	15.2	U	9.6	FAR/P	0.8	D	41.3	U	12	NPF	-2.5
HidawayR1	30.6	NPF	20.1	U	1.7	NPF	1.4	D	11.4	B/D	28.9	PF	-0.5
HidawayR2	39.2	FAR/P	15.2	U	3.2	NPF	1.6	D	10.2	B/D	29.9	PF	1
HidawayR3	43	PF	4.9	D	1.5	NPF	1.9	D	16.9	B/U	20.5	PF	2.5
HidawayR4	50	PF	9.3	B/D	0.15	NPF	1.8	D	8.5	D	51.8	PF	4
HidawayR5	19.1	NPF	18.7	U	1.2	NPF	1.5	D	30.7	U	21.9	PF	-2
DryCam.R1	21.6	NPF	13.7	B/U	0	NPF	1.27	D	23	NPF	14	NPF	-3.5
Dry CamR2	8	NPF	29.6	U	0	NPF	1.29	D	16	NPF	15	NPF	-4
Ranch.R2	20.9	NPF	30.2	U	0	NPF	1.5	D	29	NPF	22	PF	-2
Ranch.R3	2.2	NPF	83.6	U	0	NPF	1.7	D	46	NPF	4	NPF	-4
SalsburyR1	8.6	NPF	41.8	U	0	NPF	1.3	D	27	NPF	19	NPF	-4
SalsburyT1	16.8	NPF	57.1	U	0	NPF	1.3	D	27	NPF	21	PF	-4

Rancheria

Similar to Dry Camas Creek, steelhead overwintering habitat in Rancheria Creek is not desirable. Pools are sufficiently deep, albeit infrequent, and the amount of LWD in Reach 3 is desirable. All other metrics indicate that the stream provides limited habitat quality for fish during fall and winter months.

Salsbury

Salsbury Creek rated among the least favorable of all reaches assessed for steelhead overwintering habitat. The substrate is unusable, there is no off-channel refugia, there are limited pools and an infrequent amount of LWD.

Smolt migration

Since steelhead and chinook smolt outmigration timing (early April through late June) generally coincides with periods of high flow and reduced temperatures, habitat quality throughout the Camas Assessment Area is for the most part not limiting population persistence. Steelhead smolts that outmigrate late from smaller tributaries, such as Rancheria Creek or Salsbury Creek, may encounter passage problems due to reduced flows, and may subsequently residualize (Tom Macy, CTUIR Habitat Biologist, Personal Communication, September, 2003).

5 Analysis of Ecological Functions

5.1 Hydrologic Regime

The purpose of this chapter is to evaluate the hydrologic regime of streams in the Camas Assessment Area. Flood flow frequency, peak flow timing, and base flow characteristics are examined and related to events, where applicable, that may be responsible for precipitating change. An introductory overview precedes the various subsections to provide requisite background information.

5.1.1 Runoff

Spring runoff is a critical period for salmon and steelhead spawning, migration, and rearing life history stages. The annual freshet provides cues to steelhead to initiate spawning activities and provides smolts with egress from the watershed. It also represents a period of nutrient dispersal, habitat creation, and habitat access for fish that are rearing. Annual peaks, depending upon their magnitude, frequency, and timing may also be detrimental to anadromous salmonids and their habitat. Flood flows may scour spawning and rearing substrate, flush juvenile fish, export LWD, accelerate erosion, or deposit excessive amounts of sediment on otherwise usable habitat, and, depending upon their timing, may deplete stream channels of critical base flows later in the year.

Establishing the magnitude of peak flows and the probability and timing of their occurrence provides the foundation for determining whether or not natural and/or anthropogenic disturbance to the watershed has contributed to changes in the hydrologic regime of the watershed. Assessment of the possible causes associated with a given change in peak flows will provide an indication towards the level of impact the flows may be having on instream habitat conditions that affect salmonid production.

Peak Flow Magnitude and Probability of Occurrence

Peak flows in eastern Oregon watersheds result from rainstorms, winter and spring rain-on-snow events, spring snowmelt, and cloudburst storms or thunderstorms. Peak flow generating processes are driven by natural factors such as topography of the watershed, aspect, amount, form, and distribution of precipitation, soil type, climate, elevation, groundwater characteristics, and vegetation removal through fire, wind, and/or pathogens. Peak flows are equally a function of anthropogenic disturbance to the watershed, including timber harvest, road construction and maintenance, grazing, and irrigated agriculture.

Table 39 shows stream peak discharge values and associated recurrence intervals at the four gages in the Camas Assessment Area. Graphical representations of these values and associated discussion are presented below.

Table 39. Peak flow discharges (Q) and recurrence intervals (Q*n*), measured at USGS-maintained stream gages throughout the Camas Assessment Area

Gage	Q2	Q5	Q10	Q25	Q50
14041900	31	44	48	90[1]	NA
14042000	560	1,030	1,760	1,880[2]	NA
14042500	1,050	1,630	2,230	2,570[3]	3,840[4]
14043560	315	546[5]	NA	NA	NA

[1]/ Recurrence interval = 16 years
[2]/ Recurrence interval = 21 years
[3]/ Recurrence interval = 23 years
[4]/ Recurrence interval = 68 years
[5]/ Recurrence interval = 7 years

There is a very high probability (99%) that peak flows in the mainstem Camas Creek at Ukiah will meet or exceed 340 cfs once every other year (Figure 27). Conversely, flows equal to or greater than 3,840 cfs have an annual occurrence probability of only one-percent or a recurrence probability of once every 68 years. At higher elevations, annual peaks on the mainstem will typically reach 285 cfs (probability = 95%; recurrence interval = 1.05) and exceed 1,880 cfs only once every 21 years (Figure 28).

Peak flows in tributary streams are less well established due to the lack of long-term stream gage data, however hydrodata is available for two tributaries in the Camas Assessment Area. Peak flow records were collected from 1965 through 1979 at a USGS gaging station on Line Creek (gage #14041900), a tributary to Hidaway Creek. The fifteen-year period of record provides a perspective of peak flow contribution from a tributary with a small drainage area (2.4 mi^2), as shown in Figure 29. Additional peak discharge data was collected from the Snipe Creek gage (#14043560), which recorded six years worth of flows (1967 – 1973). Because of the short duration, exceedance probabilities for Snipe Creek should not be considered reliable (margin for error $\geq$50%) but are presented to provide a relative sense for gaged tributary peak flows (Figure 30).

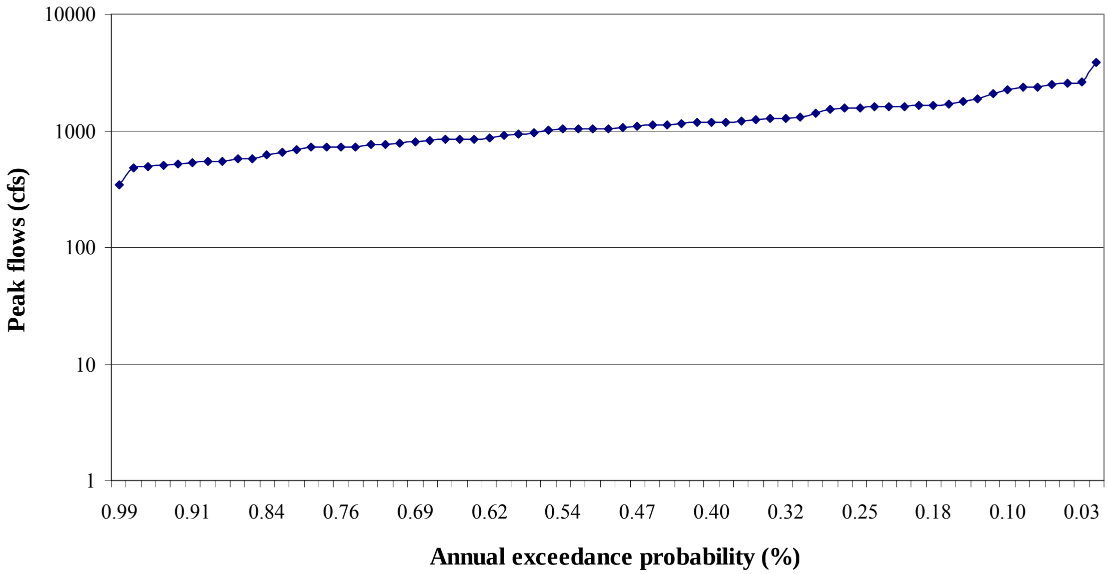

Figure 27. Peak flow frequency for the mainstem Camas Creek (gage #14042500) for water years 1914-1998

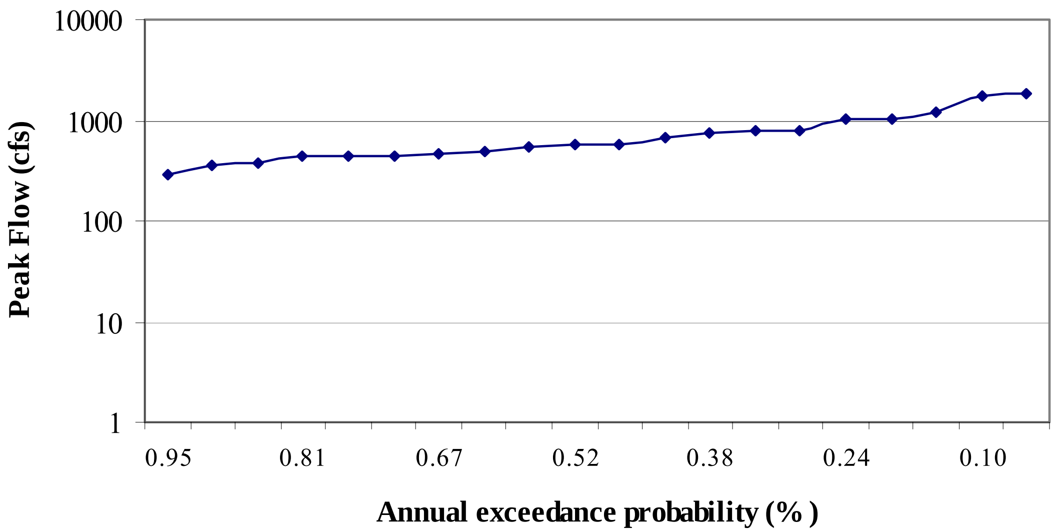

Figure 28. Peak flow frequency for the mainstem Camas Creek near Lehman (gage #14042000) for water years 1950-1970

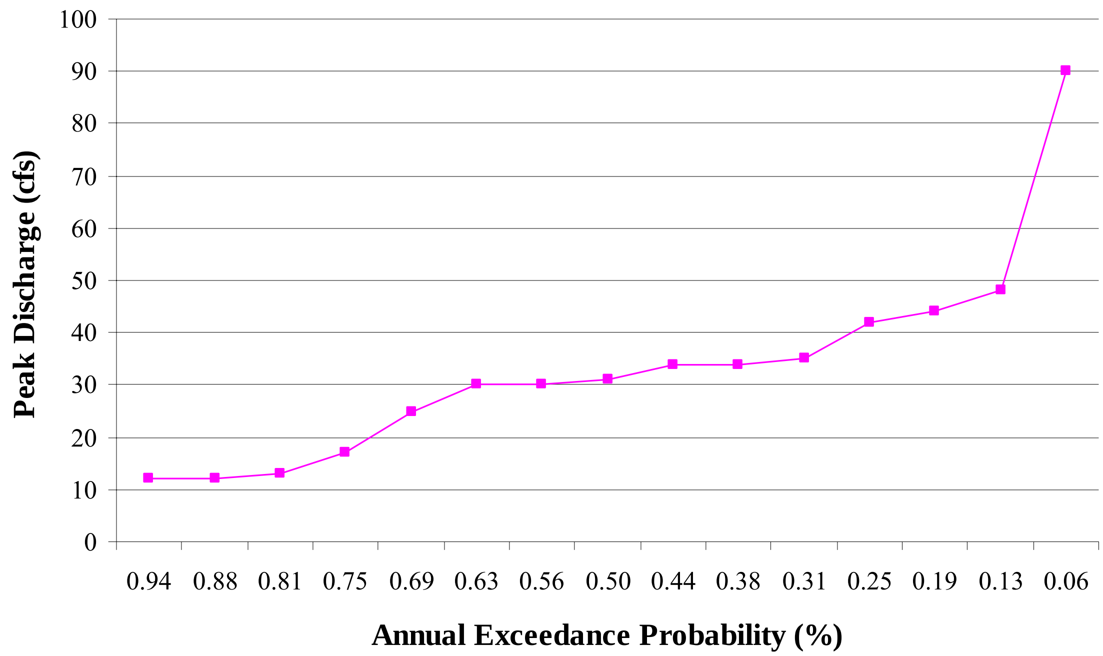

Figure 29. Peak flow frequency for Line Creek near Lehman Springs (gage #14041900) for water years 1965-1979

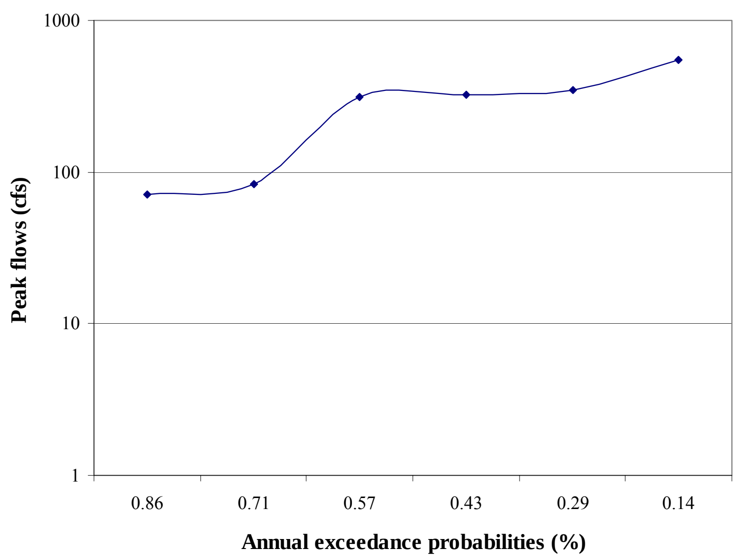

Figure 30. Peak flow frequency for Snipe Creek (gage #14043560) for water years 1967-1973

Modeled Peak Flow Frequencies in Tributaries

In the absence of gage data, methods have been developed to estimate peak flows for tributaries. The USGS has developed a technique for estimating magnitude and frequency of floods for ungaged sites (U. S. Geological Survey 1993). The model uses regression equations developed for one of four hydrologic regions throughout eastern Oregon for estimating peak discharges (QT) having recurrence intervals (T) that range from 2 to 100 years.

The explanatory variables used in the equations are drainage area (A), in square miles, percentage of the drainage area covered by forest (F) as shown on recent topographic [GIS] maps, and mean annual precipitation (P) in inches. The regression equations were developed from peak-discharge records for 148 stations in Oregon and 14 in adjacent states. The average standard errors of estimate, by region, range from 45 to 51 percent for the USGS model. Outcomes from model runs, as they pertain to ungaged tributaries in the Camas Assessment Area are shown in Figure 31.

Peak discharge values from the Hidaway subwatershed are estimated to be the highest of the nine subwatersheds modeled, while those from the Lane Creek subwatershed are the lowest (excluding the 2-year peak flow estimate). Input data are shown in Table 40.

Table 40. Explanatory variables used in estimating magnitude and frequency of floods for ungaged sites within the Camas Assessment Area (U. S. Geological Survey 1993)

Subwatershed	**Drainage Area (mi^2)**	**Percentage Forested**	**Mean Annual Precipitation (in)**
Lane	26.17	69.8	26.9
Snipe	43.21	51.4	24.4
Bowman	69.66	75.5	27.2
Upper Owens	21.70	65.1	25.7
Lower Owens	25.81	24.8	21.1
Hidaway Cr	30.05	76.9	28.4
Camas/Wilkins	39.04	49.7	21.0
Cable	38.00	79.1	27.8
Lower Camas	15.03	28.8	18.3
Total	308.67		

Upon cross validation of actual gaged flows at Ukiah and modeled flows for the contributing area upstream of the gage, the standard errors for estimated flows were lower for peaks with higher frequencies (i.e. those occurring once every 2 – 10 years) and higher for peaks with lower frequencies (i.e. those occurring once every 25 – 100 years). These differences stand to reason since flow records at the Ukiah gage extend back a total of 68 years while those from the model project estimated 100-year peaks.

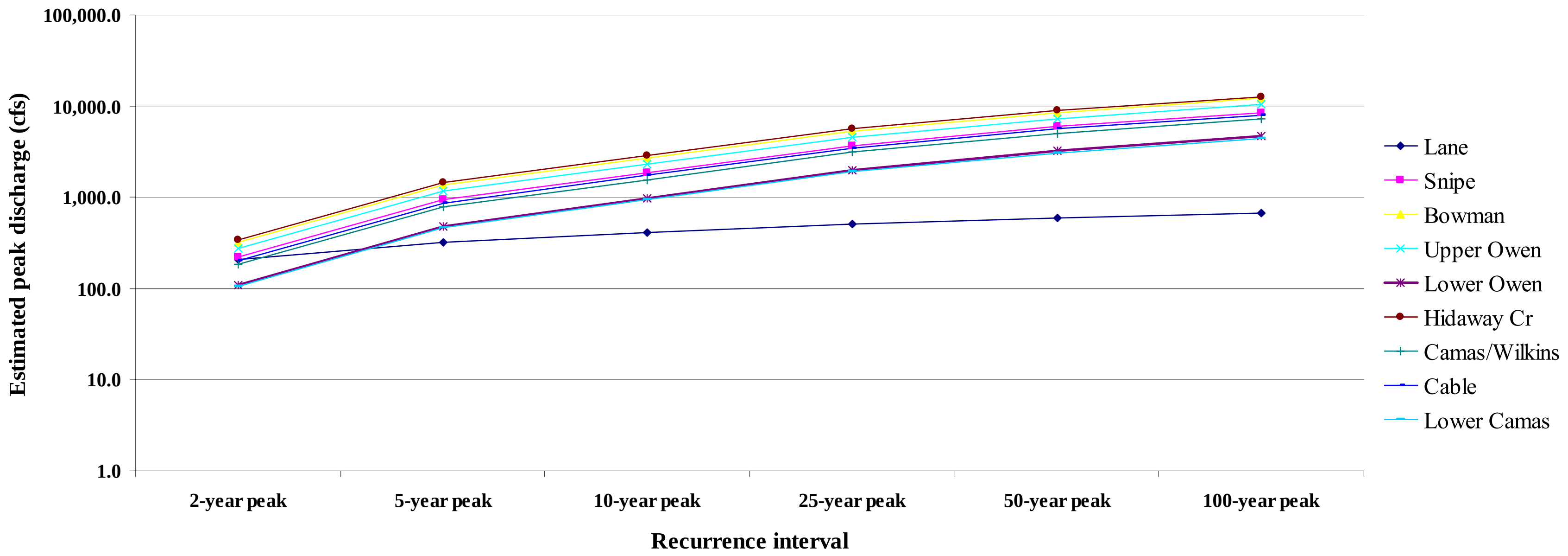

Figure 31. Peak flow estimates for ungaged tributaries occurring in the Camas Assessment Area. Estimates are based on regression equations presented in (U. S. Geological Survey 1993).

Changes in Peak Flow Frequency and Magnitude

The relative frequency and magnitude of peak flows in the Camas Assessment Area, and specifically for peak flows measured near the town of Ukiah, does not appear to have appreciably increased or decreased over the period for which flows have been recorded. The top eight peak flow events recorded at the Ukiah stream gage have all exceeded 2,000 cfs, and occur on average, once every eight years.

The UNF did not find the frequency of peak flow events to have changed significantly based on flow records from the gage on the mainstem above Cable Creek (Umatilla National Forest 1995). The Forest Service was also unable to conclude whether there had been a shift in the hydrologic response (cumulative runoff volume plotted against cumulative precipitation depth) of the watershed above the gaging station at Ukiah, and theorized that the apparent insensitivity of the watershed may be due to either 1) precipitation characteristics having a greater influence upon runoff than vegetation, and/or 2) the compensating effects of timber harvest and fire exclusion.

Reports of increases in bedload transport in the lower mainstem Camas during winter and spring runoff events (T. Macy, CTUIR Habitat Biologist, Personal Communication, April 2001) suggest that there has been a change in stream power, or that previously immobile substrate has become mobile. Ukiah residents have reported that over the last five to ten years, there has been an increased incidence in the amount of boulder-sized substrate that is heard and observed moving down the channel during runoff periods. Unfortunately, preexisting data from which a determination of whether or not a change in stream competence has occurred, is not available. Monitoring data, such as that used in the Riffle Stability Index (Kappesser 2002), would facilitate this need and should be collected to enable future determinations of changes in bedload movement.

It is possible that the increased incidence of bedload transport reported by Ukiah locals may be due to factors other than a change in the hydrologic regime of Camas Creek. Flood flows, such as those recorded in 1996 (2,420 cfs) and 1997 (2,000 cfs) may be responsible for loosening and exporting fines and smaller substrate that had previously ‘cemented’ the larger material to the channel bed. Upon the removal of the anchoring substrate, it is reasonable to assume that power needed to move the material noted by locals has been substantially reduced, even to the point where annual maintenance flows are capable of moving the larger sized material.

It is also possible that the historic ‘depositional’ reaches in the lower mainstem have been modified (i.e. straightened, channelized and armored) to such a degree to that they have in essence become transport reaches during periods of high flow, capable of moving large substrate. Channel straightening and diking have reduced floodplain interaction throughout much of the mainstem Camas (Umatilla National Forest 1995), and have subsequently increased the stream power. In response, the affected reaches are attempting to reach a new point of equilibrium and are moving historically immobile particles to new depositional reaches (Kappesser 2002).

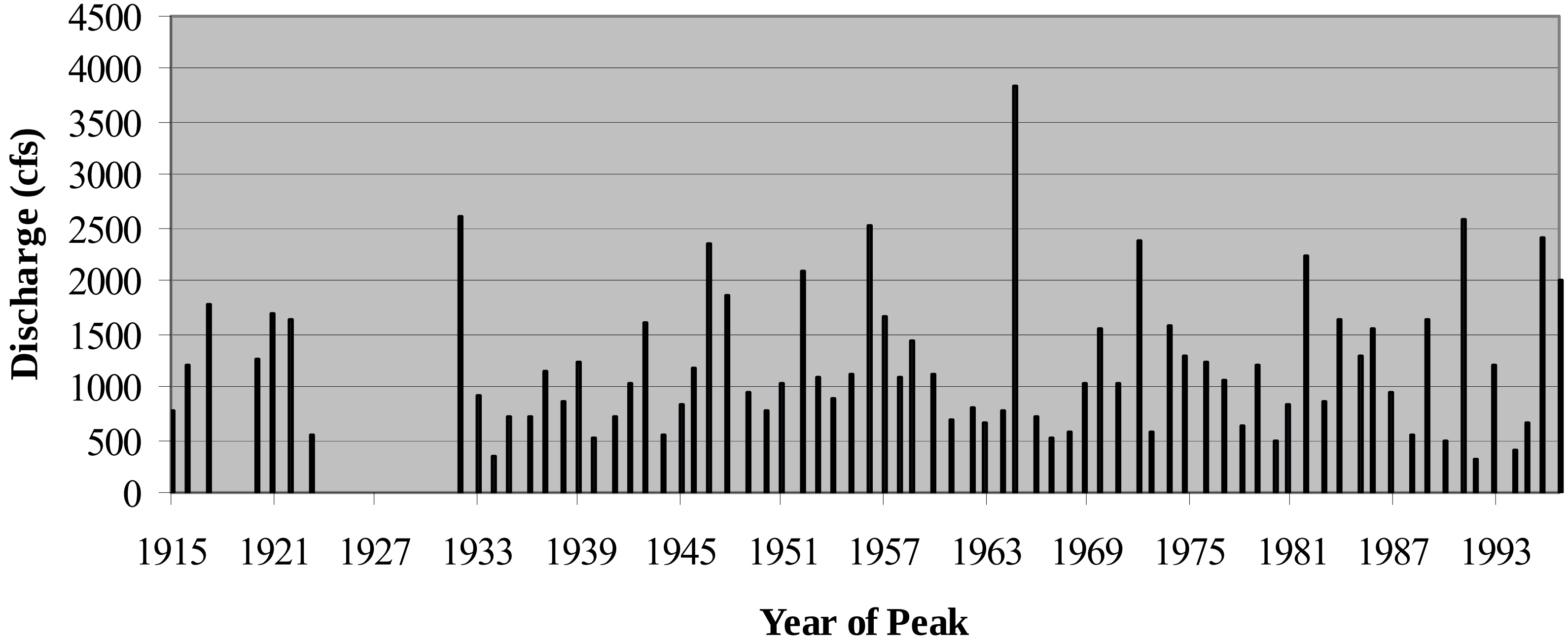

Figure 32. Peak flows measured at the Ukiah stream gage (#14042500) for the 68-year period of record

Peak Flow Timing

The timing of hydrograph peaks throughout the various subwatersheds in the assessment area is not uniform. A study conducted by the Watershed Professionals Network (Watershed Professionals Network 2001b) established peak flow timing for various drainages throughout Eastern Oregon, including those in the Blue Mountain ecoregion and in Camas Creek. Results from the study, as shown in Table 41 and Table 42, indicate that peak flows in the assessment area occur primarily during winter or spring months, the timing of which varies based on sub-ecoregion.

Table 41. Peak flow timing for sub-ecoregions in the Camas Assessment Area (Watershed Professionals Network 2001b)

Sub-region Name	Subregion Code	Primary Peak Flow Season
John Day Clarno Highlands	11b	winter or spring
Maritime-Influenced Zone	11c	winter or mixed
Blue Mountain Basins	11k	winter or mixed
Mesic Forest Zone	11l	spring or mixed

Table 42. Streamflow stations in the Camas Assessment area that were investigated for peak flow occurrence (Watershed Professionals Network 2001b)

Station #	Station Name	County	#Peak Flows within Season (%)				Season in which 5 largest floods occurred
			fall	winter (Nov-Feb)	spring (Mar-May)	summer	
14041900	Line Cr. near Leahman Springs	Umatilla	- -	8 (53)	7 (47)	- -	2 winter & 3 spring
14042000	Camas Cr. Near Leahman	Umatilla	- -	12 (60)	8 (40)	- -	3 winter & 2 spring
14042500	Camas Cr. Near Ukiah	Umatilla	- -	22 (33)	43 (64)	2 (3)	1 winter & 4 spring

Results from the study illustrate the influence of the rain-on-snow (ROS) elevation band (2,700 – 5,000 feet) on peak flow timing. For example, peak flows recorded at the Ukiah gage, which is located at 3,588 feet in elevation, occur predominately in the winter (November - February) and are a function of winter rains and/or winter rain-on-snow events. Conversely, subwatersheds, or portions thereof, occurring at higher elevations, such as Line Creek (4,517 feet ASL), experience spring snowmelt-dominated runoff events. It is clear, however, that seasonal peak flow timing (i.e. peak flows occurring during either winter or spring months) in the Camas Assessment Area is less than definitive, which is a reflection of Camas Creek being at the margin of the ROS zone.

The hydrologic response of Camas Creek to winter storm events is rapid. Examination of daily maximum-minimum temperature data from the Ukiah climate station shows that the 1965 winter peak flow event was preceded by pronounced daily temperature shifts, sometimes as great as 48°F in a 24-hour period, then by a period of rapid warming (Figure 33). Ambient temperatures for the first two-thirds of the month (January 1 – 23) averaged 26°F, whereas temperatures just prior to the event (January 24 – 30) averaged 36°F. Similar examination of daily precipitation data collected from the Ukiah climate station shows that precipitation amounts were highest just before the peak flow event of January 30 (Figure 34). Based on these records, it is reasonable to assume that the 1965 peak flow event resulted from rain falling on snow or on frozen ground.

Warm fronts from the west can quickly raise the freezing level to 7,000 feet or above. If these fronts are associated with moisture, rain falling below the freezing level can result in rapid melting of the snowpack and flash flooding. If the snowmelt and rain falls on frozen ground, the effects of the storms may be compounded. From an instream habitat standpoint, winter storms of this nature most commonly affect small intermittent and perennial tributaries more than they do the mainstem due to differences in buffering capacities, although a storm of the 1965 magnitude may potentially cause damage to all receiving waterbodies.

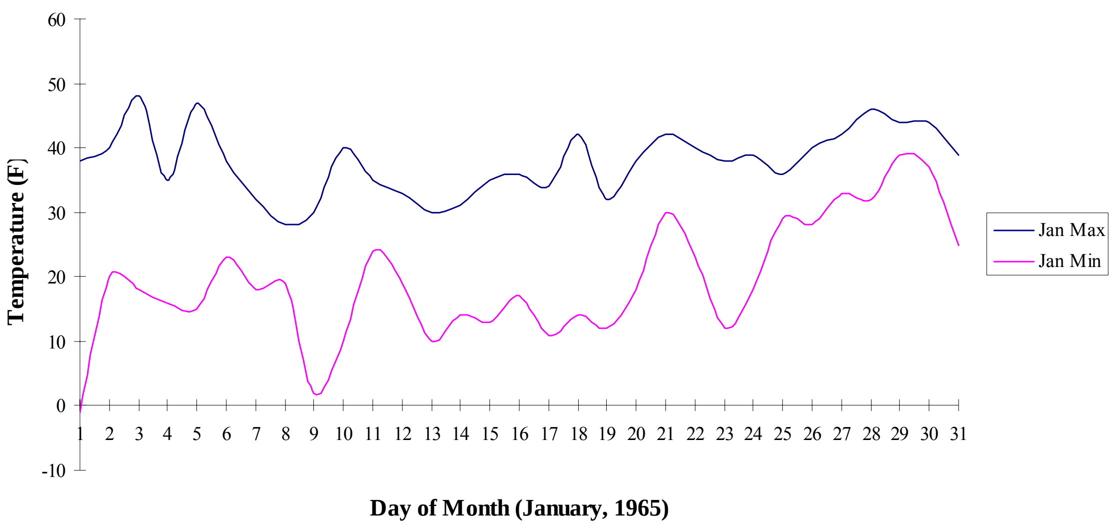

Figure 33. Daily maximum/minimum temperatures recorded at Ukiah, OR, for January, 1965

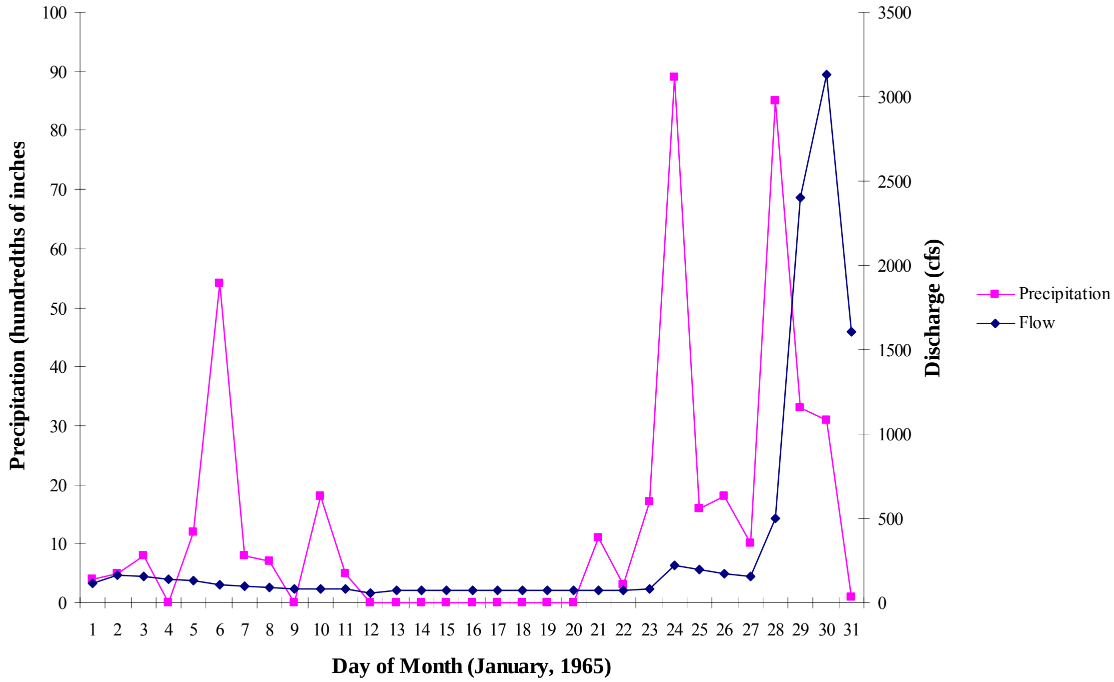

Figure 34. Daily precipitation totals and peak flows recorded at Ukiah, OR, for January, 1965

Examination of the cumulative contribution of annual winter and spring runoff totals to annual totals can also yield information relative to whether or not there has been a shift in runoff timing and amounts. For example, with the substantial (68-year) period of record, it is possible to assess seasonal changes in flow contribution to total amounts and relate these changes to disturbance, or lack thereof. Normalization of the data in this manner also takes out some of the year-to-year variability that may otherwise confound results.

Hydrodata for winter (November – February) and spring (March – May) months from the Ukiah gage is presented in Figure 35 and Figure 36. When examined over the entire period of record, seasonal changes in flow timing and contribution are not evident. There has been a slight increase in the percent contribution of winter flows ($R^2 = 0.003$), however this change appears to be primarily a result of inter-annual flow variability.

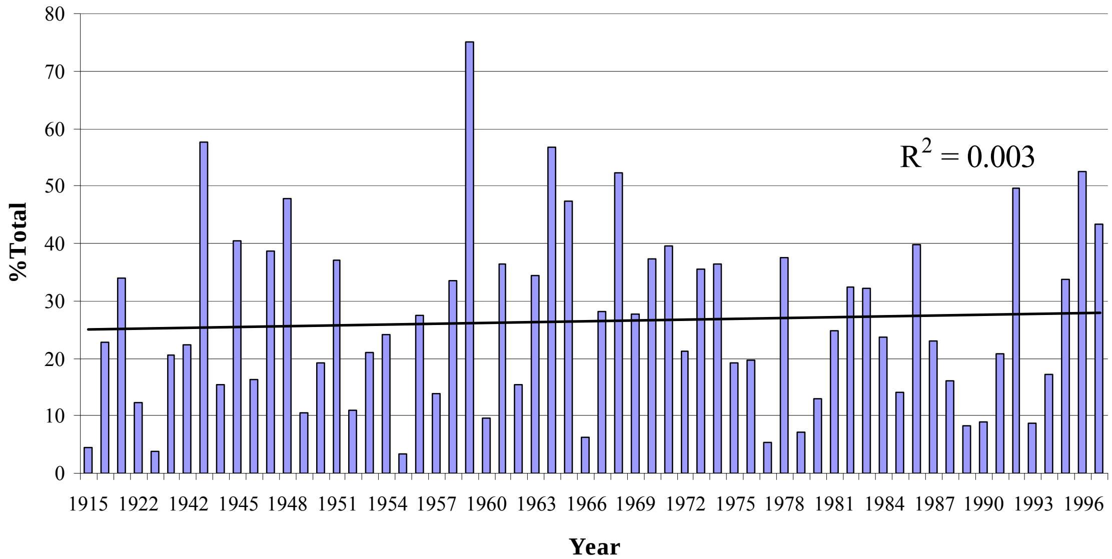

Figure 35. Percent contribution of winter flows to annual totals, as measured at Ukiah, OR for the period of record 1915-1997

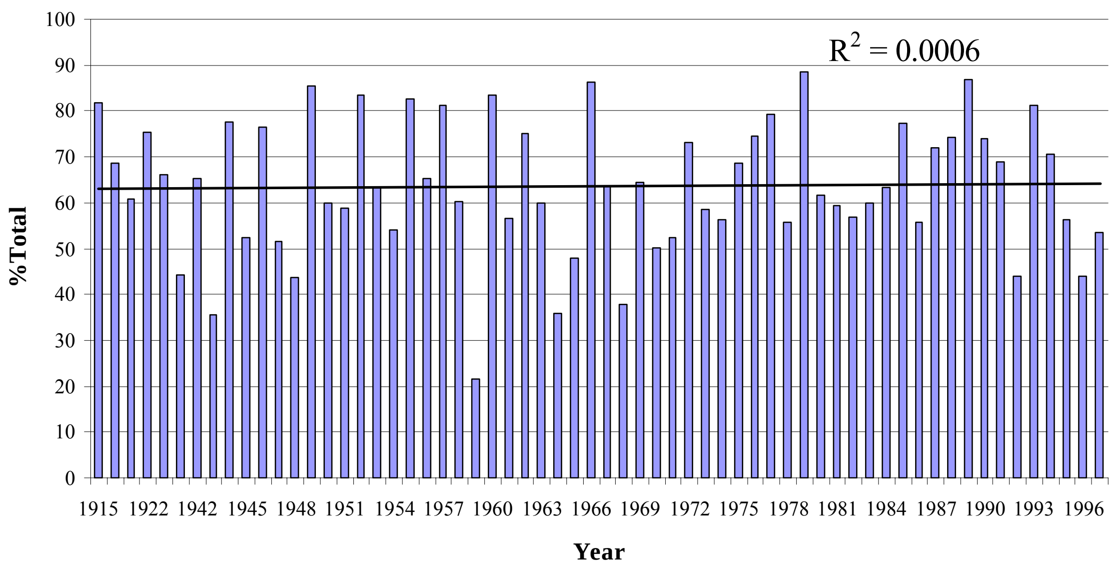

Figure 36. Percent contribution of spring flows to annual totals, as measured at Ukiah, OR for the period of record 1915-1997

Spring runoff is also variable with no distinct trends when examined over the entire period of record. Unlike the winter events however, the cumulative percent contribution of spring flows to annual totals do show some distinct patterns, especially when viewed on a decadal basis. For example, spring flow contributions between 1968 and 1978 increased, on average, more than other decades examined (Figure 37). Upon further analysis of precipitation data for the similar time period, the increase in spring flows are likely a result of an accordant annual increase in spring rains (Figure 38).

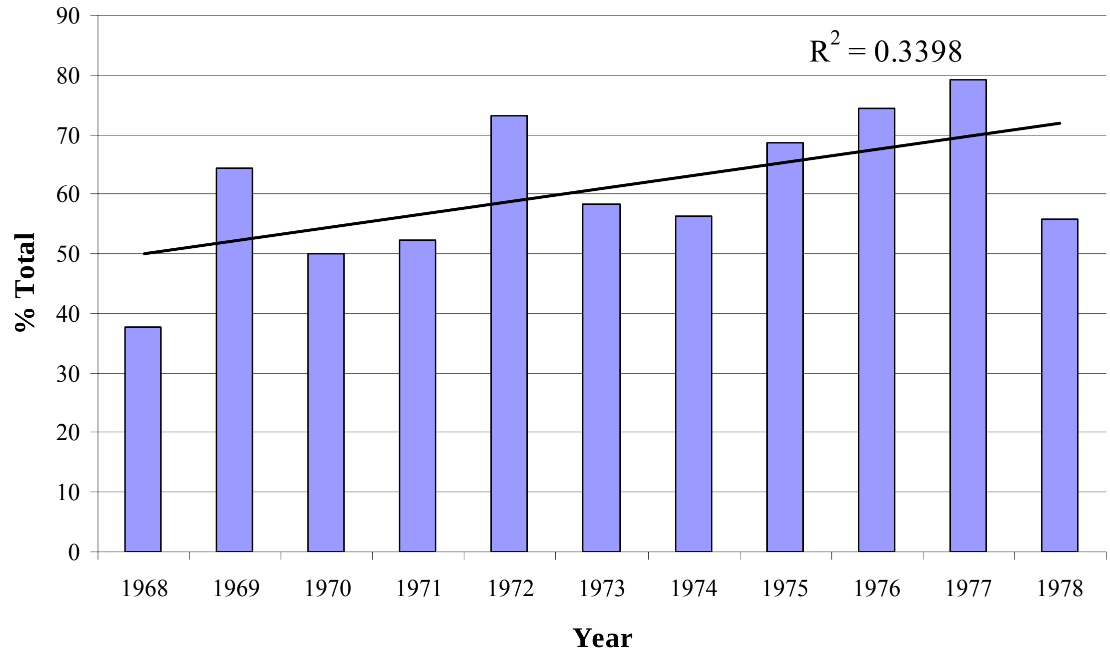

Figure 37. Percent contribution of spring flows to annual totals, as measured at Ukiah, OR for the period 1968-1978

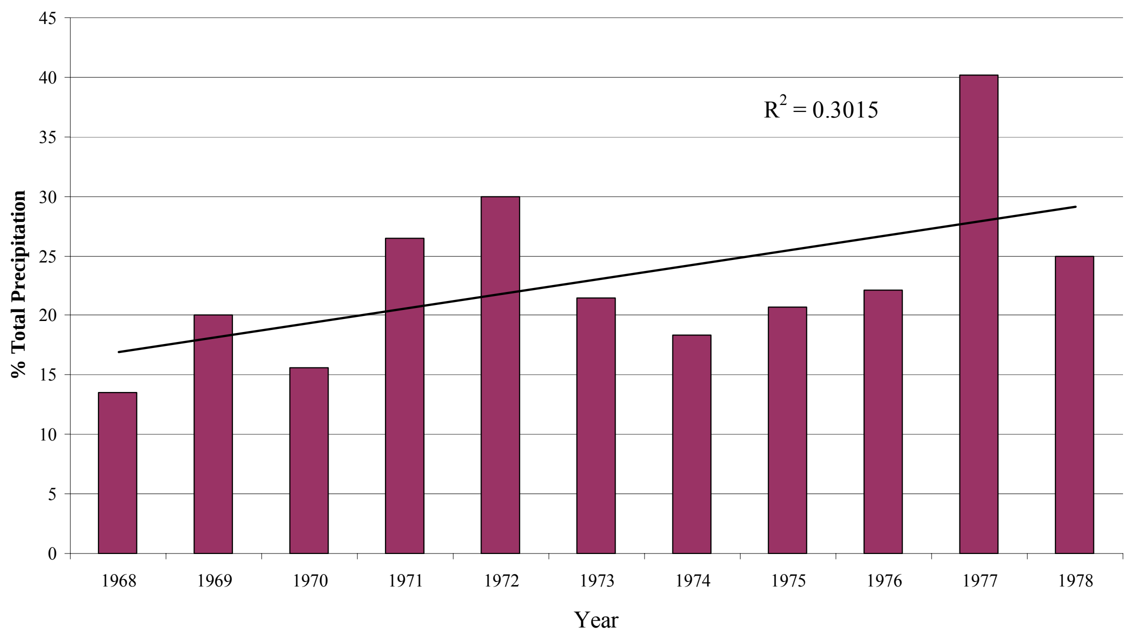

Figure 38. Percent contribution of spring precipitation to annual totals, as measured at Ukiah, OR for the period 1968-1978

5.1.2 Base Flows

Assuming base flows are those <10 cfs (Umatilla National Forest 1995), the base flow period for the mainstem Camas begins, on average, July 20 and extends through October 22 (Figure 39). Perennial tributary base flows are markedly lower.

Work by the UNF (Umatilla National Forest 1995) established that low flow discharge rates have essentially remained constant over the period of record. The Forest Service also analyzed the duration of time during which low flows occur and found that despite a wide range in variability (low flow duration ranged from 30 days to 190 days) there was no apparent trend in the persistence of flows <10 cfs. Peak flow timing was also analyzed to determine whether initiation of the low flow period had changed, although results proved inconclusive.

Highly reduced baseflows in Camas tributaries, and in portions of the mainstem itself, are not uncommon (W. Wilson, ODFW, John Day, OR, personal communication, September, 2003). Many attribute the lack of sustained surface flow to the underlying alluvium and/or shallow subsoil that is common in floodplain areas throughout the Camas Watershed. Summer flows are said to "sub out", meaning they percolate through the unconsolidated channel material and flow subsurface until they encounter an impermeable lens, at which point they will often return as surface flows. While this "deficit" of flows certainly does not contribute to salmonid habitat availability in the reach that goes dry, the water eventually resurfaces in downstream reaches, and is likely cooler than had it remained in the channel as surface flow.

Tributary Base Flows

Due to the limited amount of flow data recorded on tributaries in the Camas Assessment Area, it is difficult at best to characterize tributary base flows. The only available tributary hydrodata is from the Snipe Creek gage, which captured annual flows from 1967 to 1972. While this limited period of record may not be sufficient to accurately characterize baseflows, it nonetheless provides insight into the relative contribution Camas tributaries have on the mainstem.

As shown in Figure 40, there is an extended period of time (141 days) during which flows in Snipe Creek were at, or below, 1 cfs. On average, the period of low flow discharge (≤1 cfs) initiates July 1 and extends through November 29. Comparison of Snipe Creek baseflow timing to the mainstem Camas baseflows illustrates the response time (approximately 20 days) of downstream flows to tributary runoff.

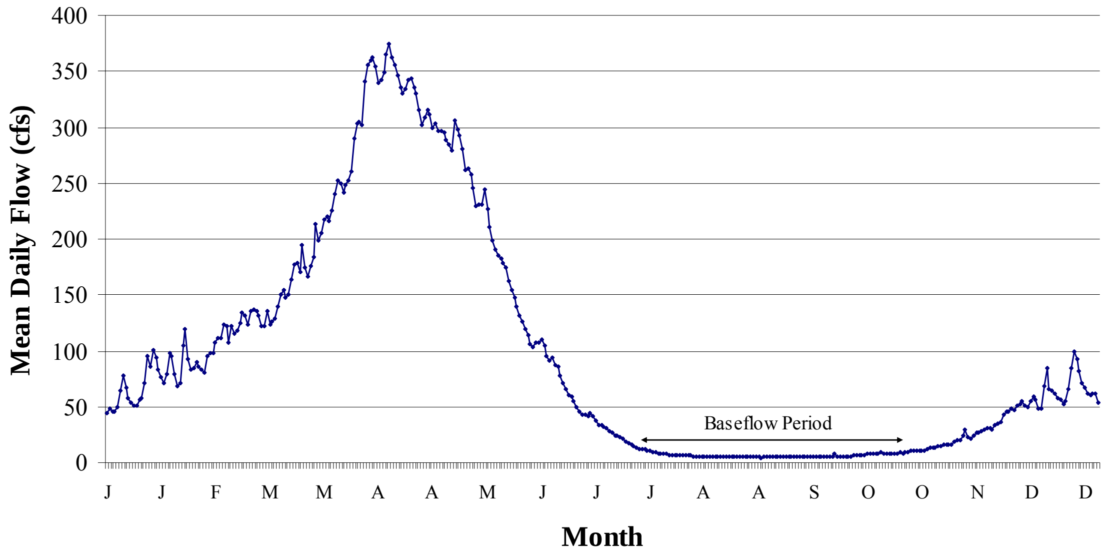

Figure 39. Baseflow period for the mainstem Camas, as measured at the Ukiah stream gage. Flows shown represent the mean of daily mean values for a given day for 69 years of record[1], in ft^3/s. Baseflows are assumed to be those <10 cfs

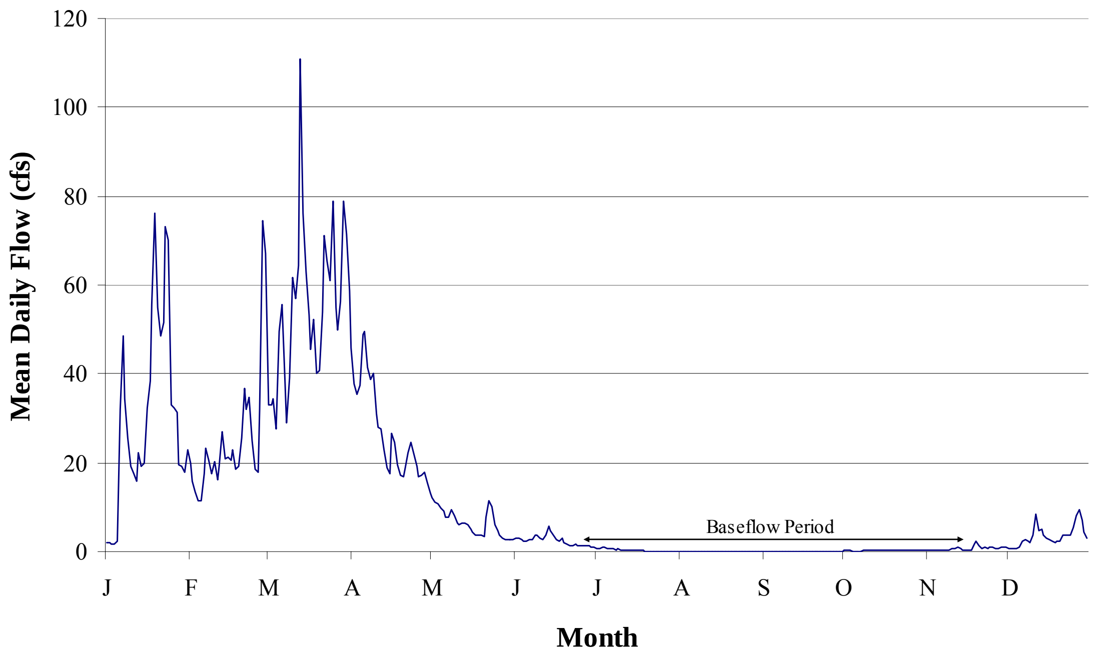

Figure 40. Baseflow period for Snipe Creek for the period of record, 1967-1972. Baseflows were deemed to be those <1 cfs

Peak Flow Magnitude and Probability of Occurrence – Summary

Peak streamflows in the Camas Assessment Area result primarily from spring snowmelt and/or winter and spring rain-on-snow (ROS) events. Maintenance flows in the mainstem Camas average 340 cfs, while those in tributaries are considerably less. On average, flows in the mainstem Camas meet or exceed 2,000 cfs once every eight years. The frequency and magnitude of peak flows does not appear to have changed appreciably over the period of record at the Ukiah gage on the mainstem Camas. Morphologic changes to streambed substrate and/or changes that limit floodplain interaction may be contributing to the mobilization of larger-sized substrate.

Peak Flow Timing – Summary

Because the Camas Assessment Area is located in a climatological transition zone, peak flow timing patterns are not easily discernable. Peak flows may occur during either winter (November – February) or spring (March – May) months, the incidence of which is dependent upon elevational gradient and marine or continental influence. Streams, or portions thereof, occurring near the 5,000 foot elevation band (i.e. Mesic Forest Zone) are more prone to peaks produced from spring snowmelt while those occurring at lower elevations are more apt to peak in the winter as a result from ROS events or rain falling on frozen ground. The hydrologic response of streams to winter storms is rapid, especially when accompanied by periods of freezing temperatures followed by rapid warming and precipitation. Seasonal (winter and spring) flow contributions are substantial when compared to annual totals. Increases in percent contribution of seasonal runoff amounts to total annual runoff have occurred, especially when viewed on a decadal basis. The increases are most likely a result of accordant increases in precipitation rather than changes in upland storage capacity.

Baseflow Summary

Baseflows in the mainstem Camas typically begin July 20 and extend through late October. The initiation and duration of baseflows has remained constant over the period of record. Shallow alluvial deposits in portions of the mainstem contribute to losses of surface flow during low precipitation years. The initiation and duration of tributary baseflows occurs earlier and lasts longer than those of the mainstem.

5.2 Riparian and Wetland Function

Data defining the current function and structure of riparian vegetation and wetland areas in the Camas Assessment Area is currently not available. It was not possible to use OWAM methods to determine riparian and wetland function due to the unavailability of recent stereo aerial photographs of sufficient resolution, and due to the lack of stream inventory data needed for the definition. Although a limited number of stream surveys document the percentage of shade by reach (Table 43), most available data does little to define the actual condition and function of streamside vegetation. Due to the lack of data, the following discussion is largely based on information provided in Umatilla National Forest (1995).

Table 43. Percent shade provided by riparian vegetation

Stream Name	Reach	Percent Shade
Dry Camas	1	14
	2	21
Rancheria	2	31
	3	22
Salsbury	1	37
	T1	35

Most riparian habitat in the Camas Assessment Area has been altered to some degree by land use activities (Umatilla National Forest 1995). Roads, timber harvest, and grazing, are cited as primary factors compromising riparian structure and function (Umatilla National Forest 1995). Caraher (et al. 1992 cited in Umatilla National Forest 1995) found that riparian shrub cover was below the range of natural variability in most river basins in the Blue Mountains, including that occurring in the Camas Assessment Area.

Roads occurring within 150 feet of fish-bearing streams in the Camas Assessment Area are considered among those most likely to compromise riparian structure and function. Based on USFS data, riparian areas in subwatersheds that are most likely to suffer deleterious impacts from roads occur in the upper Camas (Bowman subwatershed), lower portion of Hidaway (Hidaway subwatershed), and in the Cable subwatershed (Umatilla National Forest 1995) Refer to Section 6.2.1 for additional discussion of roads proximal to riparian areas.

Similar to roads, the removal of streamside vegetation through timber harvest has negative consequences to riparian function and structure. Logging has occurred adjacent to most perennial streams throughout the analysis area but has been most significant in the upper Camas area (Bowman subwatershed), the upper and lower Owens subwatersheds, and the lower reaches of the Hidaway subwatershed (Umatilla National Forest 1995) Refer to Section 6.2.2 for additional discussion of timber harvest proximal to riparian areas.

Livestock grazing has historically occurred throughout most portions of the Camas Assessment Area, and continues to impair riparian function and condition in areas where protection or management efforts have not occurred. Livestock-big game interactions are cited as being problematic in riparian management efforts, as wild ungulate populations have increased considerably from historic (pre-1950s) levels (Umatilla National Forest 1995). Of particular concern is the dual use of riparian shrubs by both livestock and large wild ungulates. Stream surveys document considerable damage to riparian vegetation by ungulates in the Dry Camas, Rancheria, and Salsbury Drainages (Schloss 1999a, 1999b, 1999c). Current efforts to minimize the effects of riparian grazing have focused on exclosure fencing, off-site watering, and rest-rotation management (Umatilla National Forest 1995).

5.3 Sedimentation

Movement of soils from hillslopes or streambanks into stream channels is a natural process with which aquatic species have evolved. Changes in the volume of sediment moved to the stream, the type of sediment moved, and the frequency of movement has occurred, however, causing reductions in salmonid habitat condition and availability.

5.3.1 Upland Sedimentation Processes

Addition of sediment to the channel from upland sources may occur through surface erosion, gully erosion, or soil mass movement (Brooks 1991). In the Camas, these processes differ both spatially and temporally and influence aquatic habitats in different ways. Processes of sedimentation in the Camas also change along an elevational gradient. Within the subbasin, variations in geology, topography, climate, soil character and soil cover characteristics are influenced by elevation, and act singularly or collectively to drive the frequency, magnitude, and process of sedimentation in streams and rivers.

Gully Erosion

Increased land use activities on inherently unstable or sensitive landforms have contributed to changes in sedimentation processes, and have been cited in portions of the Camas Assessment Area as detrimental to aquatic habitat function (Umatilla National Forest 1995). For example, road construction and road maintenance can increase the incidence of gully erosion by intercepting runoff from upland areas and concentrating it in road cuts or ditches (Huntington 1998). The road network essentially acts as a conduit for overland flow, and, in areas with inherently low soil cohesion properties (Figure 41), increases the potential for gully erosion.

Based on Figure 41, subwatersheds (on USFS-owned lands) that have the highest potential for gully erosion include the upper reaches of Cable Creek, the upper reaches of Hidaway Creek, the upper Camas [Bowman] subwatershed, and portions of the Lane Creek subwatershed. A review of the stream survey data in these areas (*refer to* Section 4.1.1) indicates that the headwater reaches are those that typically have the highest percentage of fine substrate. It is reasonable to assume that the headwater portions of most drainages are comprised of small first or second order streams, which typically don't have the necessary stream competence to flush fines out of the system, and when subjected to sediment inputs via gully erosion, will act as storage reaches until the next high magnitude storm event.

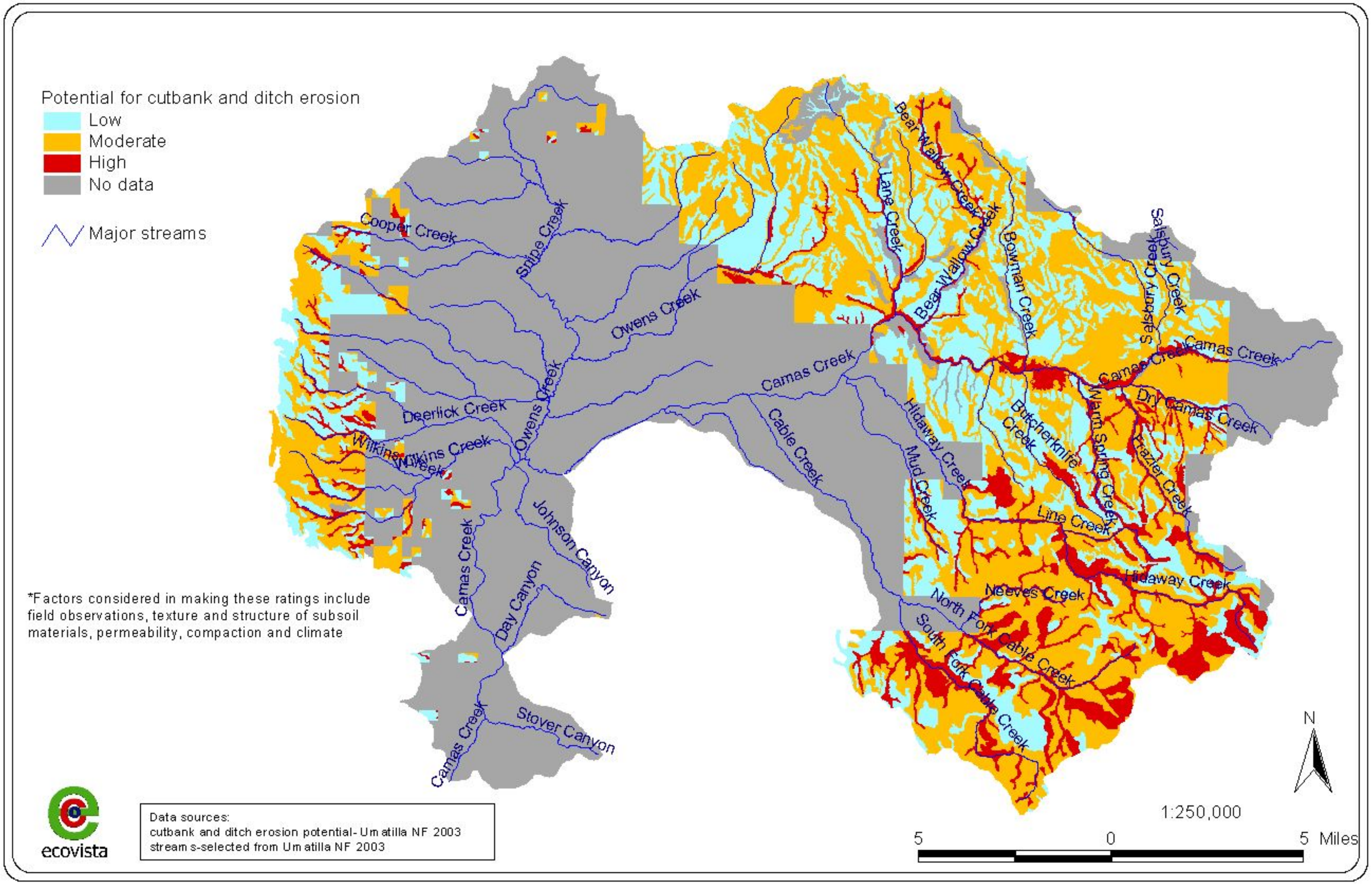

Figure 41. Potential for cutbank and ditch erosion on National Forest lands within the Camas Assessment Area (unpublished data, Umatilla National Forest, 2003)

Compaction

As mentioned previously, the ability of bedrock to store precipitation as groundwater is dependent to a large extent upon the infiltration capacity of the soil. Heavily compacted soils reduce the transmissivity of water to bedrock thereby reducing water availability to baseflows. Heavily compacted soils also act to focus runoff and precipitation on the surface of the ground, thereby increasing the potential for surface erosion. Figure 42 shows the susceptibility of the Camas Assessment Area, as it occurs on National Forest lands, to soil compaction. Areas most vulnerable to compaction occur in the Cable Creek and Hidaway subwatersheds, while those areas least susceptible to compaction occur in the Lane and Bowman subwatersheds.

Subsoil Erosion

Similar to knowing where soil compaction may be an issue, it is also important to define areas potentially susceptible to subsoil erosion. Subsoil erosion occurs when water finds cracks or fissures in compacted soils, percolates down to the underlying strata, and causes a loss of soil cohesion. This is much like liquefaction which turns the earth into a fluid mass. Subsoil material has more clay, less organic matter, lower available water-holding capacity and lower fertility status. Also, the soil structure is likely to be coarser, less stable and subject to more damage by rainfall impact, or land use disturbance. Because this kind of slope destabilization is less visible, it is often overlooked. Only permanent plants that have a network of deep, fibrous roots can improve stability at vulnerable sites.

The aquatic implications associated with the loss of this important material include a reduction in pool volume, destabilization of stream banks, a reduction in usable substrate, increased thermal loading, and a reduction of potential food sources. Subsoil erosion may also affect riparian and upland vegetation regeneration potential by reducing the available rooting substrate and eventually reducing nutrient availability.

Although much of the study area lacks data, relative comparisons of subwatersheds for which subsoil erosion potential has been estimated suggest that the Bowman and Lane Creek areas have the highest potential while the Cable Creek subwatershed is least susceptible (Figure 43).

Mass Wasting Erosion

Mass movement of soil via slumps or landslides is a form of erosion that may have particularly deleterious effects to aquatic environments. Several classifications of mass movements are distinguishable based on their mechanisms of movement. Among the most prevalent are slides, planar failures (debris slides), rotational failures (slumps), flows, debris avalanches, debris flows, and soil creep.

Soil susceptibility to slumps and landslides in the Camas Assessment Area is shown in Figure 44. By and large, the Camas Drainage is not highly susceptible to mass wasting. The least stable landforms are associated with the Mesic Forest Zone (Cable & Hidaway).

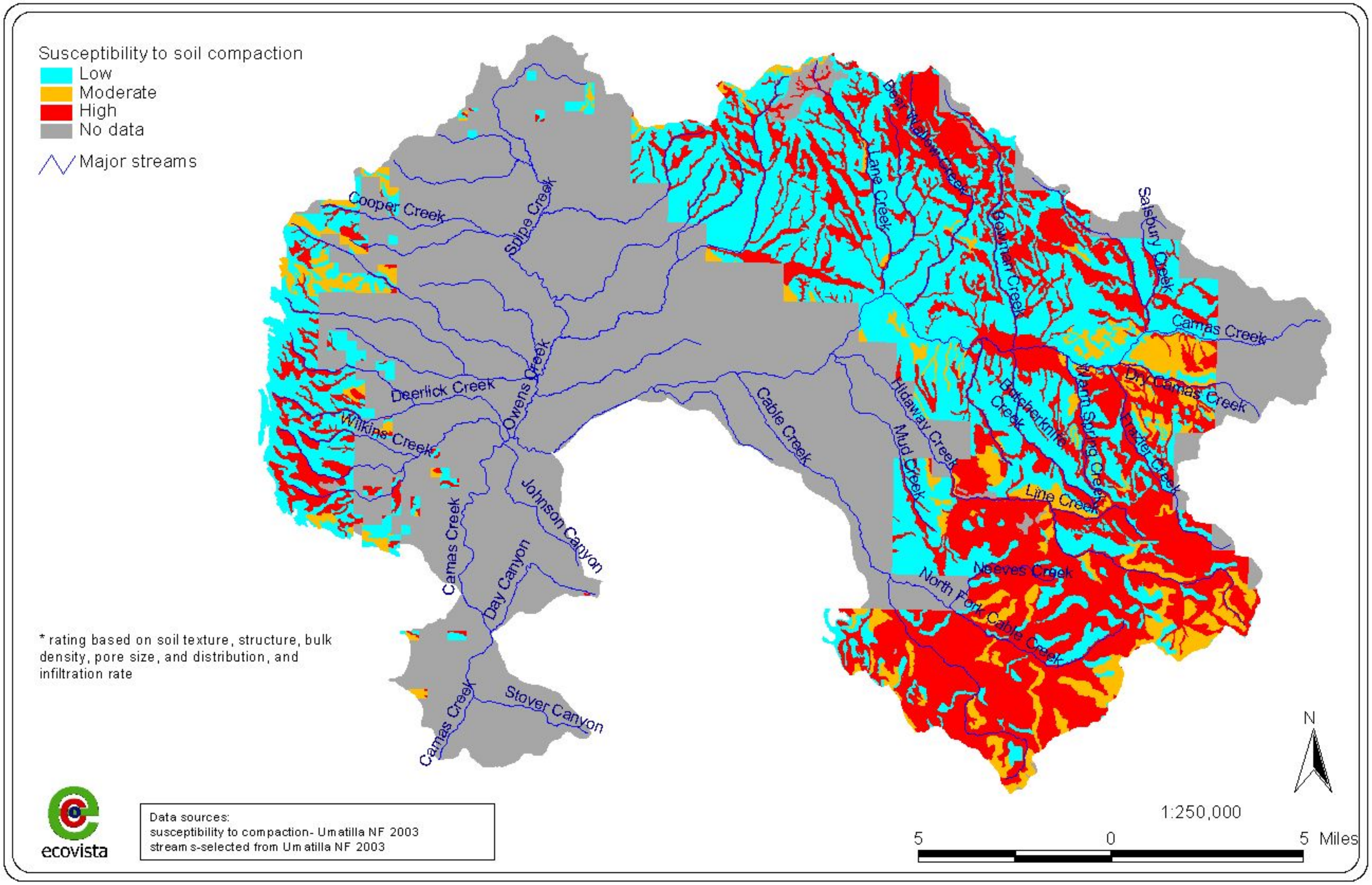

Figure 42. Susceptibility of the Camas Assessment Area to soil compaction (unpublished data, Umatilla National Forest, 2003)

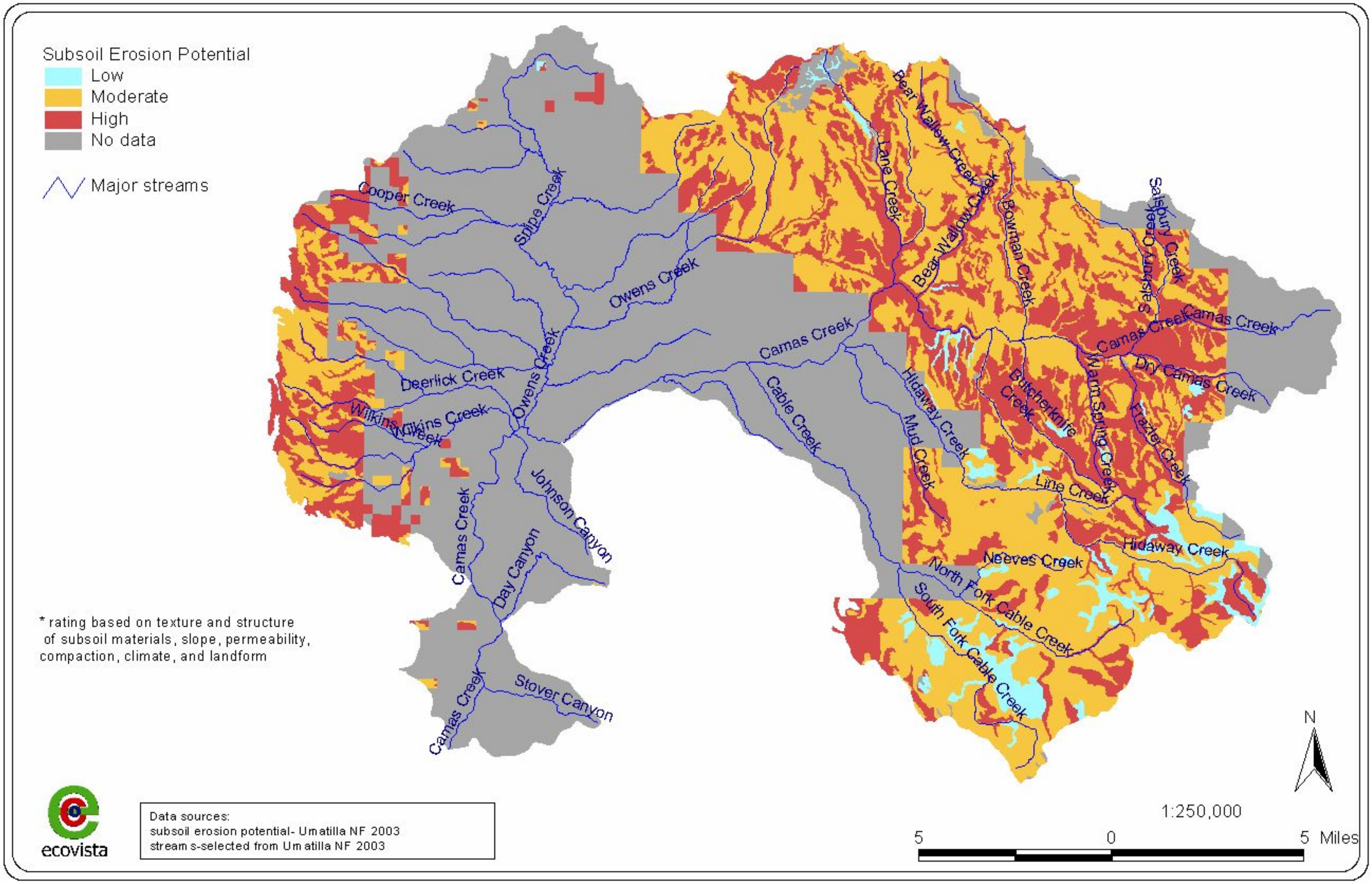

Figure 43. Susceptibility of the Camas Assessment Area to subsoil erosion (unpublished data, Umatilla National Forest, 2003)

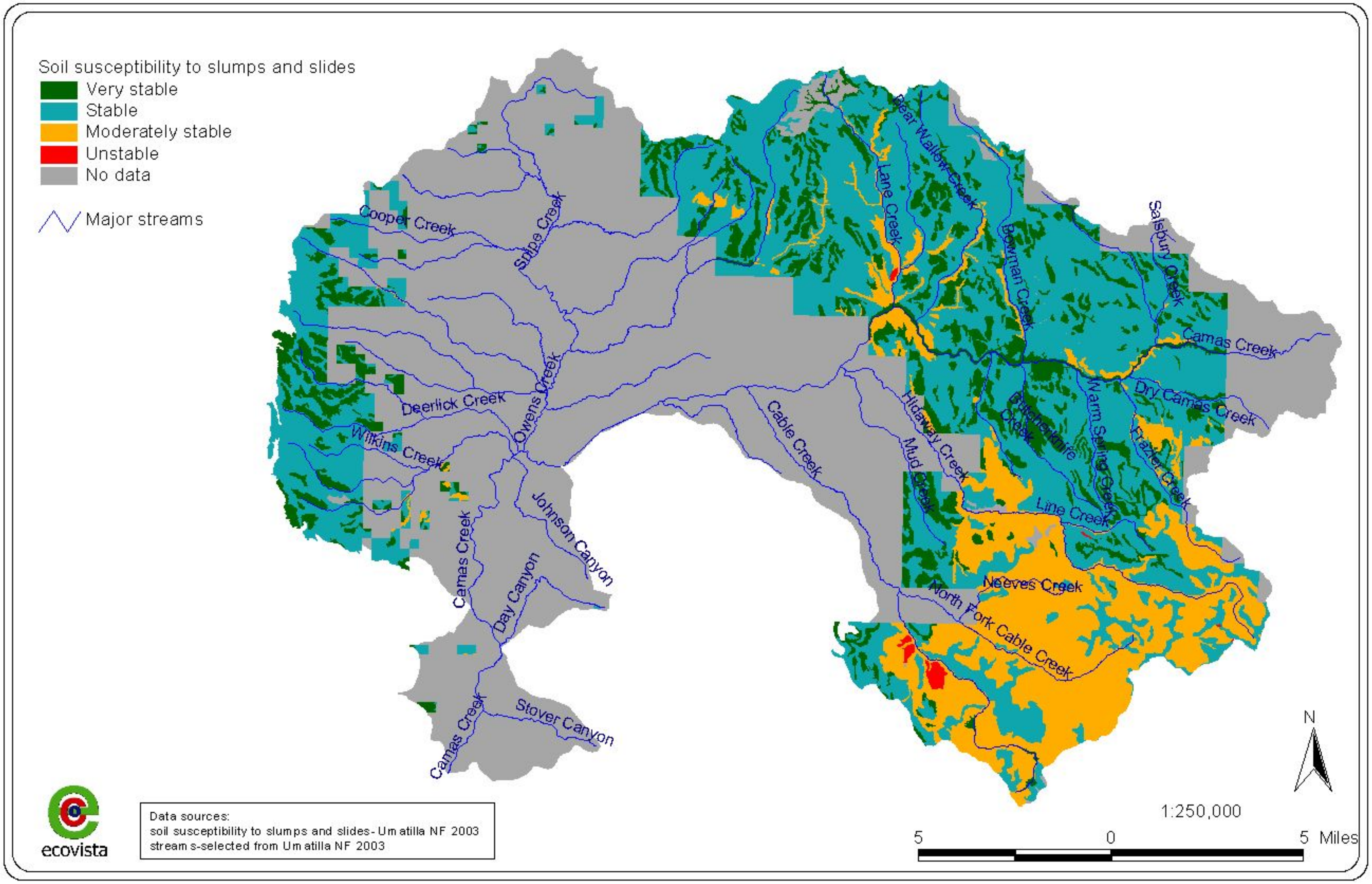

Figure 44. Mass wasting potential in the Camas Assessment Area (unpublished data, Umatilla National Forest, 2003)

Surface Erosion

Surface erosion is the movement of individual soil particles by a force, either by uniform removal of material from the soil surface (sheet erosion) or by concentrated removal of material in the downslope direction (rill erosion) or gravity inducted (dry ravel) or by mass movement as landslides and debris flows (Brooks et al. 1991). Inherent erosion hazards are defined as the site properties that influence erosion. They include the ease with which the individual soil particles are detached (soil erodibility), slope gradient and length. Forces required to initiate and sustain the movement of soil particles can be from many sources, such as raindrop impact, overland flow, gravity, wind, and animal activity (McGreer et al. 1998). Protection is provided by all material on or above the soil surface, such as vegetation, surface litter, duff, and rocks that reduce the impact of the applied forces (Megahan and Kidd 1972).

An analysis of surface erosion potential is shown in Figure 45. The assessment is based on expected losses of surface soil when all vegetative cover, including litter, is removed. Evaluations of climate, slope, gradient and length, soil characteristics, hydrologic characteristics of the soil and bedrock materials of each landtype unit are considered in rating derivations.

There is a high potential for surface erosion throughout the majority of the study area. Exceptions occur in the Cable and Hidaway subwatersheds which are characterized by moderate erosion potential. Because of the methods of derivation, it is important to keep the analysis in perspective since the erosion potential is pertinent to bare ground only. However, it is also important to realize that the Camas landscape is inherently erodible and that land uses which remove protective material are likely to affect erosion processes in most areas they occur.

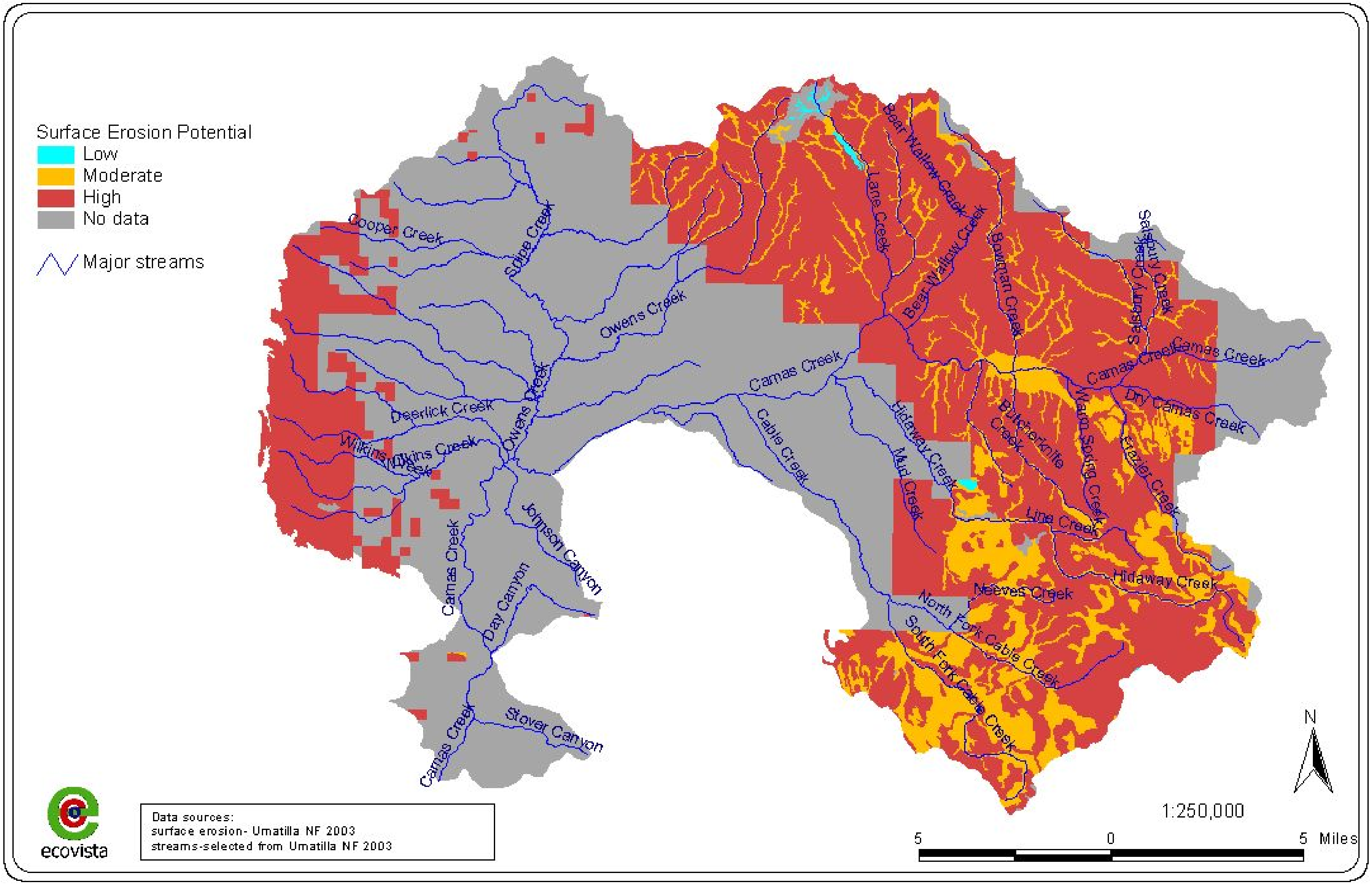

Figure 45. Surface erosion potential in the Camas Assessment Area

6 Historical and Current Context for Issues

6.1 Natural Disturbance Pressures

The primary natural disturbance pressures acting upon aquatic environments in the Camas Assessment Area are flooding and fire. These processes may operate separately or in combination to create limiting habitat characteristics in a particular stream section or system. Human activities in the stream and its parent watershed may profoundly affect these events, their frequency, and their magnitude.

6.1.1 Storm Events and Flooding

Several intense rain storms during 1996 caused widespread flooding in eastern Oregon and throughout the Pacific Northwest. Moist subtropical air masses brought record-setting rainfall on several occasions. The rain, coupled with significant snow melt and substantial runoff from saturated soil, pushed some stream levels above all-time crests. In addition, numerous landslides and mudslides occurred; these destroyed homes and roads, caused significant property damage, inundated stream channels, and killed several people.

In the Camas Assessment Area, the 1996 storm events were substantial, but due to the location of the drainage (at the margin of the ROS zone) and the comparatively subdued topography, the Camas Drainage and associated tributaries received less impact than other areas throughout the Pacific Northwest. In terms of storm magnitude, the monthly precipitation extreme for December 1996 is ranked number one, when compared to other December precipitation extremes for the period of record (refer to Table 6).

As discussed in Section 5.1, the frequency and magnitude of flooding in the study area has not changed appreciably over time, nor has the timing at which flood events occur. The results from these analyses are surprising based on the changes that have occurred in the watershed (i.e. vegetation removal, roading, channel modifications) and the effects the changes theoretically would have upon flood flows. In the absence of a more detailed study, it is reasonable to assume that the lack of changes in frequency and magnitude of flooding in the study area may be due to 1) precipitation characteristics having a greater influence upon runoff than vegetation, and/or 2) the compensating effects of timber harvest and fire exclusion.

6.1.2 Fire

Fire is a natural and important part of the disturbance regime for forested terrestrial and aquatic systems, especially in the western USA (Agee 1993). However, much uncertainty exists in quantifying fire effects on ecosystem components such as watershed condition and health.

The effects of fire, as they relate to aquatic habitat condition, are most problematic following the reduction and/or elimination of bank-stabilizing vegetation. Precipitation events after forest fires may cause high sediment inputs, destruction of aquatic habitat and downstream flooding, all which may be part of the natural ecosystem response. However, if the fires are more severe due to past fire suppression activities, then the fire effects may be greater than natural. Fire and erosion are both natural processes that have been impacted by forest management activities such as fire suppression, logging, and road building during the last century. Management activities may contribute to increased streamflows and increased sediment supplies to streams and rivers. Additional sediment places streams and rivers at a higher risk for degradation.

The effects of wildfire on aquatic environments in the Camas have not been studied. It is clear however, that higher intensity fires will have a greater effect on surface erosion processes than low intensity fires, and may subsequently pose a greater risk to the sediment transport capacity of stream systems occurring in these areas. Based on recent wildfire locations within the study area (Figure 46), these effects may be greatest in the Hidaway and Cable subwatersheds however intensity levels are unknown.

Fire risk in the Camas Assessment Area has been estimated by the UNF (Umatilla National Forest 1995). Subwatersheds in the assessment area considered to have a high priority for fuel treatment to mitigate for large fire potential include the upper portion of Owens, Lane Creek, Bowman Creek, and the Camas/Wilkins subwatershed.

6.2 Anthropogenic Disturbance Pressures

Road construction and maintenance, grazing, and timber harvest are the primary land use activities in the Camas Assessment Area based on available land types. High road densities, grazing in riparian areas, and high percentages of harvested watershed are cited as land use activities of primary concern to aquatic/riparian resource conditions in the Camas (Umatilla National Forest 1995).

6.2.1 Road Construction and Maintenance

Road construction and maintenance can affect streams directly by accelerating erosion and sediment loading, altering morphology, and changing watershed runoff characteristics (Furniss et al. 1991). As discussed previously, these changes may additionally act upon natural erosion and channel forming processes to cause secondary impacts to habitat quality and quantity.

Road construction and maintenance in the Camas Assessment Area is identified as a primary limiting factor to aquatic habitat and biota in the Camas Drainage. Road densities throughout the watershed are high, as nearly half of all subwatersheds have densities in excess of 4 miles per square mile. Based on total road densities, the Bowman, Hidaway, and Lane Creek subwatersheds are among those most likely to exhibit instream effects of roads (Figure 48). Streams that are least likely to manifest effects from roads include those occurring within the Lower Camas, Lower Owens, and Snipe subwatersheds.

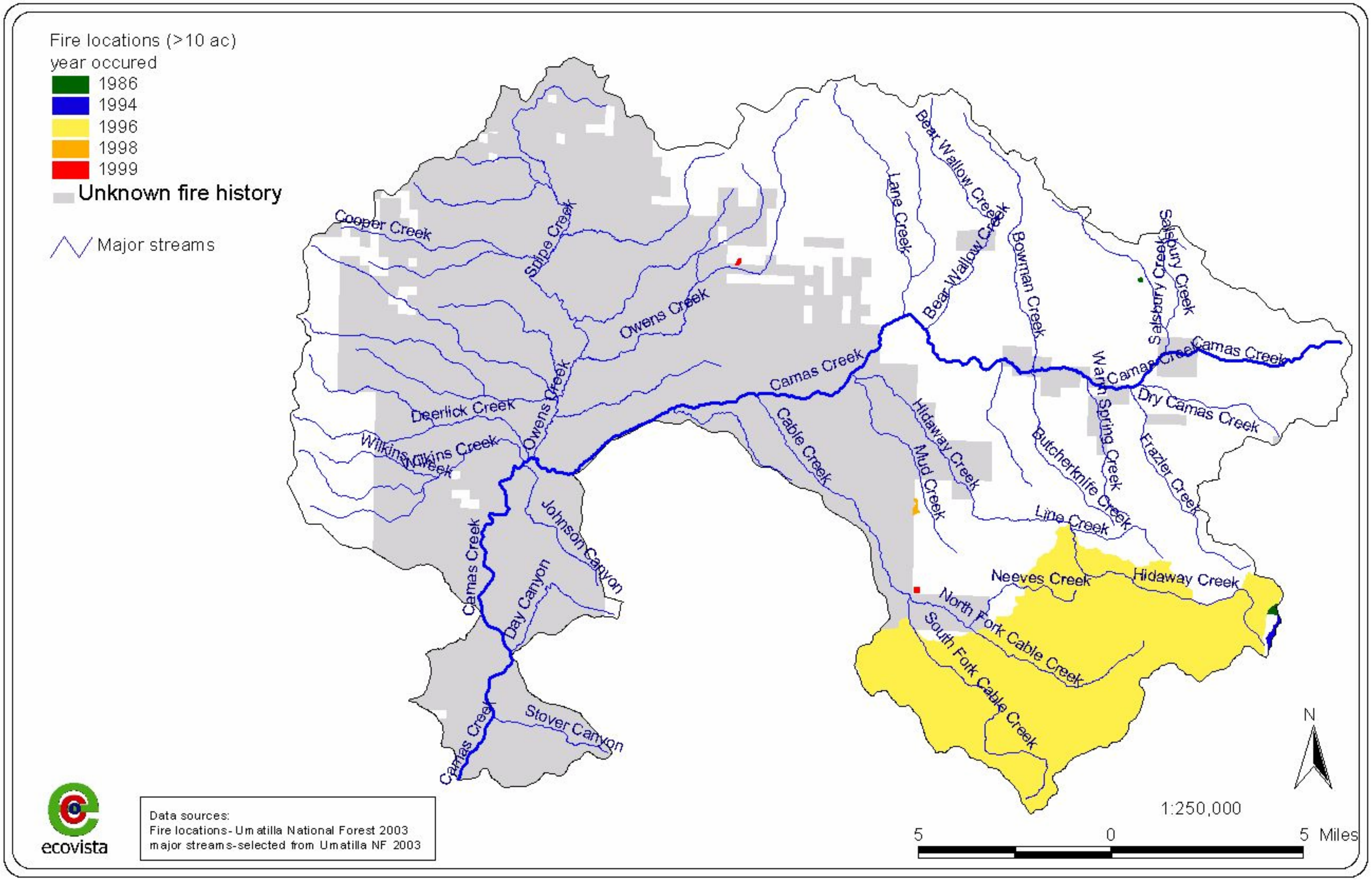

Figure 46. Locations of recent wildfires greater than ten acres in the Camas Assessment Area (unpublished data, Umatilla National Forest, 2003)

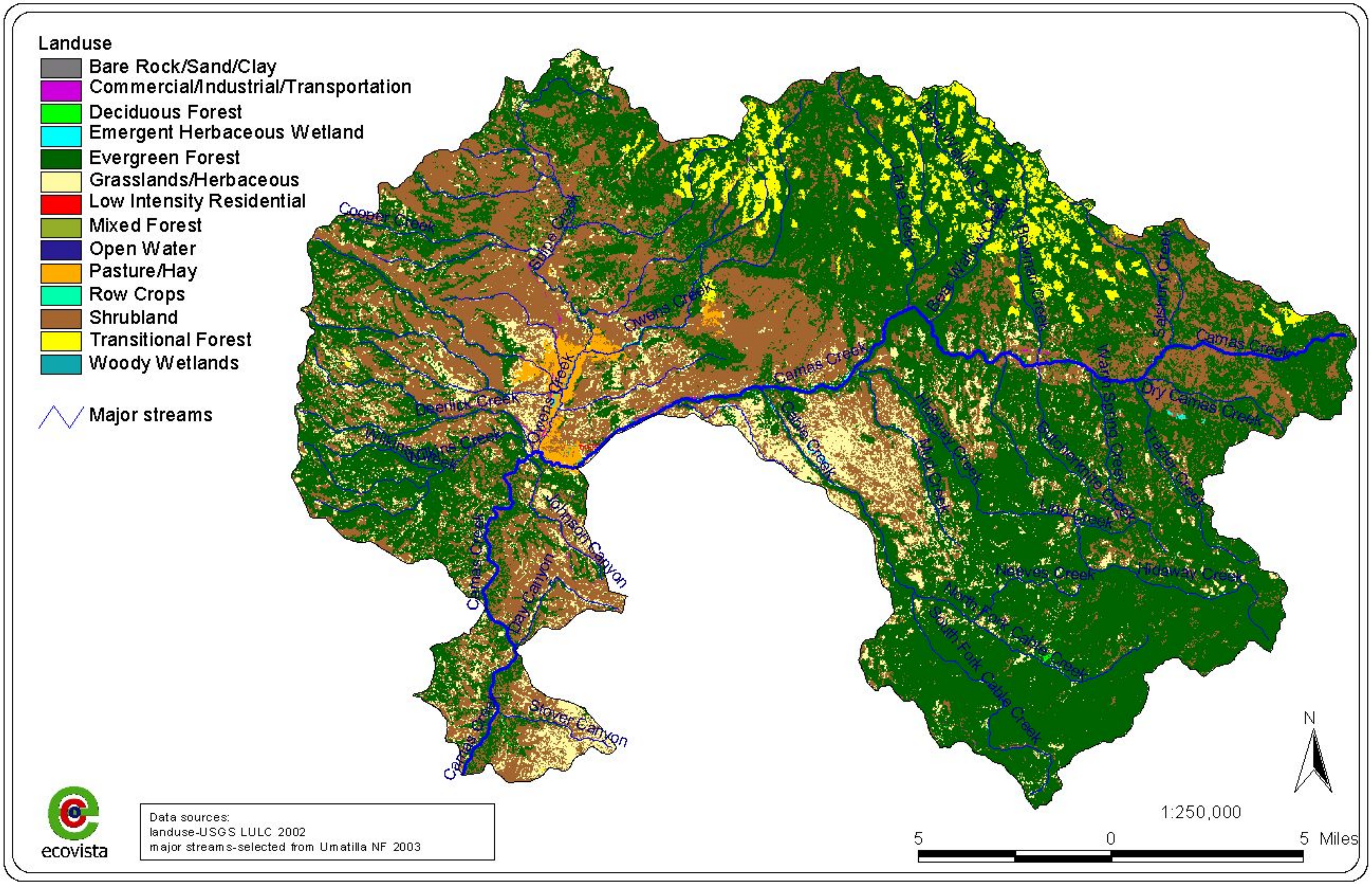

Figure 47. Land types used to define land use activities in the Camas Assessment Area

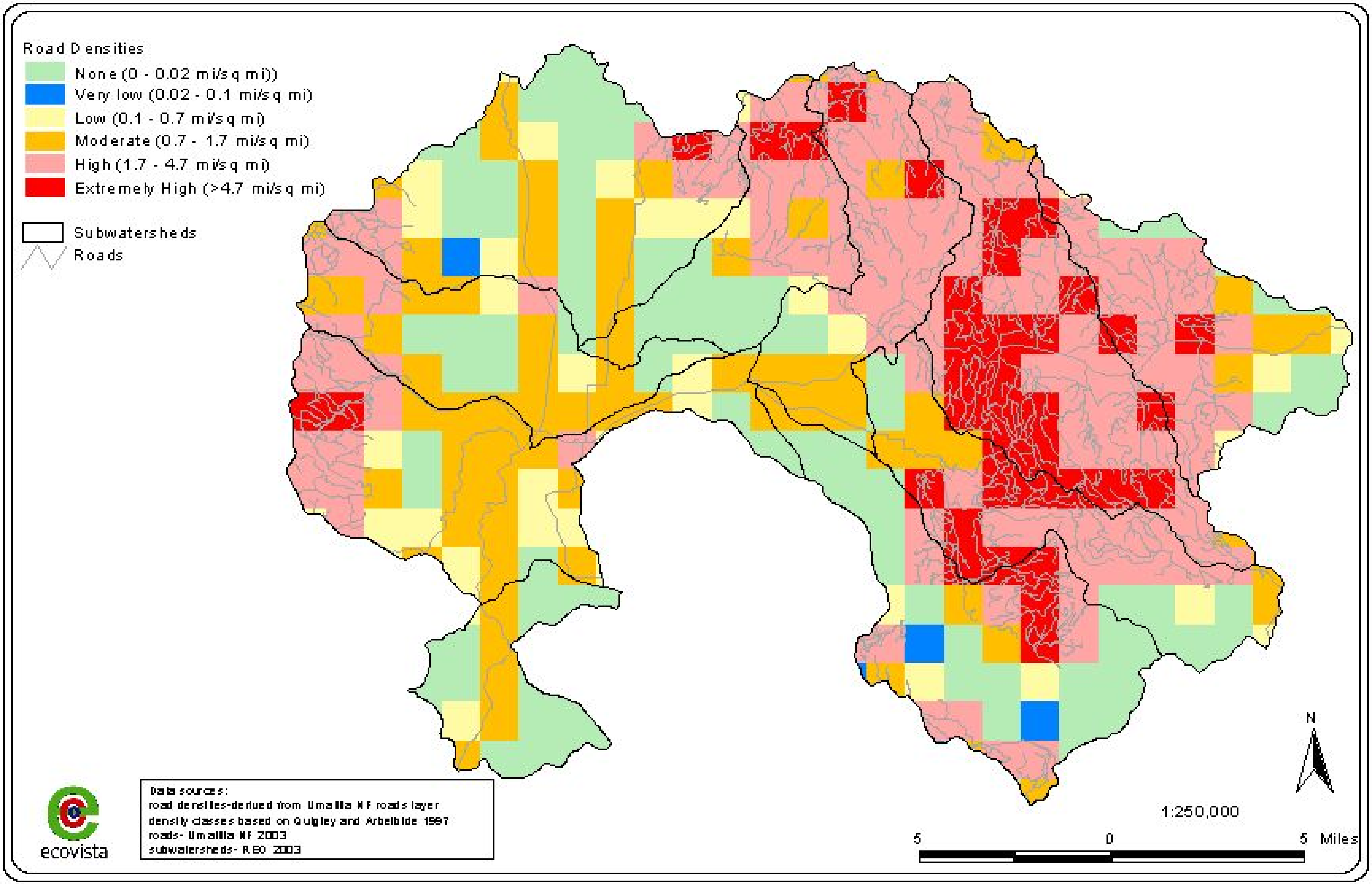

Figure 48. Total road densities for subwatersheds within the Camas Assessment Area

Many of the roads on National Forest lands have been closed, or are seasonally open during winter months (Figure 51; Table 44**Error! Reference source not found.**). Most road closures have occurred due to wildlife management concerns (Umatilla National Forest 1995).

Table 44. Road status for subwatersheds within the Camas Assessment Area

Subwatershed	Subwatershed area (miles^2)	Closed roads (miles)	Roads closed to ATVs (miles)	Open roads (miles)	Roads with seasonal closure 12/1-4/31 (miles)	Roads with seasonal closure 12/1-4/15 (miles)	Total Road (miles)	Road Density (mi/mi sq)
Bowman	69.5	123.0	11.0	99.9	18.0		251.9	3.6
Cable	37.9	42.9		22.3	2.2		67.5	1.8
Camas/Wilkins	39.0	21.0		49.3			70.3	1.8
Hidaway	30.0	53.7	2.6	22.4	3.9		82.6	2.8
Lane	26.1	34.7	4.1	31.3	0.3		70.4	2.7
Lower Camas	15.0			5.5			5.5	0.4
Lower Owens	25.8	9.6		17.5		0.1	27.1	1.1
Snipe	43.1	17.4		23.5	4.3	2.3	47.5	1.1
Upper Owens	21.7	16.4		23.3	0.2		39.9	1.8
Total	**308**	**318.7**	**17.7**	**295.0**	**28.8**	**2.4**	**662.6**	**2.2**

1/ Roads are closed to ATVs but open to other motor vehicles (miles)

Although total road density by subwatershed provides a reasonable indication of those aquatic areas most likely to experience roading impacts, the location of roads relative to stream channels is equally important. The UNF assessed the number of roads that occur within 150 feet of stream channels on Forest lands in the Camas and found that the highest streamside road densities occur in the Snipe subwatershed and the lowest densities occur in the Lower Camas subwatershed (Umatilla National Forest 1995).

Table 45. Streamside ($\leq$ 150 ft. from channel) road length, density, and rank by subwatershed on National Forest lands in the Camas Assessment Area (Umatilla National Forest 1995)

Subwatershed	Total Riparian Road Length (mi)	Area (mi^2)	Road Density (mi/mi^2)	Rank†
Bowman	237	55.1	4.30	3
Cable	69	28.5	2.41	2
Camas/Wilkins	40	9.4	4.28	3
Hidaway	75	23.4	3.20	2
Lane	58	16.6	3.50	2
Lower Camas	0	0.1	0.00	1
Lower Owens	12	2.8	4.21	3
Snipe	27	5.6	4.82	3
Upper Owens	33	10.0	3.27	2

† 1= (0 – 2 mi/mi^2); 2 = (2 – 4 mi/mi^2); 3 = (4 – 6 mi/mi^2)

One of the most significant streamside roads is Highway 244, which parallels the majority of the mainstem Camas. Highway 244 was originally a county (Umatilla and Union Counties) road before the Oregon Department of Transportation (ODOT) assumed maintenance responsibilities in 1931. The road surface remained gravel until 1956 when it received its first oil job (Brown 2003). The ODOT maintained the oiled surface for 19 years, prior to its paving in 1977. The UNF states that the original east-west highway route between Camas Spring and Ukiah was primarily on the uplands adjacent to the mainstem canyon (Umatilla National Forest 1995).

The construction and maintenance of Highway 244 resulted in a loss of channel sinuosity and complexity (Umatilla National Forest 1995). A total of nineteen sections of the mainstem are defined as being channelized, which has contributed to an increase in channel gradient and erosion (Umatilla National Forest 1995). As discussed previously (*refer to* page 82), the result of mainstem channelization may be affecting bedload transport and deposition, and may be partially responsible for continuing damage to private land and restoration efforts.

6.2.2 Timber Harvest

Timber harvest in the Camas Drainage was historically low but increased in the 1930s. Technological advancements and development of a transportation infrastructure allowed companies to selectively access timber, including large pine (Umatilla National Forest 1995). Approximately 80 square miles of land in the northeast portion of the subbasin (Bowman Creek subwatershed) was selectively harvested over a 30-year period (1939 – 1969), removing an estimated 290 MBF of ponderosa pine, and a large percentage of the old growth yellow pine that once dominated the area (Umatilla National Forest 1995).

Timber continues to be harvested from federal and private lands, albeit at levels significantly lower than historic. Harvest locations throughout the Camas have varied, but have consistently occurred in the Fivemile subwatershed (not in this analysis area), the Hidaway subwatershed, the Bowman subwatershed, and the Upper Owens subwatershed (Figure 49). Percentage of riparian timber harvested from various subwatersheds is shown in Table 46. USFS harvest records predating the early 1970s are limited, as is data for private lands, causing an underestimation of total subbasin harvest percentages. Total acreage of USFS lands in the study area that were harvested between 1973 and 1990 is shown in Figure 50.

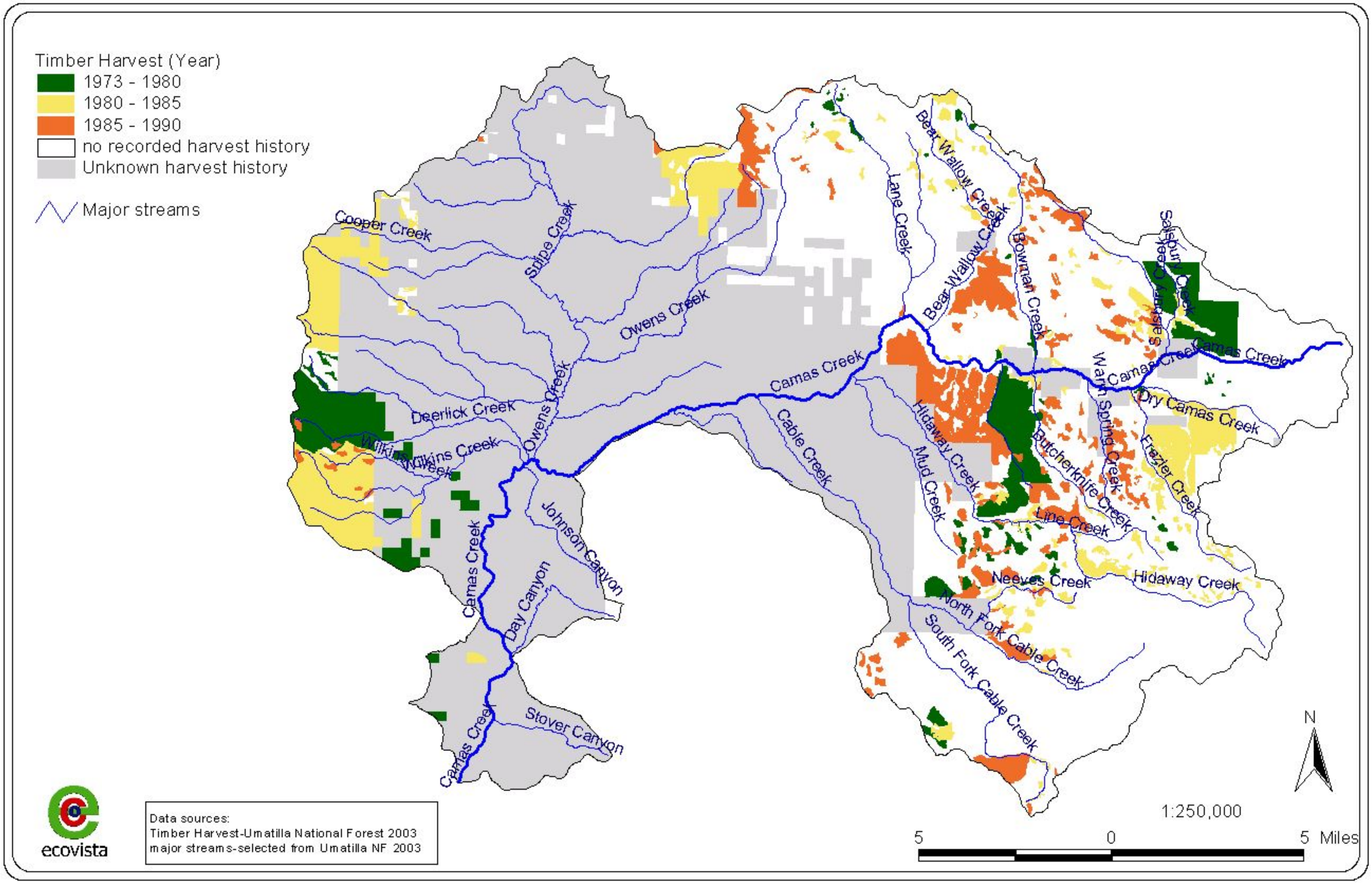

Figure 49. Recent (1979 – 1990) timber harvest on National Forest lands occurring within the Camas Assessment Area

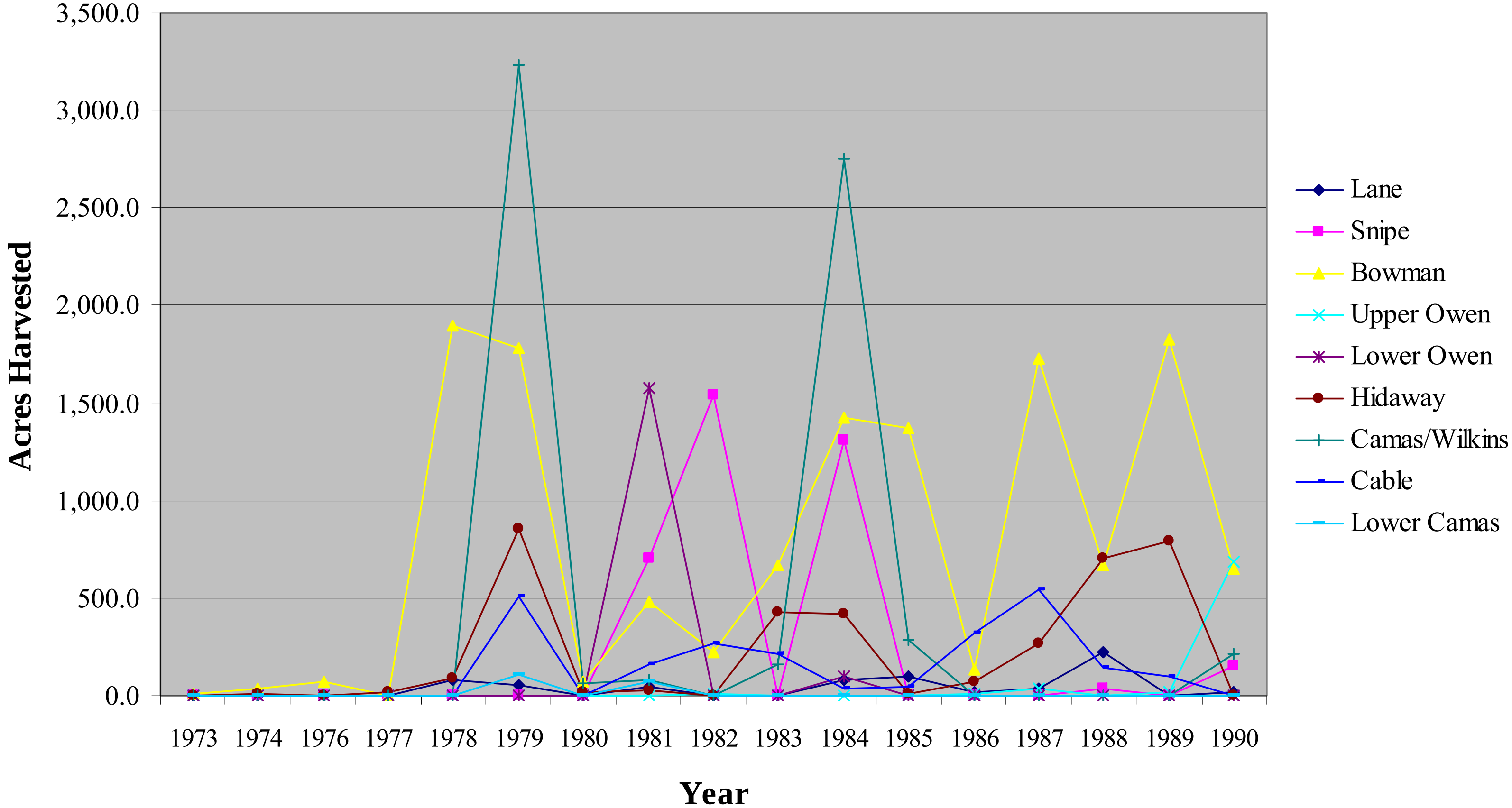

Figure 50. Acreage harvested on USFS lands as they occur relative to the Camas Assessment Area

Table 46. Riparian timber harvest within 150 feet of perennial streams (Umatilla National Forest 1995)

Subwatershed	Riparian Timber (acres)	Percentage Harvested	Rank†
Lane	53.0	10.0	1
Snipe	23.0	100.0	3
Bowman	898.0	34.2	3
Upper Owen	48.0	56.0	3
Lower Owen	16.0	59.0	3
Hidaway	189.0	29.0	2
Camas/Wilkins	0.0	0.0	1
Cable	504.0	37.8	3
Lower Camas	0.0	0.0	1

† 1 = (0 – 15%); 2 = (16 – 30%); 3 = (≥31%)

6.2.3 Grazing

Livestock grazing has occurred in the Camas for well over a century. The effects of historic grazing are still evident today due to the intensity at which lands were grazed. Near the turn of the century, Umatilla County boasted nearly 300,000 sheep as well as thousands of cattle and horses, most of which were grazed open range. Allotments were eventually established, but were not effectively managed for rangeland conservation until the passage of the Taylor Grazing Act in 1934. Prior to the passage of the act, many wetland and meadow areas were used as watering sites, which in some areas, caused irreparable damage (Umatilla National Forest 1995). It wasn't until the 1960s that upland range conditions started showing signs of improvement, however riparian grazing continued. In the 1970s concern for the effects of grazing in riparian areas began to develop, which issued proactive management by the USFS in the following two decades.

Currently, an estimated 40 percent of USFS land is deemed suitable for livestock grazing. Allotments on federal lands include Matlock, Texas Bar, Cunningham, Hidaway, and Lucky Strike (Figure 52). Seven term-grazing permits and six on/off permits exist on USFS lands, accommodating around 10,750 animal unit months (Umatilla National Forest 1995).

Grazing is cited as a contributing factor to the high stream temperatures common throughout the drainage (Umatilla National Forest 1995). Although not evident from hydrologic analysis, grazing effects may also be altering the groundwater storage capacity in some areas of the Camas thereby contributing to unnaturally low baseflow levels and indirect high temperatures. Grazing-related soil compaction has been documented in many of the wet meadow areas, causing reductions in soil permeability and infiltration capacity (Umatilla National Forest 1995).

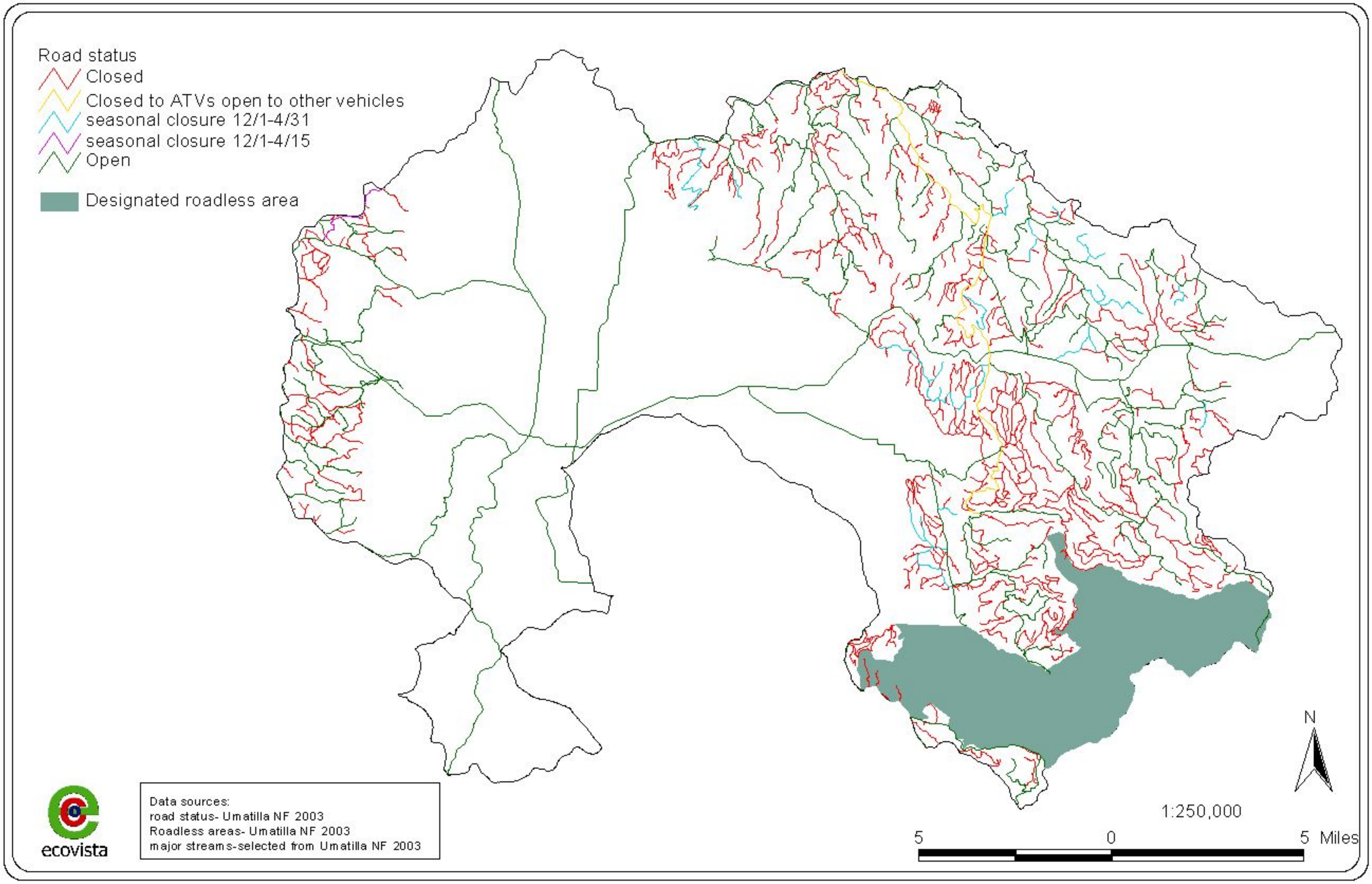

Figure 51. Open/closed status of roads in the Camas Assessment Area

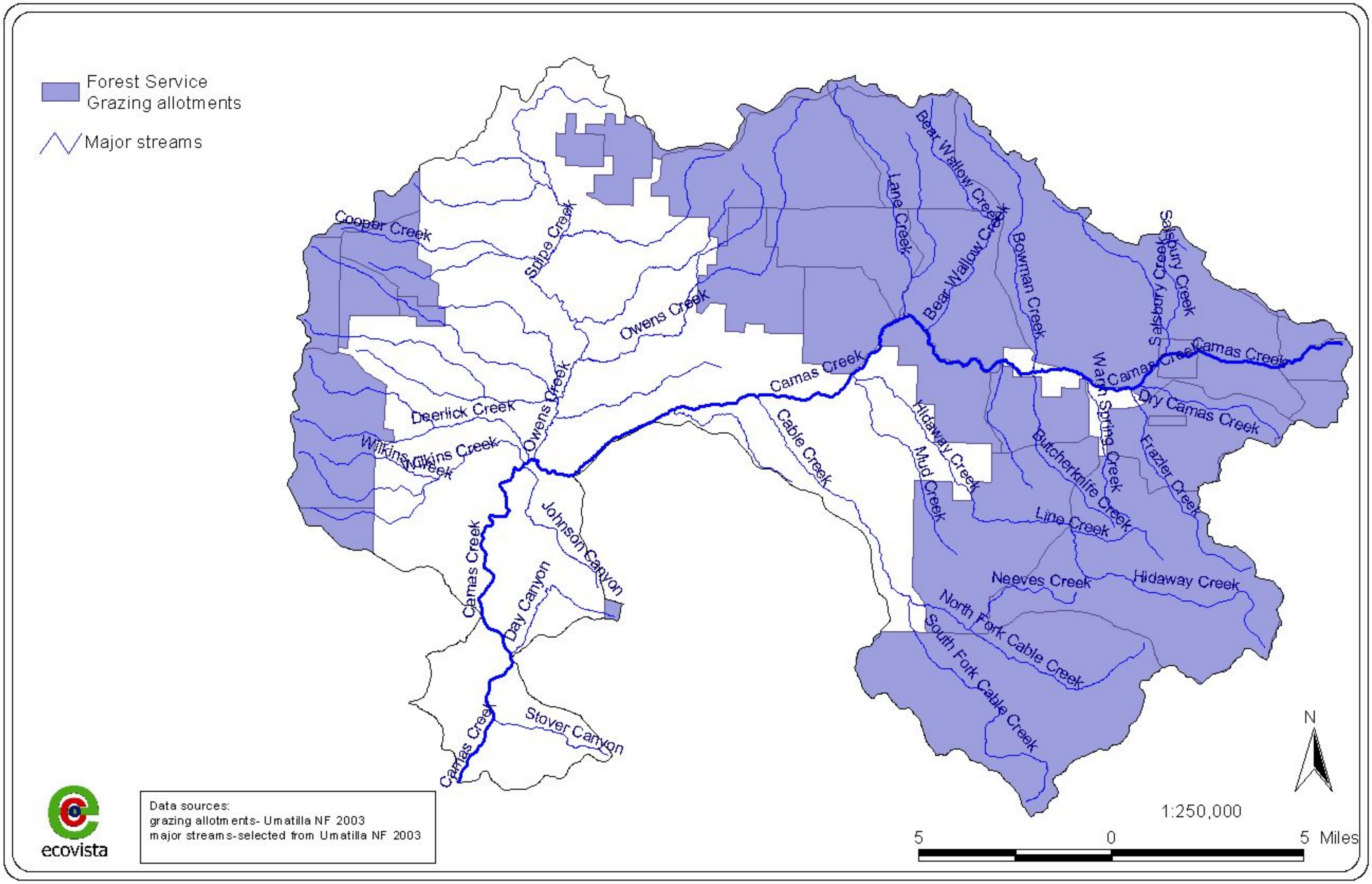

Figure 52. Grazing allotments on USFS land in the Camas Assessment Area

Data from utilization surveys and livestock exclosures indicate that hardwood growth and recruitment has been suppressed from grazing by both livestock and big game (Umatilla National Forest 1995). Current increases in population densities of wild ungulates from pre-1900s levels is suspected to have increased competition with domestic livestock for riparian resources, ultimately slowing riparian recovery efforts (Umatilla National Forest 1995).

7 Inventory

The following summary of ongoing fisheries-related projects and programs is taken from the John Day Subbasin Summary that was produced as part of the Northwest Power and Conservation Council (Knapp 2001). BPA-funded projects are presented separately from non-BPA projects. Only those projects pertinent to the Camas Assessment Area (or subbasin-wide projects) are listed.

BPA-Funded Past/On-Going Projects   Source: (Knapp 2001)

Proj #	Organization	Type of Project	Date	Location	Summary
20003100	CTUIR, NRCS, USFS, ODFW, NMFS, NF Watershed Council, CTWSRO, and SWCDs	protecting and enhancing habitat for improved natural production of wild Chinook salmon and steelhead stocks		North Fork John Day	installing riparian fencing, developing off-stream water sources, conducting instream work, mechanical bank stabilization, bioengineered stream structures, channel reconfiguration, and vegetation planting.
Results: Unknown					
9303800	USFS	enhancing fish habit by restoring riparian vegetation and ecosystem function in areas impacted by grazing	1993+	North Fork John Day	fences constructed to control cattle and sheep grazing in riparian areas
Results: About 76 miles of seasonal electric livestock exclosure fence has been constructed. Monitoring results indicate that the fences are 98% effective in excluding livestock.					
9801800	USBR, CTWSRO, GSWCD	Water conservation/ flow improvement Passage improvement land acquisition demonstration	ongoing	Entire John Day Basin	Return flow cooling, Replace flood irrigation and open systems with sprinkler and closed systems, Pushup dams replaced with pumping systems, infiltration galleries and permanent diversions, Land acquisition and conservation easements, Seasonal corridor fencing, beaver management, and native plant nurseries
Results: Implementation activities completed. This program has received considerable recognition for its effectiveness and ability to maximize on-the-ground achievements.					

Non-BPA Funded Past/On-Going Projects Source: (Knapp 2001)

Organization	Type of Project	Date	Location	Summary
ODFW (funded by OWEB via grant to OWRD)	Stream flow restoration prioritization	1999	Entire John Day Basin	Prioritized stream flow restoration needs based on: physical/biological factors, water use patterns and restoration optimism; identified measures include: transfers and leases to in-stream uses, cancelled water rights, enforcement and monitoring, improved diversion methods, stream inventories, conservation planning, improved efficiencies, and measurement and reporting of use
Results: Unknown				
Oregon State Police	Enforce laws and regulations		Oregon	actions include monitoring anglers for illegal harvest and licensing requirements and responding to natural resource violations regarding fish passage and habitat protection. Lower river monitoring reflects harvest of hatchery stray steelhead
Results: Unknown				
Bridge Creek Watershed Council	monitoring		Uplands John Day River Basin	volunteer monitoring of upland projects using photographs
Results: Unknown				
John Day Bull Trout Recovery Team	Bull Trout Recovery		Entire John Day Subbasin	Strategies for bull trout recovery are currently being drafted besides the placement of angling regulations in 1994, instream water rights for bull trout have been issued for 24 streams or stream reaches
Results: Unknown				
Umatilla NF, North Fork John Day RD		1998	Bear Wallow Creek	Cattle exclosure fence
Results: Unknown				
Umatilla NF, North Fork John Day RD		1997	Little Indian, Butcherknife Spring, Sugarbowl, Taylor, Smith, Park, and Dry Camas creeks	Riparian exclosures to exclude livestock access
Results: Unknown				
Umatilla NF, North Fork John Day RD		1997	South Cable Creek	Road obliteration and recontouring
Results: Unknown				

Organization	Type of Project	Date	Location	Summary
Umatilla NF, North Fork John Day RD		1997	Deer Lick Creek	Buck and pole aspen exclosure
Results: Unknown				
Umatilla NF, North Fork John Day RD		1993	Camas, Bear Wallow, Lane, Clear, Butcherknife Sugar Bowl, Dry Camas, Taylor Creeks and NFJD River	4,786 black cottonwood, willow, ponderosa pine, and alder seedlings planted
Results: Unknown				
Umatilla NF, North Fork John Day RD		1993	Kelsay, Sponge, Desolation, Indian, Bruin, Cable, Hidaway, Dry Camas, Morsay, Sugar Bowl, Taylor, Tribble, Matlock, Smith, Hinton, Bear Wallow, Squaw, and Owens creeks and Albee Meadows	Livestock fencing exclosures were constructed to protect 33 miles of riparian habitat
Results: Unknown				

BPA Funded Past/On-Going Studies Source: (Knapp 2001)

Organization	Project No.	Study	Date	Location	Summary
ODFW	*7900400*	Wild Spring Chinook Salmon Life history Natural escapement	1978-1985	Entire John Day River	information on production and productivity of the John Day spring Chinook and determined timing of migration
Results: recommended escapement levels for harvest regulations, determination of necessary operational changes at Columbia River dams to increase survival of John Day migrants, recommended habitat improvements to increase smolt production within the basin.					
ODFW	*980160*	Spring Chinook Salmon Escapement Productivity	1998-Present	Entire John Day Basin	annual estimates of spring Chinook spawner escapement, age-structure, productivity, and smolt-to-adult survival
Results: estimated number of spring Chinook escapement and redds for the entire basin, age composition, sex ratios, rearing origin.					
ODFW	9405400	Bull Trout Life history	1994+	Entire John Day Basin	determines status, life history, genetic, habitat needs, and limiting factors for bull trout populations
Results: Documentation of bull trout movement and age composition; population estimates in the Middle Fork and distribution in Middle Fork tributaries, and genetic profiling.					
CTUIR, ODFW	8201000	Salmon		Umatilla Reservation	compile a database, develop priorities, and recommend initiatives for a coordinated approach to restore and enhance anadromous fish
Results: Information was used to identify, evaluate, prioritize, and recommend site-specific solutions to major problems affecting the salmon resource.					
ODFW		Genetic Profiling			several studies have been completed on summer steelhead and westslope cutthroat trout
Results: Unknown					
ODFW		Habitat inventories		Middle, North Fork and main stem John Day River	Habitat and fish production surveys have been conducted for bull trout surveys and westslope cuttroat trout; there are still large gaps in habitat surveys for summer steelhead.
Results: Unknown					
CTUIR	9402600	Pacific Lamprey Population	1998-present	Entire John Day Basin	assess status and survival limitations, examine physiochemical and micro and macro habitat factors affecting distribution and abundance
Results: Unknown					
US Geological Survey	2000052	Pacific Lampreys Upstream migration	2000+	Entire John Day Basin	provide documentation of life history strategies and habitat preferences to help identify factors limiting lamprey populations, identify areas in need of rehabilitation, and help to assess the efficacy of management actions
Results: Initial radio tracking has identified erratic movements with most movement in the fall, refuge areas, and passage problems at Tumwater Falls in the lower river.					

Organization	Project No.	Study	Date	Location	Summary
USFS, Pacific Northwest Research Station	9307000	Spring Chinook Salmon fresh water life history patterns and use of thermal refugia		Entire John Day Basin	using radio-tagged fish, GPS data enhanced accuracy of fish locations; thermal infrared videography examined the spatial variability of stream temperatures
Results: Mapping of cold-water habitats and documentation of use by spring Chinook. High stream temperatures limit the distribution of adult spring Chinook salmon in the John Day Basin.					
US Corps of Engineers	9204100	Assess the success of adult salmon and steelhead into tributaries	1996-2000	Lower Columbia and John Day River	evaluate specific flow and spill conditions on adult fish migration; provide data on which dam and system operations can be based to ensure adequate fish passage conditions
Results: Unknown					
ODFW	199602000	Comparative Survival Study		John Day River	Proposes the use of Smolt to Adult Survival Rates (SAR) from John Day River, wild stock for comparisons to Snake River stocks.
Results:					
Misc. Entities and Agencies	9106900	habitat projects meeting enhancement goals	1991	John Day River Basin	obtain specific recommendations for improving future projects
Results: Study concluded that habitat projects, particularly those for instream structure, did not always address the most critical limiting factors.					

Non-BPA Funded Past/On-Going Studies Source: (Knapp 2001)

Organization	Type of Study	Date	Location	Summary
OSU research studies	Effects of temperature on fish		John Day Subbasin	longitudinal temperature profiles and the effects of land use on those profiles
Results: Fish species richness was correlated to changes in longitudinal temperature profiles. Temperature signals indicate the value of riparian vegetation as a component of salmon habitat; human effects have reduced stream and floodplain interactions; grazing has compacted the soil and removed riparian vegetation. The capacity of meadows to contribute to the salmon food chain has been greatly reduced.				
OSU Adams et al.	bioeconomic study of habitat restoration	1993	John Day Subbasin	increased summer streamflow and reduced temperatures could increase fish use of habitats
Results: Unknown				
OSU Li et al.	sill/log weir emplacements	1992	Camp Creek	installation of log weirs did not address the critical problem and limiting factor of temperature
Results: Unknown				
OSU Beschta et al.	field review of stream enhancement	1991	John Day Subbasin	log weirs were not effective in increasing pool volume
Results: Unknown				
OSU Close et al.	status report of Pacific lamprey	1995	John Day Subbasin	
Results: Unknown				

Organization	Type of Study	Date	Location	Summary
OSU Torgersen et al.	adult spring Chinook salmon	1999	John Day Subbasin	quantified distribution and behavior related to stream temperature and physical habitat
Results: Unknown				
OSU Li et al.		1994	John Day Subbasin	cumulative effects of riparian disturbance by grazing on the trophic structure of streams
Results: Unknown				
OSU Li et al.	factors leading to salmonid recovery	2000	John Day Subbasin	characterized the status, integrity, and functioning of watersheds using temperature as an indicator
Results: Unknown				
OSU Tait et al.		1994	John Day Subbasin	influences of riparian cover on benthic community structure
Results: Unknown				
OSU Wissmar et al.		1994	John Day Subbasin	assessment and synopsis of human-caused disturbances on stream and riparian ecosystems
Results: Unknown				
OSU	Strategies for Riparian recovery	present	John Day Subbasin	Evaluate status of plant succession and its relationship to salmon
Results: Unknown				
OSU	Research/Evaluate Restoration of Streams		John Day Subbasin	evaluate passive and active restoration projects; establish future guidelines for restoring stream systems
Results: Unknown				
OWEB	Stream flow		John Day River	Establish streamflow restoration priorities in Columbia River tributaries

8 Limiting Factors

Numerous sources were reviewed for documentation of limiting factors at scales similar to the defined subwatersheds. Note that factors limiting local fish production or survival may differ from those defined across broader scales, and that limiting factors in a given location may vary between species. The information presented in Table 48 attempts to address these issues by summarizing limiting factors over areas of intermediate size for steelhead and chinook. It does not address factors found to limit fish production or survival in individual streams or stream reaches.

In order to comparatively assess conditions, limiting factor designations have been standardized. Limiting factors have been assigned a value of 1-3, depending on the degree to which they are thought to limit specific species within each subwatershed. A value of 3 indicates a principal or most influential limiting factor, whereas a value of 1 indicates a less influential factor limiting population(s). A value of 2 represents factors of intermediate influence on populations.

The limiting factor ratings presented in Table 48 are based on averages from multiple attributes (see Table 47). Each attribute that is averaged is also standardized based on the 1-3 scale. Attribute standardization was done by calculating the dominant percentage of a given subwatershed that fell into one of three predefined classes provided in each GIS dataset. For example, for the 'water yield' attribute, the total acreage of a given subwatershed was ranked as either 'high', 'moderate', or 'low' based on its water retention/storage capacity. Therefore, if 75% (or whichever category is dominant) of the given subwatershed was deemed to have 'high' water retention capacity, a final rating of '1' (1 being the least potentially adverse) was assigned. A 'total score' column is included to provide a relative comparison between subwatersheds.

The limiting factors table is stratified by subwatershed and applies to both steelhead and chinook. For steelhead, ratings from all subwatersheds apply due to the species' widespread distribution throughout the study area. For chinook, only ratings for mainstem subwatersheds apply due to the species somewhat restricted distribution. A textual discussion of limiting factors by subwatershed accompanies the limiting factors table.

Due to dataset limitations, the Limiting Factor analysis likely fails to address many issues that may be limiting steelhead and salmon in the Camas. For example, it was not possible to factor in habitat ratings for the entire assessment area since data was collected in only four of the ten subwatersheds. Similarly, not all subwatersheds that were evaluated had complete GIS coverages, thereby necessitating analyses on only those areas for which there were data. In light of these limitations, the limiting factors analysis presented in Table 48 should be considered to be only partially representative of factors that may be affecting the persistence of Camas steelhead and salmon.

Table 47. Limiting factors categories and attributes that were averaged to derive category ratings

Limiting Factor Category	Riparian Timber Harvest	Subwatershed Timber Harvest	Canopy Cover	Riparian Roads	Road Density	Surface Erosion	Slumps & Slides	Subsoil Erosion	Cutbank and Ditch Erosion	Soil Compaction	Soil Water Detention and Storage Capacity	Bedrock Water Storage Capacity
Temperature	*		*	*								
Flow Variation		*		*	*				*	*	*	*
Sediment		*		*	*	*	*	*	*			
Habitat Simplification	*			*								

Table 48. Steelhead and chinook salmon limiting factors analysis for the Camas Assessment Area. Rating methodology is discussed above, but is based on previous analysis, research or assessments. Factors are ranked from most (3) to least (1) substantial

Subwatershed	Temperature	Flow Variation	Sediment	Habitat Simplification	Total Score
Bowman	2.7	1.7	2.3	3.0	**9.7**
Cable	2.7	1.7	1.9	2.5	**8.8**
Camas/Wilkins	2.3	1.6	2.3	2.0	**8.2**
Hidaway Creek	1.7	1.9	1.9	2.0	**7.5**
Lane Creek	1.3	1.6	1.9	1.5	**6.3**
Lower Camas	1.7	1.7	1.4	1.0	**5.8**
Lower Owens	3.0	1.9	2.1	3.0	**10**
Snipe	2.7	1.9	2.1	3.0	**9.7**
Upper Owens	2.3	1.6	1.9	2.5	**8.3**
Total	**20.4**	**15.6**	**17.8**	**20.5**	

8.1 Bowman Creek

Steelhead and salmon populations in the Bowman subwatershed, which is among the largest subwatersheds in the assessment area, are limited by habitat simplification and temperature.

Habitat simplification is problematic in many portions of the Bowman subwatershed. An estimated 34% of riparian vegetation has been harvested from streams throughout the subwatershed, which helps explain the lack of LWD noted in stream surveys of Dry Camas, Rancheria, and Salsbury Creeks. The high streamside road density (4.3 miles/miles^2) presents another problem for habitat diversity, as the roads act to constrict the stream channel and prohibit it from interaction with the floodplain. The reduction in sinuosity reduces potential overwintering habitat and limits the streams ability to trap and maintain organic matter that could potentially be used by juvenile salmonids for summer rearing. Other factors, such as the presence of a historic railroad grade along Rancheria Creek, contribute to the lack of stream channel/floodplain interaction and reductions in potentially available habitat.

Excessive stream temperatures are a universal limiting factor to anadromous salmonids throughout the Camas. In the Bowman subwatershed, the temperature problem is exacerbated by riparian timber harvest, roads built in the riparian area, and low canopy closure. Most (64%) of the subwatershed is defined by a total canopy closure of less than 60%. The seven-day moving average of maximum daily temperatures measured in the Bowman Creek subwatershed (1992 – 2002) was in excess of 73° F for the period that data was recorded. This is well above the state standard of 64° F, and is approaching near-lethal conditions for steelhead and salmon.

8.2 Cable Creek

Similar to Bowman Creek, habitat simplification and excessive stream temperatures are the primary constraints to anadromous salmonid production/productivity in the Cable Creek subwatershed.

Where they occur within 150 feet of streams, road densities in the Cable subwatershed are 2.41 miles/miles^2. The effect of streamside roads on stream habitat diversity can only be inferred due to the lack of recent stream survey data however it is likely that stream sinuosity values, floodplain and/or bankfull width averages, and pool frequency and quality values are less than their potential throughout the reaches encroached upon by roads. Clearly, the presence of streamside roads has not improved thermal loading to Cable Creek. Seven-day maximum stream temperatures recorded at the mouth of Cable Creek have exceeded 73° F since 1992.

An estimated 38% of riparian vegetation in the Cable Creek has been subjected to timber harvest. Similar to the effects from streamside roads, the harvest of shade-providing vegetation has cumulatively contributed to stream temperature problems, and when coupled with the generally low percentage of canopy closure (65% of the watershed by area is defined by a total canopy closure of <30%), Cable Creek streams are likely to become uninhabitable by summer steelhead during baseflow conditions.

8.3 Camas/Wilkins

Temperature and sediment problems are those most likely to limit anadromous salmonid production/productivity in the Camas/Wilkins subwatershed.

There are no instances during the years 1992-2002 for which the mean seven day moving average of maximum daily temperatures was less than 71° F for any of the 12 monitoring sites that recorded data. The temperature issues are most likely related to the high density of streamside roads (4.28 miles/miles^2) rather than streamside harvest, which in the Camas/Wilkins subwatershed is negligible.

Sedimentation problems would most likely result from surface erosion and subsoil erosion processes. The potential for subsoil erosion throughout the Camas/Wilkins unit is between moderate and high, indicating that disturbance or removal of surface soils may likely cause rill or gully formation. Similarly, removal or loss of soil stabilizing vegetation in this area has a very high potential for causing surface erosion.

8.4 Hidaway

Temperature and habitat simplification are factors most likely to limit anadromous salmonid production/productivity in the Camas/Wilkins subwatershed.

Despite Hidaway Creek exhibiting some of the lowest stream temperatures in the assessment area, it, like most other subwatersheds, suffers from excessive summertime temperatures. Seven-day maximum average stream temperatures measured at the Hidaway/Camas confluence were in excess of 70° F from 1992 – 2000. Other reaches, however, were sufficiently cool to support steelhead and salmon spawning and rearing.

Road densities (riparian and total) in the lower reaches of Hidaway Creek are the highest in the subwatershed, and most likely to negatively influence habitat diversity.

8.5 Lane Creek

Limiting factors to anadromous salmonids in Lane Creek are considerably lower than in other subwatersheds. The primary issues that may reduce steelhead and salmon productivity in the Lane Creek subwatershed are temperature and sediment.

Lane Creek is currently listed by ODEQ for temperature violations. Based on USFS monitoring data at the Lane/Camas confluence, the 7 day average of daily maximum stream temperatures were 64.3, 65, and 64°F in 1993, 1995, and 1996 (respectively).

Sediment concerns in Lane Creek are based on the fact that four of the seven attributes used to rate the 'sediment' limiting factor category received 'moderate, or high-concern' ratings. There are approximately 2.7 miles of road per square miles in the subwatershed, approximately 3.5 miles per square mile of riparian area, a high potential for surface erosion, and a moderate potential for subsoil and cutbank erosion. The cumulative effects from these sources may be manifested by the infrequency of pool habitat and comparatively low pool residual depth documented in 2000 stream surveys. The percentage of instream fine sediment calculated along transects is highest in the uppermost reach of Lane Creek, which is also coincident to the portion of the subwatershed with road densities in excess of 4.7 miles/miles^2.

8.6 Lower Camas

The Lower Camas subwatershed ranked the lowest in terms of limiting factors to anadromous salmonid production/productivity. Although the Lower Camas is also the smallest (based on area) of the subwatersheds assessed, it should be considered a critical reach for chinook and steelhead spawning and rearing.

The entire mainstem Camas is listed for temperature violations by ODEQ, the lowest reaches not withstanding. The mean seven-day moving average of maximum daily temperatures averaged nearly 78° F for the years 1993, 1995-1999, 2001-2002. Although these temperatures are likely due to upstream influences, the aspect, low canopy closure, and low water storage capacity of local soils are undoubtedly providing cumulative impacts to the thermal loading problem.

8.7 Lower Owens

Unlike the Lower Camas subwatershed, the Lower Owens subwatershed ranked the highest in terms of factors potentially limiting production/productivity of steelhead and salmon. Specifically, Lower Owens is limited by high densities of streamside roads, riparian and upland timber harvest, low canopy cover, a high potential for surface and subsoil erosion, and a high percentage of its total area covered by shallow soils with low ash content.

The entire mainstem of Owens Creek is listed on the 303d list for excessive temperatures. The seven-day moving average of maximum daily temperatures for the monitoring station at the Owens/Camas Creek confluence was 77° F in 1992 and 1993. Upper reaches of Owens Creek do not appear to be an ameliorating influence on downstream temperatures, as both are well above the state standard.

High streamside road densities and timber harvest within the riparian area are likely contributors to temperature and habitat simplification problems. An estimated 59% of the riparian area has been subjected to timber harvest, while streamside road densities are in excess of 4.2 miles/miles^2. Also contributing is the low percentage of canopy closure, as 79% of the subwatershed is categorized as having a total canopy closure of 0 – 30%.

In addition to sedimentation problems created by upland timber harvest and streamside roads, the Lower Owens subwatershed has an inherently high surface and subsoil erosion potential. Based on the portion of the subwatershed for which there is data, almost 57% of the area has a high potential for subsoil erosion, while 100% of the area is classified as having a high potential for surface erosion.

8.8 Snipe

Limiting factors to anadromous salmonid production/productivity in Snipe Creek include habitat simplification, sedimentation, and stream temperature-modifying land use activities. The subwatershed exhibits a high percentage of its total area covered by shallow soils with low ash content, high densities of riparian roads, high riparian buffer harvest, a high percentage of its total area harvested, and a high potential for surface erosion.

Surprisingly, Snipe Creek is not listed by the state of Oregon for stream temperature violations. The mere fact that 100% of riparian vegetation has been subjected to timber harvest makes the lack of its listing noteworthy. It is likely that groundwater influences and spring discharge moderate temperatures to some degree, as streamside road densities (4.82 miles/miles^2) are the highest of anywhere in the assessment area.

Clearly, the excessive density of streamside roads, coupled with the high amount of riparian harvest has simplified habitat in Snipe Creek. Reductions in habitat diversity may also be caused by a potentially flashy flow regime. The dominant soil type in the Snipe Creek subwatershed has a very low water detention/storage capacity, thereby contributing to unsustained, rapid runoff events capable of exporting habitat-forming components such as LWD or even boulder substrate.

8.9 Upper Owens

The factors limiting anadromous production/productivity in the Lower Owens subwatershed are similar to those inhibiting steelhead in the Upper Owens subwatershed, albeit at slightly lower levels. Habitat simplification issues are considered moderate-high while activities contributing to high stream temperature problems are moderate.

The seven-day moving average of maximum daily temperatures measured at the USFS boundary was in excess of the 64° F standard in 1995, 1997, and 1999-2002. Stream temperature and habitat diversity problems are likely exacerbated by the extremely high (>4.7 miles/miles^2) density of roads in the headwaters, and/or may be compounded by the moderate-high density of streamside roads (3.27 miles/miles^2). Approximately 59% of the riparian vegetation bordering streams in the Upper Owens subwatershed has been subjected to timber harvest, which is also a likely contributing factor to temperature and habitat diversity problems.

9 Recommendations

9.1 Data Gaps

Similar to other subbasins with large amounts of private and federal land, drainage-wide data collection in the Camas has not occurred. This lack of coverage presents problems when conducting assessments at the watershed scale, as it is only possible to make value judgments or inferences regarding conditions on private lands, thereby precluding scientifically-based conclusions at the ecosystem level. Inquiries to other federal and state management agencies yielded little additional information for private lands.

Specific data limitations when conducting this assessment include:

- A lack of recent, regionally acceptable stream survey data. Recent stream survey data that was collected using R6 survey protocol was limited in this assessment. Until stream survey data is collected for the entire Camas, there will continue to be a lack of baseline information from which trend comparisons can be made, and management effects evaluated.

- Collections of stream substrate from mid-channel gravel bars or other depositional areas. Riffle particles smaller than the dominant large particles on the bar are interpreted as mobile. The mobile percentile of particles on the riffle is termed "Riffle Stability Index" (RSI) and provides a useful estimate of the degree of increased sediment supply to riffles in mountain streams. The RSI addresses situations in which increases in gravel bedload from headwaters activities is depositing material on riffles and filling pools, and it reflects qualitative differences between reference and managed watersheds.

- Bedload data. Because there appears to be a problem with bedload mobility during runoff or storm events, it seems reasonable that information required to ascertain the cause or magnitude of movement should be collected. Monitoring data, such as that used in the Riffle Stability Index (Kappesser 2002), would facilitate this need and should be collected to enable future determinations of changes in bedload movement. Any direct measurement of bedload movement should occur during both winter and spring months due to runoff period variability. Measurement locations should occur on the mainstem Camas Creek in the Camas/Wilkins subwatershed (near the town of Ukiah), and below the Hidaway confluence (Lane Creek subwatershed).

- Drainage-wide hydrodata. Streamflow information, especially from primary perennial tributaries is limited, thereby making determinations of changes in peak and base flow timing and magnitude difficult. Although there is a sufficient flow record at the town of Ukiah, the location of the gage does not allow for the assessment of changes in flow patterns due to upland management effects.

- Riparian/wetland condition information. The available stream survey data used in this assessment included only a very limited amount of information regarding riparian and wetland condition and/or information that would allow for assessment of riparian function. Future data collection efforts should incorporate stream shading percentages, riparian width, wetland location and condition, etc.

- Grazing effects data. Although there is sufficient information regarding the ownership and distribution of cattle allotments throughout the Camas, spatially organized data pertaining to forage condition (especially in riparian areas), prior to and following livestock utilization, needs to become available. The lack of this type of information is significant in the Camas, as grazing and the effects from grazing, represent one of the most widespread land uses in the drainage.

- Stream monitoring data. Permanent monitoring sites from which habitat trend data can be compared annually, are currently lacking in the Camas. Data collected from these types of stations should include that which evaluates stream substrate, temperature, flow, and biological conditions.

- Road Survey data. There is currently a lack of comprehensive road inventory data, including information describing road surface condition, culvert condition, construction method, construction year, maintenance schedules, vehicle use data, and/or other statistics that would be useful in making determinations relative to the importance of the road and/or need for closure or decommissioning.

9.2 Protection Opportunities

Based on our habitat assessment and evaluation of limiting factors, several subwatersheds, or portions thereof warrant consideration for protection (Table 49). Protection determinations are based on the areas biological potential for production of anadromous species, its current condition, its potential condition, and the type and magnitude of limiting factors affecting its condition.

Table 49. Protection opportunities defined for the Camas Assessment Area

Subwatershed/Reach for Protection	Rationale	Protection Recommendations
Lower Camas	The lower Camas represents an area that is used by both steelhead and chinook for spawning and rearing. Due to its proximity to the NF John Day, it represents an area that could potentially be used by multiple species for refugia. It has comparatively good habitat for both species (multiple life history stages), and due to its location (canyon area), is fairly well protected from direct impacts associated with land use activities	Limit road building, grazing, or other activities that may compromise habitat condition and function. Identify areas where livestock exclosure would be beneficial
Upper Hidaway and Cable	The upper reaches in Hidaway Creek warrant consideration for protection due to current habitat conditions. Based on 2003 survey data, habitat quality in upper Hidaway is sufficient to support	Identify areas for road decommissioning, restrict future road building and/or any

Subwatershed/Reach for Protection	Rationale	Protection Recommendations
	most life history stages of steelhead, and is among the most diverse in the entire drainage. The roadless designation in the upper reaches of Cable Creek (i.e. SF Cable) should be upheld due to its ability to produce cold water and habitat for cold-water biota.	additional land use activities that may otherwise compromise habitat condition and function.

9.3 Restoration Opportunities

Several subwatersheds in the Camas Drainage warrant consideration for restoration (Table 50). Areas identified for restoration are based on previous habitat/limiting factors analysis and includes those that provide habitat for anadromous species, albeit at levels less than desirable. Special consideration is given to areas which occur in small clusters and may be adjacent to habitat that is in better condition, or may afford opportunities for the restoration of migratory linkages to other [core] populations. Consideration is also given to restoration feasibility (i.e. potential cost associated with reparation efforts).

Table 50. Restoration opportunities defined for the Camas Assessment Area

Subwatershed/Reach for Protection	Rationale	Restoration Recommendations
Lane Creek	The proximity of Lane Creek to other key steelhead and salmon production areas, coupled with the comparatively minimal number of limiting factors potentially affecting the habitat and biota, make it a logical subwatershed to implement restoration activities. Unlike other subwatersheds, Lane Creek is estimated to have a relatively stable flow regime, which may contribute to its fairly high habitat condition. A lack of pool frequency, slightly elevated amounts of fine sediment, and somewhat elevated stream temperatures limit its potential for steelhead production/habitat utilization.	Based on its high percentage of shallow soils and low ash deposition, management activities that potentially disturb soils (i.e. timber harvest or road construction) should be minimized. Road decommissioning should occur in unstable areas. Bioengineering efforts designed to improve pool frequency may be appropriate in some areas, but only after sufficient analysis and/or consideration of less invasive alternatives
Lower Hidaway	Lower Hidaway provides potential habitat for both spring chinook and steelhead, and contains some of the best salmonid habitat in the Camas Drainage. Restoration efforts are needed in the lower reaches, however, due to riparian habitat degradation from grazing, timber harvest, and roads. Improvements in Reaches 1 and 2 (RM 1.1 – 2.63) would benefit the subwatershed on the whole, and would likely	• Road surveys • Road rehabilitation or decommissioning, based on survey results • Riparian fencing • Riparian planting

Subwatershed/Reach for Protection	Rationale	Restoration Recommendations
	provide refugia and a genetic reserve for adjacent populations residing in less than hospitable environments	• Land acquisition or establishment of conservation easements
Upper Owens	Restoration of steelhead spawning habitat in Upper Owens would likely benefit populations residing in the Lower Owens subwatershed and in the Snipe Creek subwatershed. There appears to be sufficient connectivity between the three subwatersheds during periods of high flow, allowing for genetic exchange, refounding, etc.	Efforts should be directed at minimizing disturbance to the inherently shallow soils common to the area and planting shallow-rooted riparian vegetation in critical reaches. Attempts to minimize the effects of riparian timber harvest and riparian roads should also occur.
Bowman Creek	It would not be feasible to identify the entire Bowman Creek subwatershed for restoration, due to the mosaic of ownership, presence of the highway, etc. A high priority area is the reach of the mainstem between Bowman Creek and Bear Wallow Creek. The reach provides key spawning and rearing habitat for both spring chinook and steelhead, and represents core habitat for the upper Camas system. Past restoration efforts have been made in the Bowman subwatershed, but have yet proved to be highly beneficial to anadromous species.	• Riparian plantings • Exclosure fencing in key spawning areas • Reparations and maintenance to existing instream structures

9.4 Recommendations for Future Studies

Future studies should be designed to address the question regarding bedload movement, changes in peak flow magnitude (and mechanisms responsible for causing changes), and the overall function/condition of riparian vegetation. Although unlikely, it would also be informative to obtain a better understanding of historic fish use in the Camas Drainage, specifically that of spring chinook. Knowing the degree to which the Camas system has changed from reference conditions would better enable scientifically-based fisheries management decisions in the John Day Subbasin.

As discussed previously, there is a current lack of monitoring sites in the Camas Drainage. This is somewhat surprising, based on the fact that monitoring was identified in the 1995 assessment as a need.

Similar to other drainages throughout the Columbia River Basin, there is a general lack of salmon and steelhead genetics information. Defining the genetic lineage of Camas fish would better enable management decisions and prioritization.

10 Summary

Summer steelhead escapement to the Camas Assessment Area has fluctuated both spatially and temporally. Between-stream comparisons show that the number of redds observed in the mainstem Camas and Cable Creek index areas were consistently higher than in other streams surveyed. The most successful period for redd construction occurred during the late 1960s and then again in the mid-1980s. On average, 17 steelhead redds are observed during annual surveys.

The Camas Drainage accounts for only a small percentage of spring chinook production in the John Day Subbasin, which therefore precludes quantitative determinations of population trends. Based on the limited data, it appears that spring chinook use the Camas somewhat opportunistically, and will spawn and rear during years where escapement to the John Day is exceptionally high and/or when environmental (i.e. temperature and flow) conditions in the watershed permit. Current chinook distribution is largely restricted to portions of the mainstem Camas, but may include primary tributaries during years defined by adequate streamflow and stream temperatures.

Riffle habitat quality and quantity is high throughout the Camas Assessment Area, although the quantity and quality of pool habitat is generally poor. One explanation for the lack of pool habitat is the overall low relative abundance of LWD in most reaches. The quality of steelhead spawning and incubation habitat is highest in the mainstem, and lowest in the Bowman (upper Camas area) subwatershed. Steelhead summer rearing and overwintering habitat is generally lacking throughout the Camas Drainage, but is highest in the Hidaway subwatershed, and lowest in the Bowman subwatershed.

Although there have been extensive modifications to upland and lowland resources throughout the drainage, it was not possible to identify a shift in peak or base flow magnitude or frequency. Of the various processes of erosion that may affect salmonid habitat, surface erosion is the highest and most widespread form.

Excessive stream temperatures and habitat simplification represent the most common limiting factors to anadromous salmonid production/productivity throughout the Camas Assessment Area. Six of the nine subwatersheds assessed are on the state of Oregon's 303d list for temperature violations (Lower Camas, Camas/Wilkins, Lane, Bowman, Cable, and Hidaway). High streamside road densities limit stream channel interaction with floodplain areas, and contribute to an overall lack of overwintering and summer rearing habitat.

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12 Appendices

12.1 Habitat Ratings

Appendix 1. ODFW habitat benchmarks (reproduced from Watershed Professionals Network 1999)

Habitat Attribute	Undesirable	Desirable
Pools		
Pool Area (% total stream area)	<10	>35
Pool Frequency[1] (avg. # of channel widths between pools)	>20	5-8
Residual Pool Depth:		
Small Streams (<7m wide)	<0.2	>0.5
Medium Streams (≥7m & <15m wide)		
Low Gradient (slope <3%)	<0.3	>0.6
High Gradient (slope >3%)	<0.5	>1.0
Large Streams (≥15m wide)	<0.8	>1.5
Riffles		
Width:Depth Ratio (active-channel based)		
East Side	>30	<10
Gravel[2] (% transect)	<15	≥35
Silt-Sand-Organics (% transect)		
Volcanic Parent Material	>15	<8
Sedimentary Parent Material	>20	<10
Channel Gradient <1.5%	>25	<12
Large Woody Debris[3]		
Pieces per mile	<20	>20
Key pieces per mile	<20	>20

1/ Pool frequency based on #pools/mile and rated according to NMFS matrix in Rancheria, Salsbury, and Dry Camas Drainages
2/ Value represents an average of data collected from (2) Wollman Pebble Count transects measured within the respective reach
3/ USFS survey methods identify LWD in three size classes – small (), medium (), and large (). "Key" pieces of LWD refers to those >12" diameter and >35 ft length

Appendix 2. Matrix of pathways and indicators (reproduced from (National Marine Fisheries Service 1996)

Pathway/Indicators	Properly Functioning	At Risk	Not Properly Functioning
Water Quality			
Temperature (1)	50-57°F (max 7-day average)	57-60°F (max 7-day-spawning) 57-64°F (migration/rearing)	>60°F (max 7-day spawning) >64°F (migration/rearing)
Sediment/Substrate (1)	Embeddedness <20%. Dominant substrate is gravel or cobble. Gravel/cobble bars stable. Turbidity low.	Embeddedness 20-30%. Gravel and cobble is subdominant. Gravel/cobble bars are in the process of stabilizing. Turbidity moderate.	Embeddedness >30%. Bedrock, sand, silt, or small gravel dominant. Gravel/cobble bars very mobile. Turbidity high.
Chemical Contamination	Low levels of chemical contamination; no CWA 303(d) designated reaches.	Moderate levels of chemical contamination; one CWA 303(d) designated reach.	High levels of chemical contamination; more than one CWA 303(d) designated reach.
Habitat Access			
Physical Barriers	Man-made barriers do not restrict fish passage.	Man-made barriers present restrict fish passage at base/low flows.	Man-made barriers present restrict fish passage at a range of flow conditions.
Habitat Elements			
Large Woody Material (1) >20 pieces/mi.	Meets standards (left). Adequate sources for LWM recruitment from riparian areas.	Currently meets standards for properly functioning, but lacks potential sources from riparian areas of LWM recruitment to maintain that standard, <u>or</u> Doesn't meet standard, but has recruitment potential.	Does not meet standards for properly functioning and lacks potential LWM recruitment.
Pool Frequency and Quality (1) <u>Width (ft.)</u> <u>Pools/mi.</u> 5 184 10 96 15 70 20 56 25 47 50 26	Meets pool frequency standards (left) and LWM recruitment standards for properly functioning habitat, or has adequate flow and bedrock to maintain pools. Residual (holding) pool depth greater than 3 meters with good cover and cool water. Minor reduction of pool volume by fine sediment acceptable.	Meets pool frequency standards (left) but LWM recruitment standards inadequate to maintain pools over time. Lacks adequate flow or bedrock to form stable pools. Residual (holding) pool depth less than 3 meters with less than adequate cover/temperature. Moderate reduction in pool volume by fine sediment.	Does not meet pool frequency standards. Does not contain deep pools. Pool volumes are reduced by fine sediment.
Off-Channel habitat	Natural potential *or* backwaters with cover and low energy off-channel areas	Some backwater and high-energy side channels.	Few or no backwaters; no off-channel ponds.
Refugia	Habitat refugia exists and are buffered	Habitat refugia exists but are not adequately buffered	Habitat refugia does not exist.
Channel Conditions and Dynamics			
Width:Depth ratio (1)	Meet Rosgen's classification system (Rosgen 1996).	Does not meet Rosgen's classification system, but morphology/vegetation components are in place and system is moving towards meeting this classification.	Does not meet Rosgen's classification system and morphology/vegetation components are not in place.
Streambank Condition (1)	$\geq$90% stable.	80-90% stable.	<80% stable.
Floodplain Connectivity	Off-channel areas are hydrologically connected to the main channel. Overbank flows occur and maintain wetland functions, riparian vegetation and succession, where channel type allows.	Reduced linkage of wetland floodplains. Overbank flows are reduced relative to historic frequency as evidenced by moderate degradation of wetland function, where channel type allows formation of wetlands.	Severe reduction in hydrologic connectivity. Wetland functions degraded, where channel type allows formation of wetlands.

Pathway/Indicators	Properly Functioning	At Risk	Not Properly Functioning
Hydrology/flow			
Changes in Peak/Base Flow	Watershed hydrographs indicated peak flow, base flow, and flow timing characteristics comparable to an undisturbed watershed.	Some evidence of altered peak flow, base flow, and/or flow timing.	Pronounced changes in peak flow, base flow, and/or flow timing.
Increase in Drainage Network	Zero or minimum increase in drainage network density due to roads.	Moderate increases in drainage network density due to roads (5%).	Significant increases in drainage network density due to roads (>20%).
Watershed Conditions			
Road Density and Location	<2 mi/sq.mi.; no valley bottom roads.	2-3 mi/sq.mi.; some valley bottom roads.	>3 mi/sq.mi.; many valley bottom roads.
Disturbance History	<15% ECA with no concentration of disturbance in unstable areas or riparian areas.	<15% ECA with some disturbance in unstable areas or riparian areas.	>15% ECA with disturbance concentrated in unstable areas or riparian areas.
Riparian Reserves	Riparian reserves provide shade, LWM recruitment, habitat protection, and connectivity in all subwatersheds. Riparian plant community has the vigor, health, composition and diversity to support riparian reserve values.	Moderate loss of connectivity or function or riparian reserves. Riparian plant community lacking the vigor, health, composition and/or diversity to support riparian reserve values, but is in an upward trend.	Riparian reserves are fragmented with poor connectivity and little protection of habitats. Riparian plant community lacking the vigor, health, composition and/or diversity to support riparian reserve values, and is in a static or downward trend.