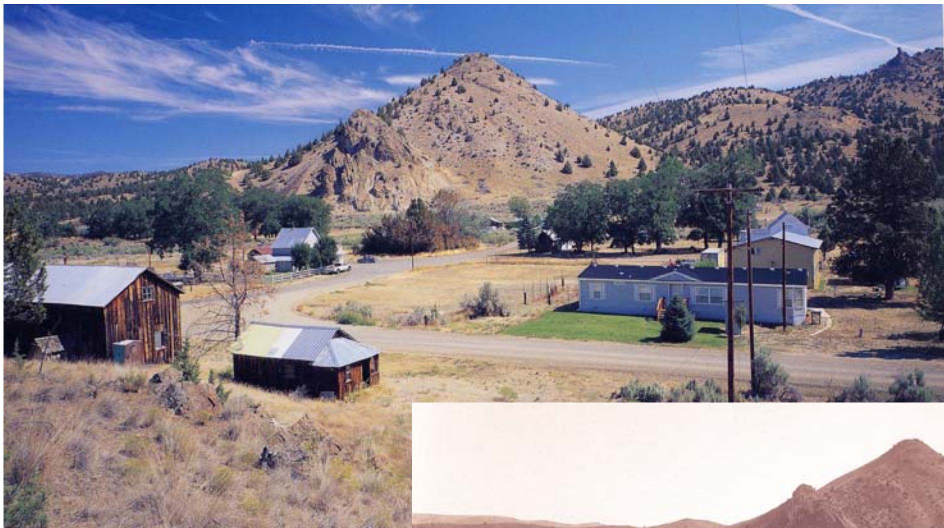
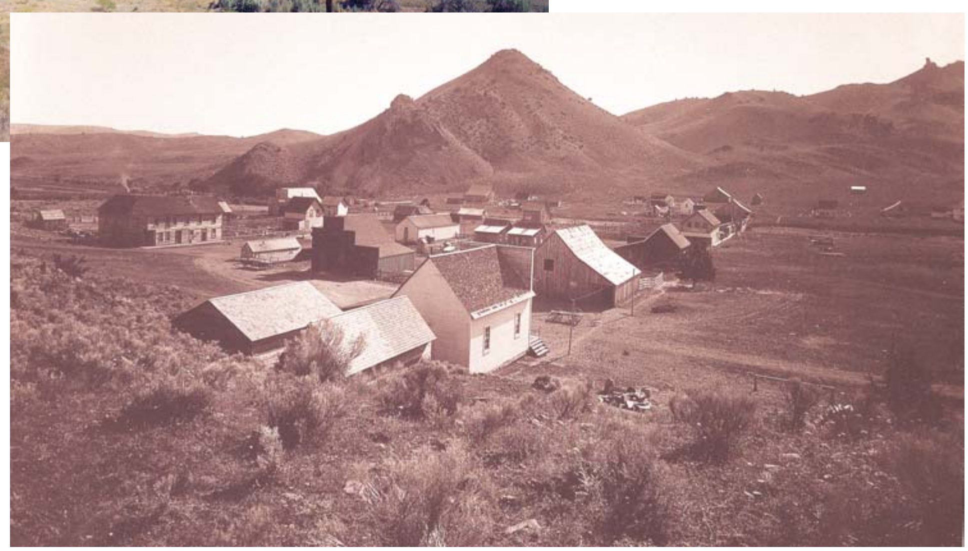
Trout Creek Watershed Assessment

Part 1: Findings



Ashwood, August 1999



Ashwood, Circa 1897-1918
(Photos: Gifford and Terrel, *Oregon Then & Now*)

August 2002

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1.0 INTRODUCTION

1.1.1 Purpose

The purpose of the assessment is to characterize historical and current watershed conditions in the Trout Creek Watershed. Information from the assessment is used to evaluate opportunities for improvements in watershed conditions, with particular reference to improvements in the aquatic environment. Existing information was used, to the extent practicable, to complete this work. The assessment will aid the Trout Creek Watershed Council in identifying opportunities and priorities for watershed restoration projects.

1.1.2 Approach

The assessment followed the general framework described in the Oregon Watershed Enhancement Board's Watershed Assessment Manual (WPN, 1999). The assessment focused on the following components: Channel habitat classification and modification; hydrology and water use; riparian/wetlands; sediment sources; water quality; and fisheries.

1.1.3 Project Assumptions

The assessment relied primarily on existing data, aerial photography, and previously published reports. Supplementary fieldwork was conducted to: 1) gain an overview of the watershed; and 2) verify or check aerial photographic interpretations, riparian and channel habitat, and other classifications and anomalous field data. Supplementary fieldwork was conducted under the general supervision of the Trout Creek Watershed Council's watershed coordinator.

1.1.4 Organization of Document

This document follows the overall organization of the assessment itself. Seven resource assessment components were conducted. These included the following:

- Historical Overview, contributed by Jefferson County SWCD (Section 2.0 of this report);
- Classification of channel habitat types, and an assessment of channel modifications (Section 3.0 of this report);
- Assessment of hydrology and water use (Section 4.0);
- Assessment of riparian and wetland habitat conditions (Section 5.0);

- Assessment of sediment sources in the watershed (Section 6.0);

- Assessment of water quality in the watershed (Section 7.0);

- Assessment of fish and fish habitat (Section 8.0);

The watershed condition evaluation is a separate document (Part Two). The watershed condition evaluation summarizes the information collected in the previous components of the assessment process. Primary products from this section are:

- Summary of information collected for each of the assessment components,

- Identification of missing or unavailable information,

- List of issues that may require additional assessment or data-gathering,

- Overall evaluation of the condition of the aquatic–riparian system, fish populations, and water quality,

- Prioritization of watershed areas and issues that should be the focus for action, including habitat restoration/protection opportunities.

1.2 STUDY AREA OVERVIEW

The purpose of this section of the report is to provide an overview of the study area providing a general overview of the Trout Creek watershed including watershed location, a description of the watershed subbasins used in the assessment, land ownership, a summary of water features, and an overview of the ecoregions found within the watershed.

1.2.1 Study Area Location

The study area includes the Trout Creek watershed, located in Wasco, Jefferson, and Crook Counties, Oregon (Figure 1-1). Elevations in the watershed range from 5,940 feet to 1,280 feet where Trout Creek joins the Deschutes River at river mile (RM) 87.2. Primary population centers within the watershed include Antelope and Ashwood (unincorporated). Population centers surrounding the watershed include Madras – located southwest of the watershed, Shaniko (north), and Prineville (south). Federal highways 26, 97, and 197 pass through or are adjacent to the northwest portion of the watershed, and State route 218 passes through the northeast corner (Figure 1-1). A railroad jointly owned by the Union Pacific / Burlington Northern Santa Fe passes through the western portion of the watershed.

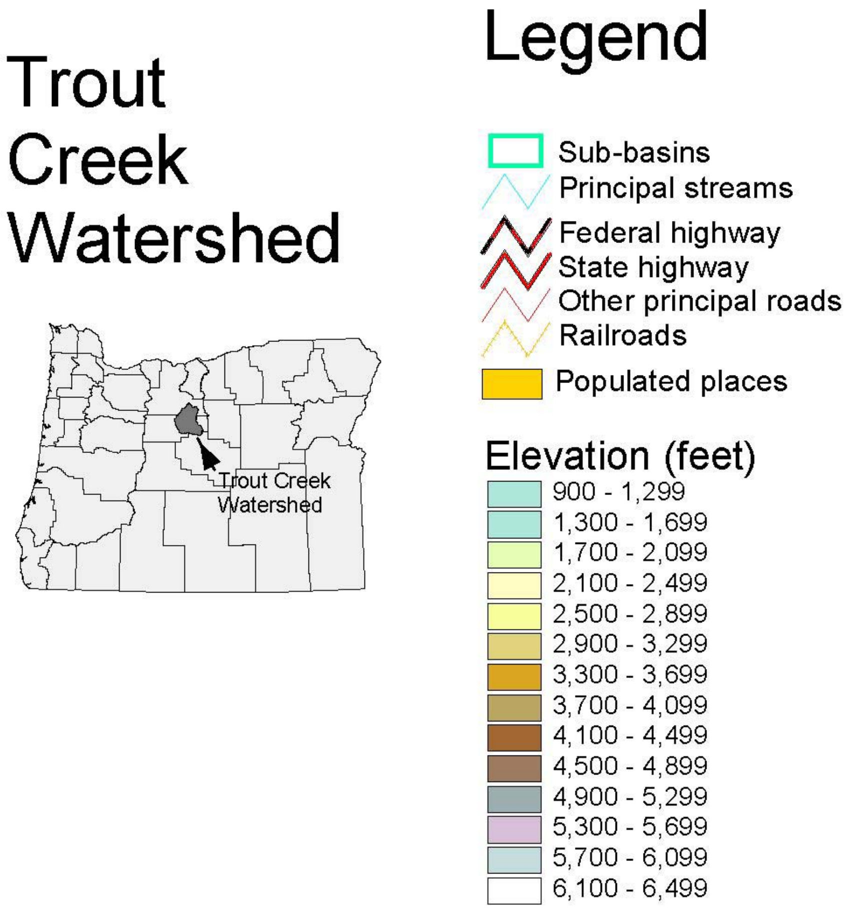
1.2.2 Assessment Subbasins

For the purposes of this assessment the Trout Creek watershed has been subdivided into five subbasins (Figure1-1):

- Antelope Creek
- Hay Creek
- Lower Trout
- Mud Springs Ck
- Upper Trout
- Entire watershed

Subbasin characteristics are given in Table 1-1. Note that the subbasins defined for this assessment differ from the nine "fifth-field" subwatersheds defined for the Trout Creek watershed by the US Forest Service Regional Ecosystem Office (REO, 1996). Use of the subbasins shown in Figure 1-1 rather than the nine fifth-field watersheds was suggested by staff at the Jefferson County Soil & Water Conservation District (SWCD). It was felt that the subbasins defined here better represent the areas of critical resource concern within the assessment area.

Figure 1-1. Trout Creek watershed location map (below) and shaded-relief map (next page). Legend for shaded-relief map given above.



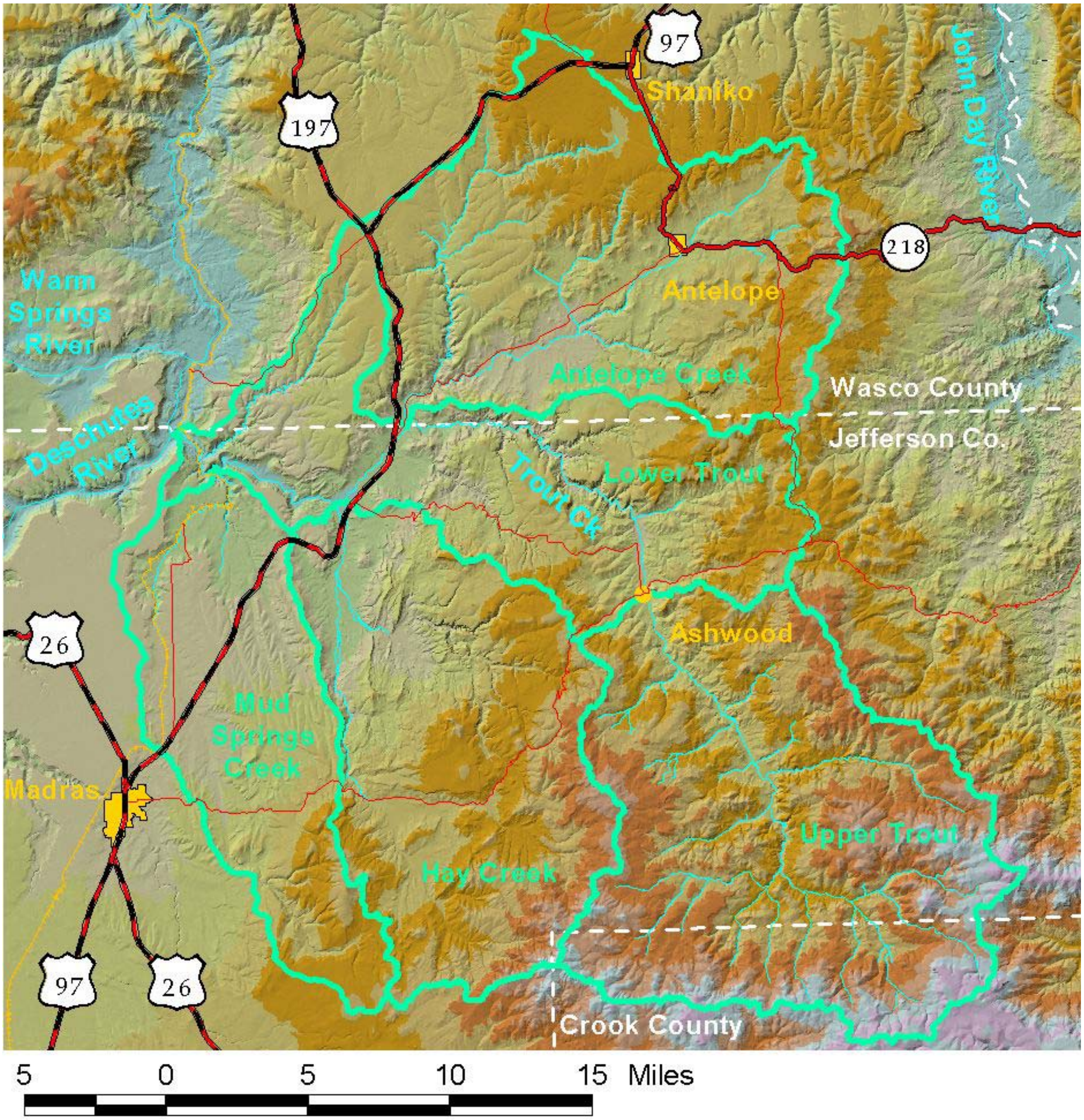


Figure 1-1 (continued). Shaded-relief map of the Trout Creek watershed. Refer to previous page for map legend.

Table 1-1. Characteristics of subbasins within the Trout Creek watershed.

Sub basin	Area (mi^2)	Elevation (feet)		
		Mean	Minimum	Maximum
Antelope Creek	157.3	3,048	1,805	4,311
Mud Springs Ck	92.7	2,621	1,411	4,187
Hay Creek	137.9	3,266	1,657	5,443
Upper Trout	176.6	4,117	2,507	5,940
Lower Trout	127.8	2,788	1,280	4,364
Entire watershed	692.4	3,259	1,280	5,940

1.2.3 Ownership

Information on land ownership was available from the Bureau of Land Management (BLM, 2001). Land ownership within the watershed is shown in Figure 1-2, and summarized in Table 1-2.

Table 1-2. Summary of land ownership within the Trout Creek watershed. Shown are % of subbasin area, and square miles (in parentheses). Data source: BLM "Landlines" GIS coverage, dated 8/1/01 (BLM, 2001).

Sub basin	BLM	USFS	Other USDA	Private
Antelope Creek	8.1% (12.8)			91.9% (144.5)
Mud Springs Ck	1.6% (1.5)		23.1% (21.4)	75.3% (69.8)
Hay Creek	0.4% (0.6)		0.8% (1.1)	98.8% (136.2)
Upper Trout	3.2% (5.6)	19.3% (34.1)		77.5% (136.9)
Lower Trout	6.6% (8.5)			93.4% (119.4)
Entire watershed	4.2% (29.0)	4.9% (34.1)	3.2% (22.5)	87.6% (606.8)

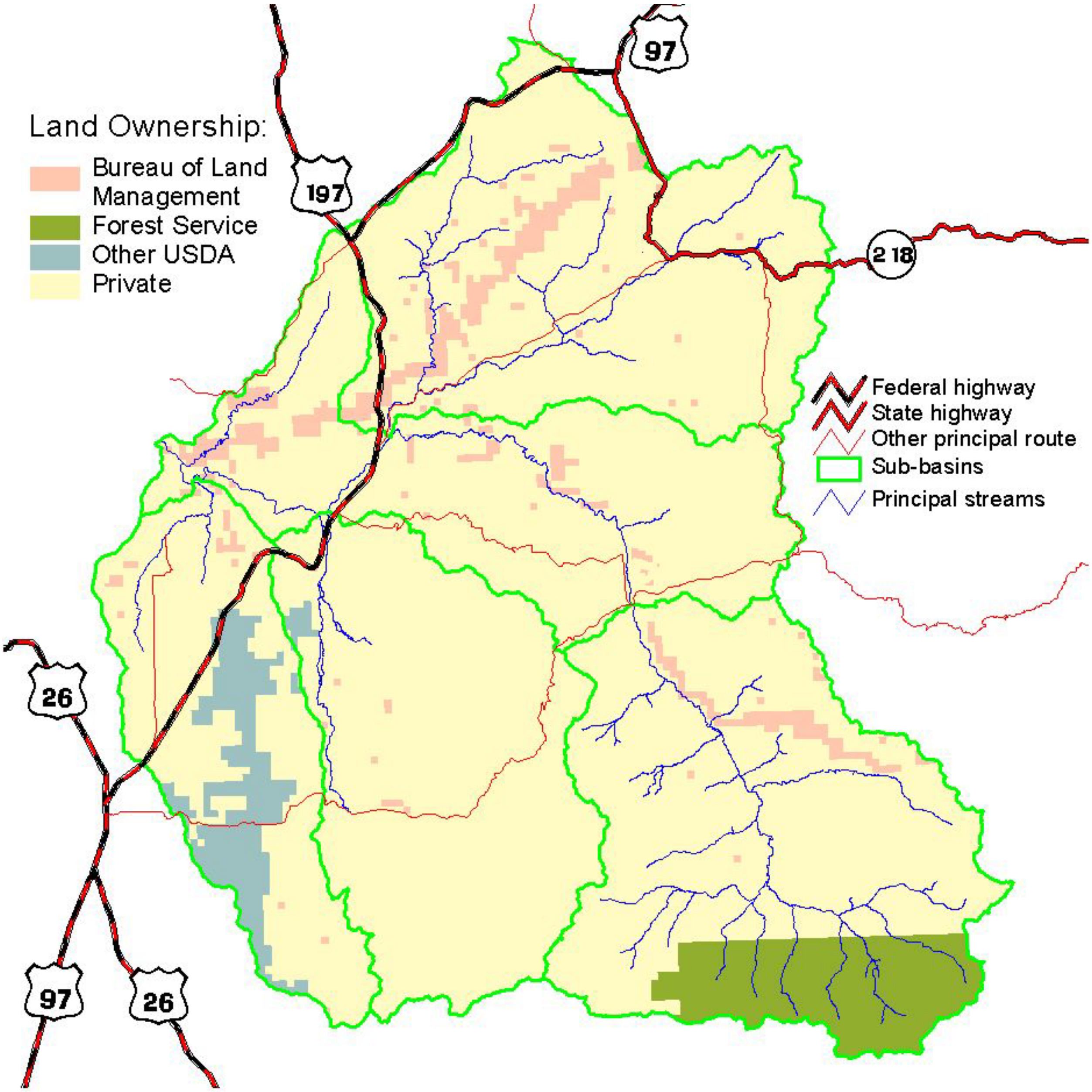


Figure 1-2. Land ownership within the Trout Creek watershed. Refer to Land Use

Land Use

Current land use in the Trout Creek watershed was estimated using the state Department of Land Conservation and Development (DLCD) 1:100,000 GIS zoning coverage (DLCD, 1986) and the Oregon Water Resources Department (OWRD) "irrigation place of use" GIS coverage (OWRD, 2001a). The DLCD coverage identified five separate land use categories in the watershed. The "agriculture" land use category was further divided into "irrigated" and "rangeland" categories using the OWRD place of use coverage. Agricultural lands were placed in the "irrigated" category if the water use was designated by the OWRD as being "Irrigation", "Irrigation–Supplemental", "Irrigation & domestic", "Irrigation & stock", or "Irrigation, domestic & stock"[1]. Current land use within the watershed is shown in Figure 1-3 and summarized in Table 1-3.

Table 1-3. Summary of current land use within the Trout Creek watershed. Shown are % of subbasin area, and square miles (in parentheses). Data sources: DLCD "Zoning" GIS coverage (DLCD, 1986), and OWRD "Place of Use" GIS coverage (OWRD, 2001a).

Subbasin	Rangelands	Agriculture - irrigated	Forestry	Rural Residential	Rural Service Center	Urban
Antelope Creek	98.7% (155.3)	1.0% (1.6)				0.3% (0.5)
Mud Springs Ck	97.0% (89.9)	2.1% (1.9)		0.7% (0.7)	0.1% (0.1)	
Hay Creek	93.7% (129.3)	2.2% (3.1)	4.0% (5.6)			
Upper Trout	55.8% (98.6)	0.5% (0.9)	43.7% (77.1)			
Lower Trout	97.8% (125.1)	2.2% (2.8)				
Entire Watershed	86.4% (598.1)	1.5% (10.3)	11.9% (82.7)	0.1% (0.7)	0.02% (0.1)	0.1% (0.5)

[1] The "place of use" GIS coverage (OWRD, 2001a) may not accurately show all locations where water is applied. For example, the irrigated lands shown in the Mudsprings subbasin appears to be missing areas that should be included in the North unit irrigation district.

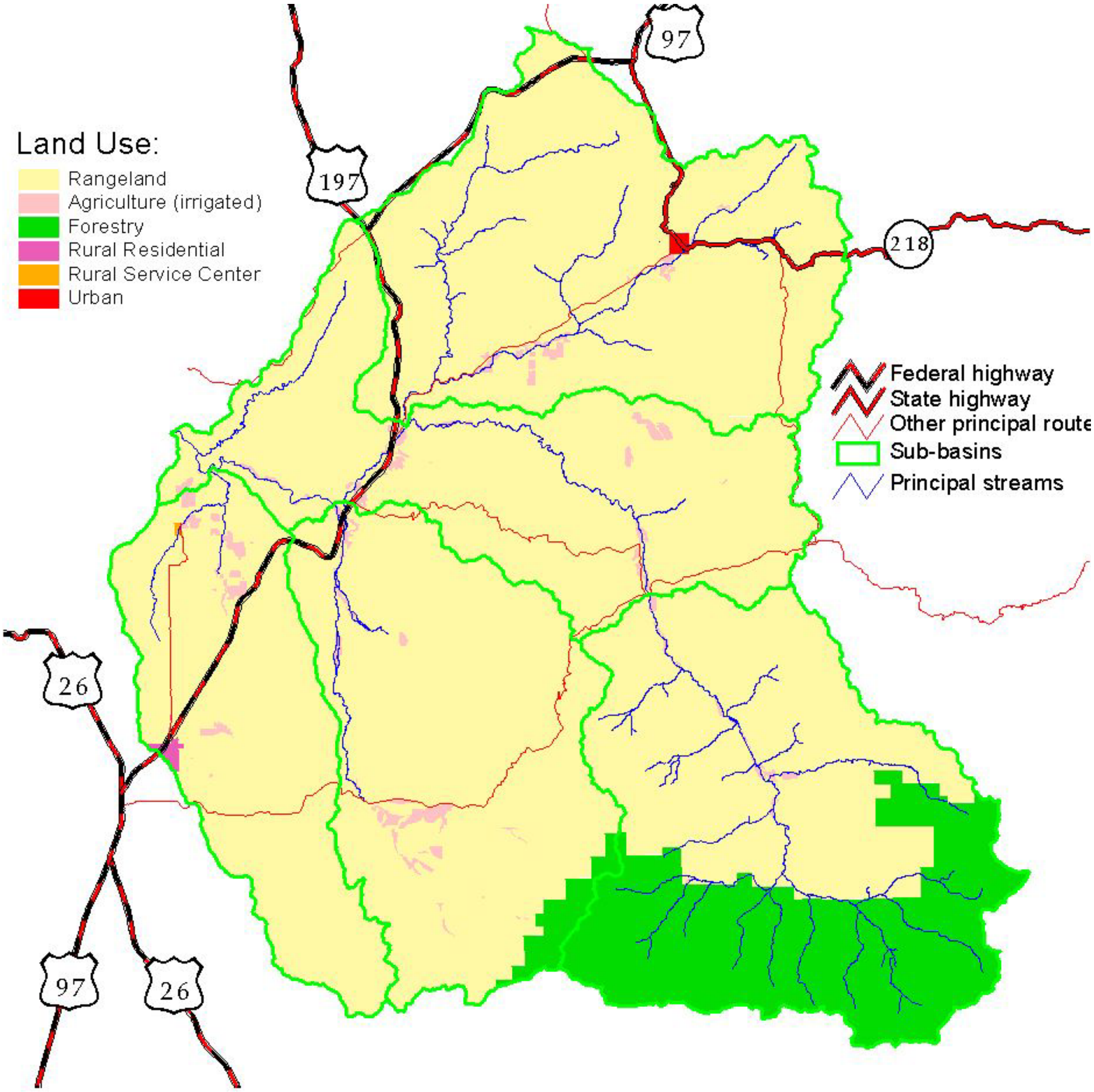


Figure 1-3. Current land use within the Trout Creek watershed. Refer to Table 1-3 for land use summary. Data sources: DLCD "Zoning" GIS coverage (DLCD, 1986), and OWRD "Place of Use" GIS coverage (OWRD, 2001a).

1.2.4 Water Features

Information on water features found within the Trout Creek watershed was compiled from a variety of sources. The primary source of information used was the BLM's "Streams, Linear Features" and "Lakes, Reservoirs, and Ponds" GIS coverages for the Prineville District (BLM, 2001). The BLM coverages did not cover the entire watershed, consequently, the remaining water features were mapped using USGS Digital line graph (DLG) coverages (USGS, 2001a) or digitized from digital 1:24,000 scale USGS quad maps (REO, 2001). Information on usage of the streams by summer steelhead was available from the Oregon Department of Fish and Wildlife (ODFW, 2001), and was modified by the Fisheries analyst to reflect observed field conditions. Historical fish distributions were based on professional judgment, looking at flow and potential habitat conditions. Information on water features found within the watershed are shown in Figure 1-4 and summarized in Table 1-4. In addition Figure 1-5 through Figure 1-8 show the key streams[2] in each of the subbasins.

[2] Key streams are defined as those streams that were included in the Riparian Assessment, described in section 5.0 below. Key streams were chosen in consultation with staff of the Jefferson County SWCD, and Tom Nelson of the ODFW. A total of 254 miles of key streams were included in the assessment. In general, key streams include all streams identified as having perennial stream flow (as identified on 7.5" USGS topographic maps).

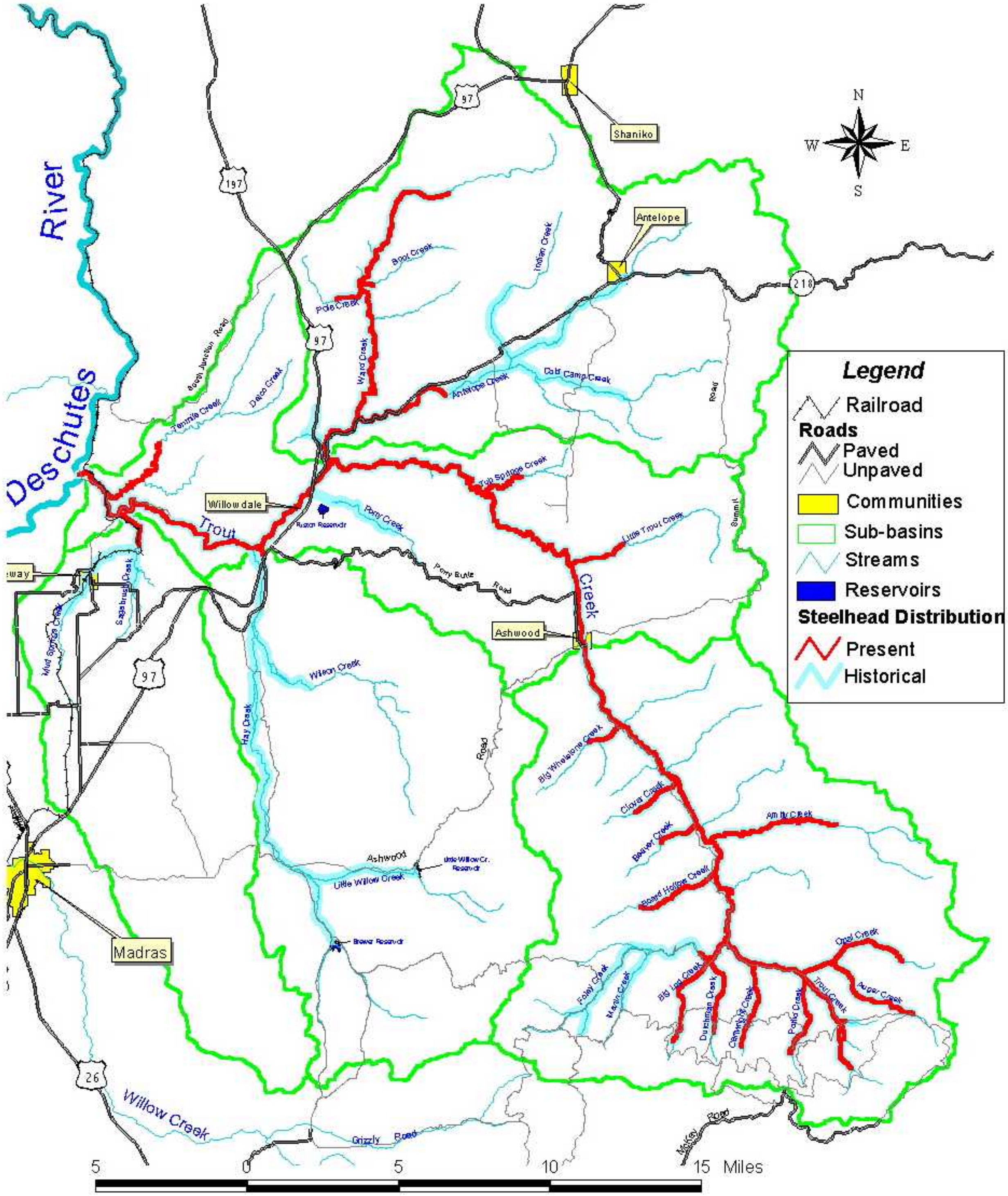


Figure 1-4. Principal water features found within the Trout Creek watershed. Refer to narrative and Table 1-4 for summary information and data sources.

Table 1-4. Summary of water features within the Trout Creek watershed.

		Antelope Creek	Mud Springs Ck	Hay Creek	Upper Trout	Lower Trout	Entire watershed
Perennial streams [a]	(miles)	64.9	11.3	13.1	96.4	36.6	222.4
Intermittent streams	(miles)	247.5	207.2	250.4	243.4	203.7	1,152.1
Ditch/ canal	(miles)	-	41.6	-	0.5 [b]	5.8	47.9
Perennial Lake/ Pond [c]	(acres)	5.1	7.1	57.5	4	2.8	76.6
	(#)	14	12	11	6	4	47
Intermittent Lake/Pond	(acres)	13.3	11.6	3.4	4.2	6.1	38.6
	(#)	39	32	14	11	24	120
Reservoir [d]	(acres)	-	-	103.3	-	-	103.3
	(#)	-	-	2	-	-	2
Summer Steelhead use (miles)	Historic	34.8	7.3	24.3	65.0	38.9	170.3
	Current	17.1	1.6	0.4	55.7	38.3	113.0

Notes:

a Flow status (i.e., perennial or intermittent) was determined from USGS 7.5" topographical maps

b Length of dithes and canals in the Upper Trout subbasin may be much greater than shown above. Members of the Trout Creek Watershed Council report that there are at least seven miles of ditches in the subbasin.

c Members of the Trout Creek Watershed Council claim that there are no natural lakes or ponds in the watershed, therefore all bodies of water should be listed as "reservoirs". The distinctionbetween lakes/ponds and reservoirs was based on the GIS source data (BLM, 2001; REO, 2002; USGS, 2001).

d including inundation area

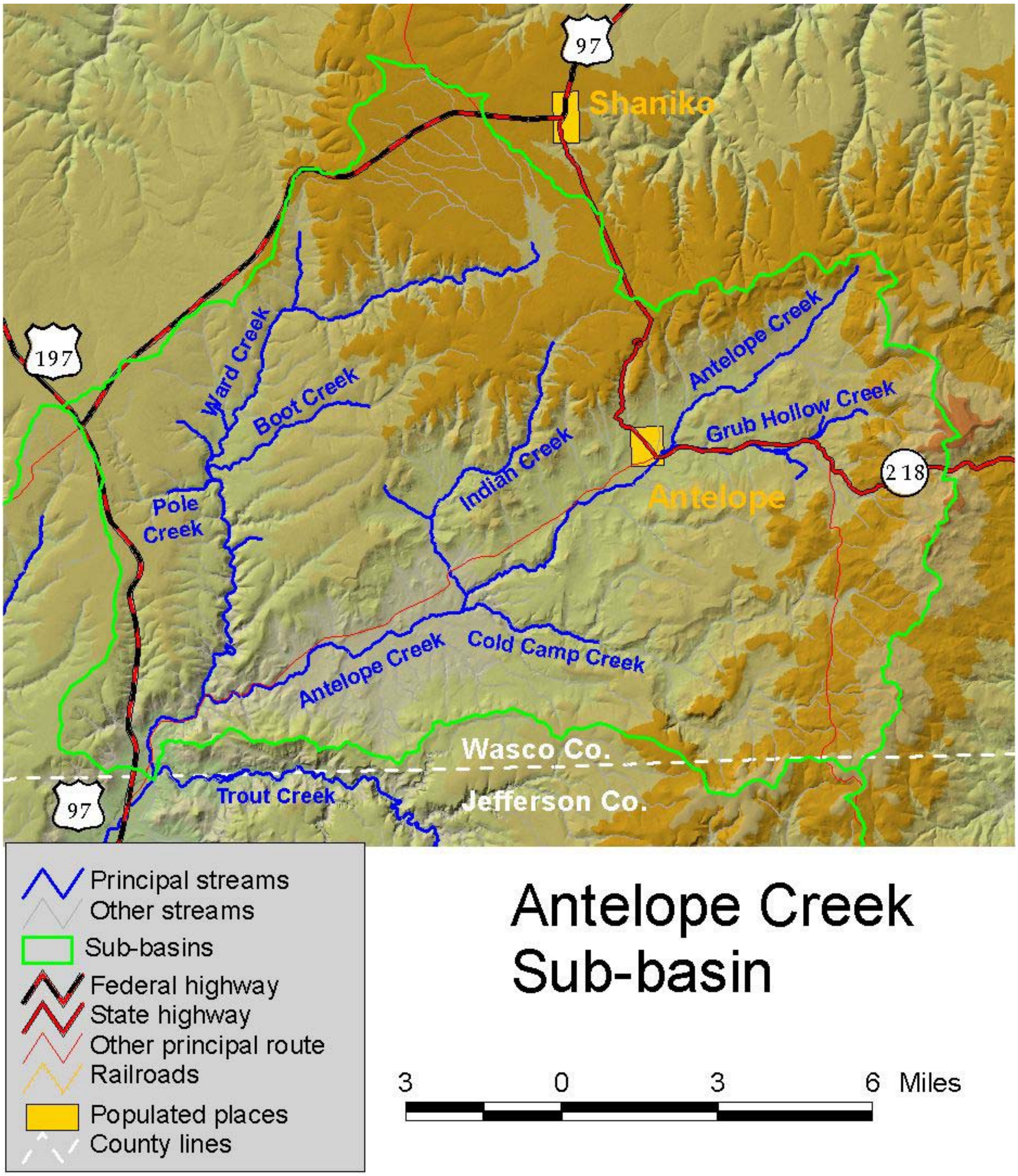


Figure 1-5. Key streams - Antelope Creek sub-basin.

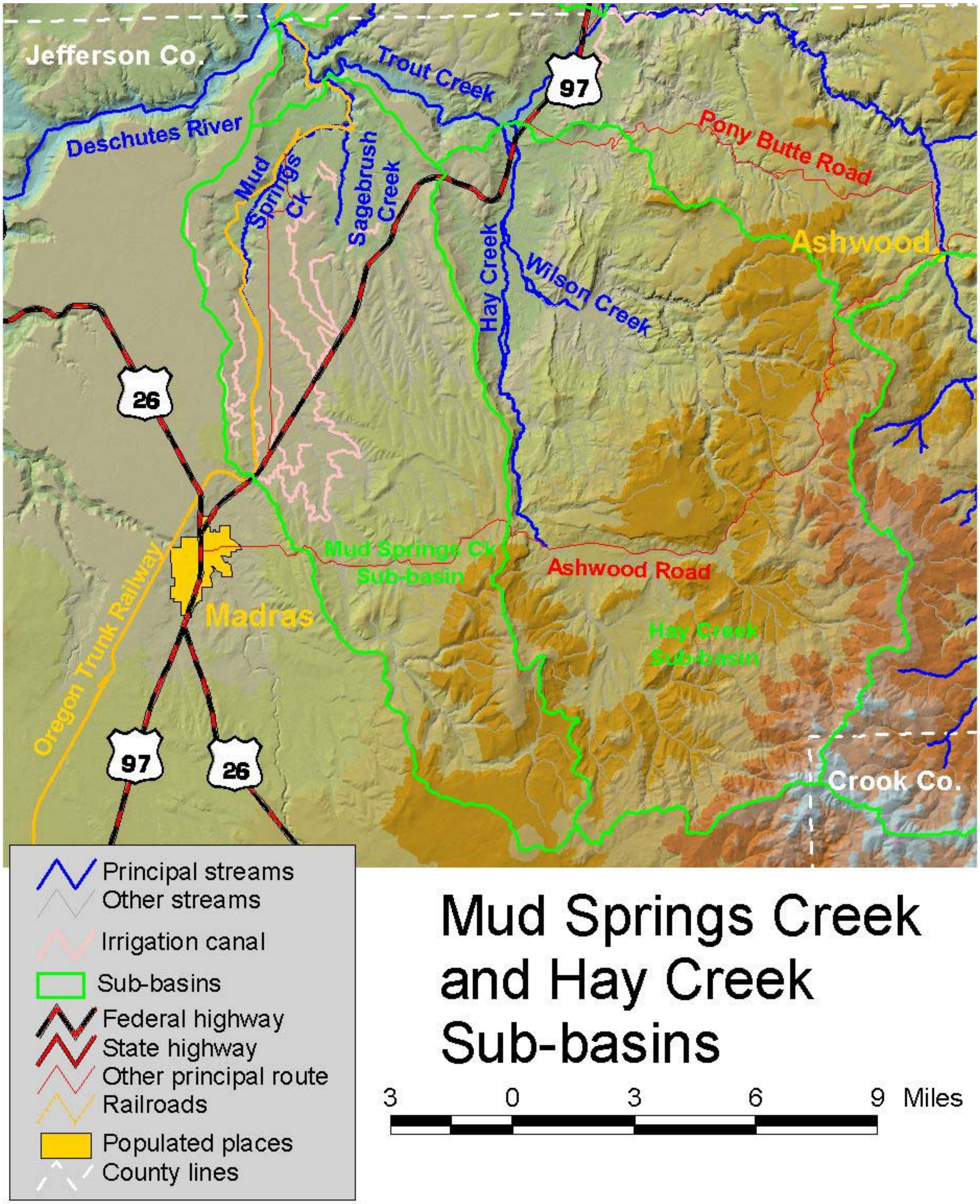


Figure 1-6. Key streams – Mud Springs Creek and Hay Creek sub-basins.

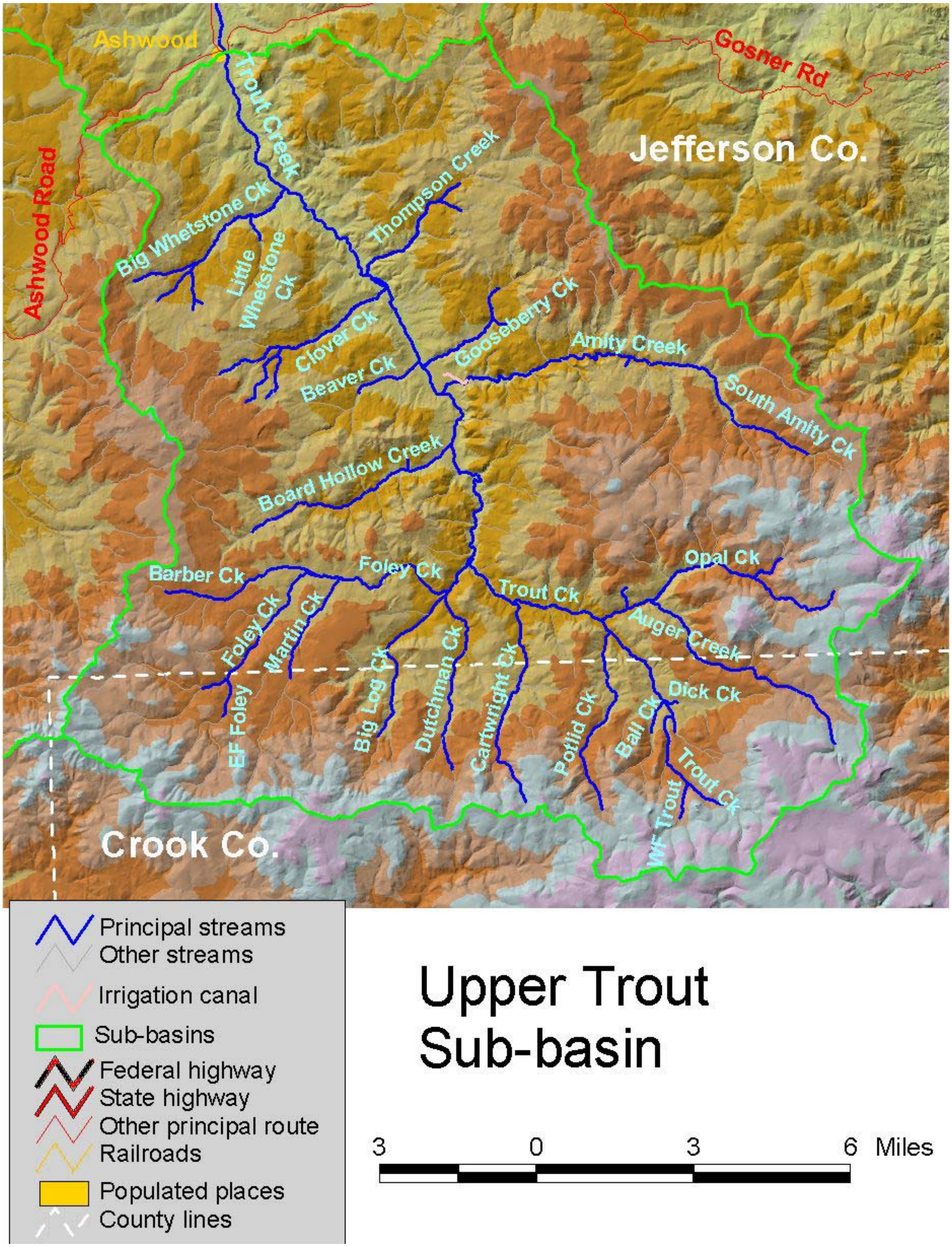


Figure 1-7. Key streams – Upper Trout sub-basin.

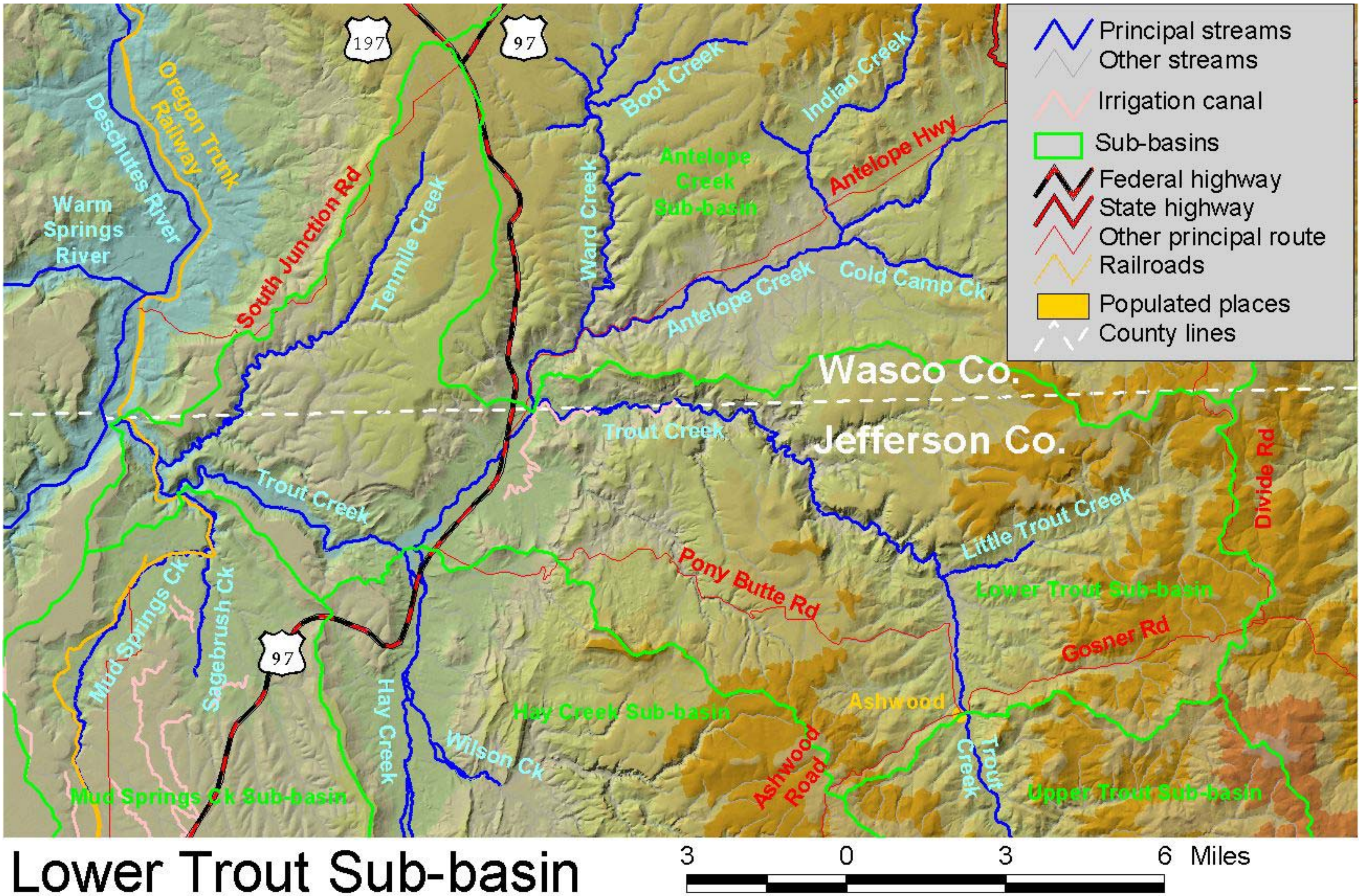


Figure 1-8. Key streams – Lower Trout sub-basin

1.2.5 Ecoregions

Information on level III and level IV ecoregions[3] found within the Trout Creek watershed was available from the US Environmental Protection Agency (EPA, 2001). Ecoregions denote areas of general similarity in the type, quality, and quantity of environmental resources (Pater et al., 1998). They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components (Pater et al., 1998). The underlying premise of this approach is that ecological regions can be identified through the analysis of the patterns and the composition of biotic and abiotic phenomena (e.g., geology, physiography, vegetation, climate, soils) that reflect differences in ecosystem quality and integrity. Level III and IV ecoregions found within the Trout Creek watershed are shown in Figure 1-9. A summary of areas by ecoregion is given in Table 1-5.

Historic upland vegetation conditions were similar within Level IV ecoregions 10c, 11a, and 11n; consisting primarily of bluebunch wheatgrass, Idaho fescue, rose, hawthorn, snowberry, hawkweeds, bitterbrush, and juniper (Watershed Professionals Network, 2001). Historic upland vegetation conditions within Level IV ecoregion 11b included grasses, ponderosa pine, Douglas fir, and true firs. Within Level IV ecoregion 11l historic upland vegetation consisted of Engelmann spruce, Douglas fir, true firs, lodgepole pine, ponderosa pine, and western larch.

Fires were the primary natural disturbances found in all of the Level IV ecoregions found within the Trout Creek watershed (Watershed Professionals Network, 2001). The U.S. Forest Service (USFS, 1999) estimates that historically fires were “very frequent” (0 to 25 years mean fire interval) in approximately half of the watershed (Antelope Creek subbasin and higher elevation areas of the Upper Trout, Hay Creek and Lower Trout subbasins), “frequent” (26 to 75 years mean fire interval) in approximately ¼ of the watershed (lower elevation areas of the Upper Trout, Hay Creek and Lower Trout subbasins), and “infrequent” (76 to 150 years mean fire interval) in the remaining ¼ of the watershed (Mud Springs Creek subbasin).

[3] Ecoregions are classified using a hierarchical system; Level III ecoregions are compiled at a coarser resolution than level IV ecoregions.

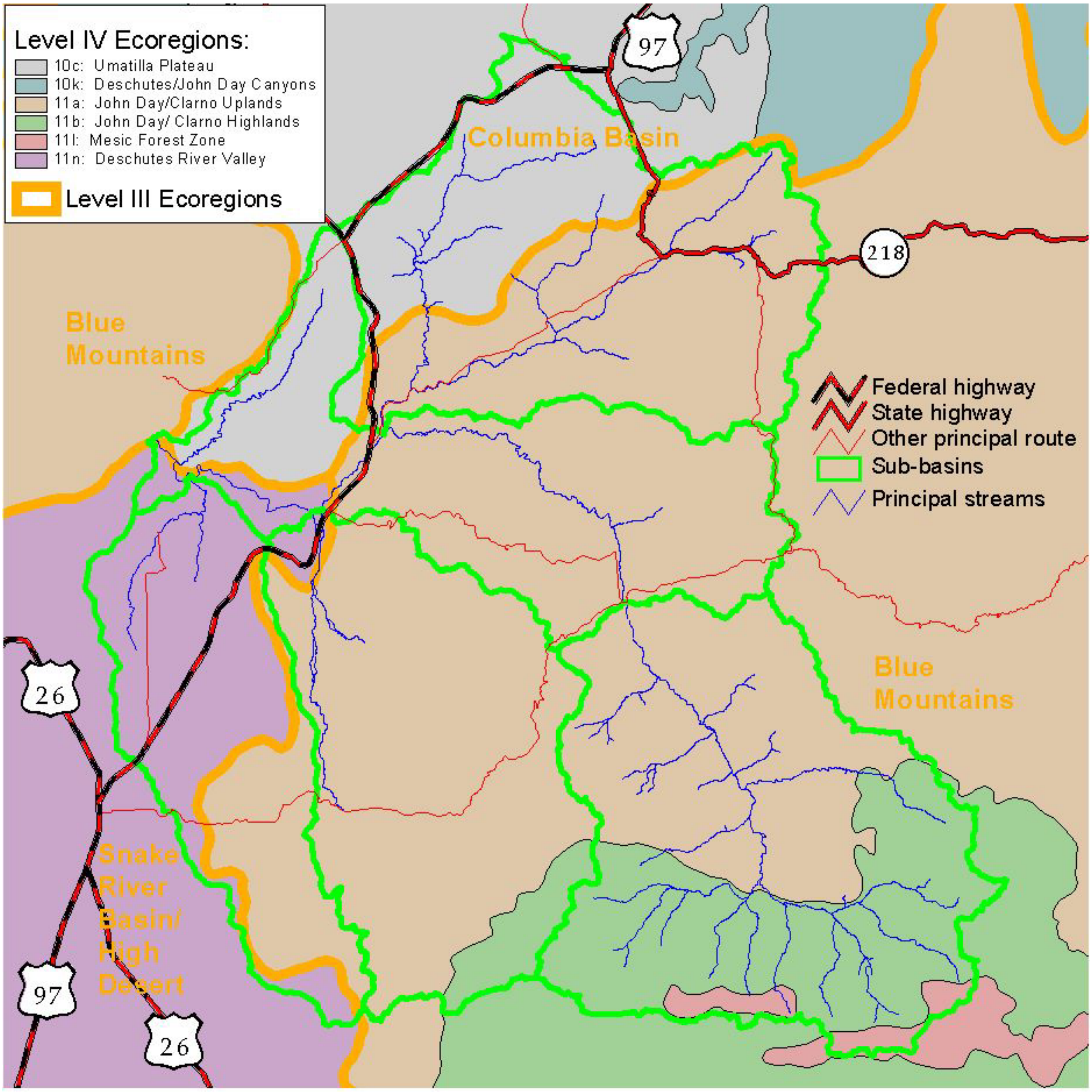


Figure 1-9. EPA Level IV ecoregions within the Trout Creek watershed. Refer to Table 1-5 for summary. Data source: US EPA GIS coverage, dated 2/20/01 (EPA, 2001).

Table 1-5. Summary of percent subbasin (and watershed) area by EPA Level IV ecoregion within the Trout Creek watershed. Data source: US EPA GIS coverage, dated 2/20/01 (EPA, 2001).

Subbasin	10c: Umatilla Plateau	11a: John Day/Clarno Uplands	11b: John Day/ Clarno Highlands	11l: Mesic Forest Zone	11n: Deschutes River Valley
Antelope Creek	39%	61%			
Mud Springs Ck		34%			66%
Hay Creek		89%	8%		3%
Upper Trout		50%	45%	4%	
Lower Trout	23%	71%			7%
Entire Watershed	13%	62%	13%	1%	11%

1.2.6 Geology

Information on surficial geology found within the Trout Creek watershed was available from the US Geological Survey (Walker and MacLeod, 1991). Surficial geology found within the Trout Creek watershed is shown in Figure 1-10, and summarized in Table 1-6. The geology of the watershed consists primarily of sedimentary and volcanic rocks. Volcanic basalts and andesites make up approximately ¾ of the watershed. Alluvial deposits make up only 1% of the watershed area.

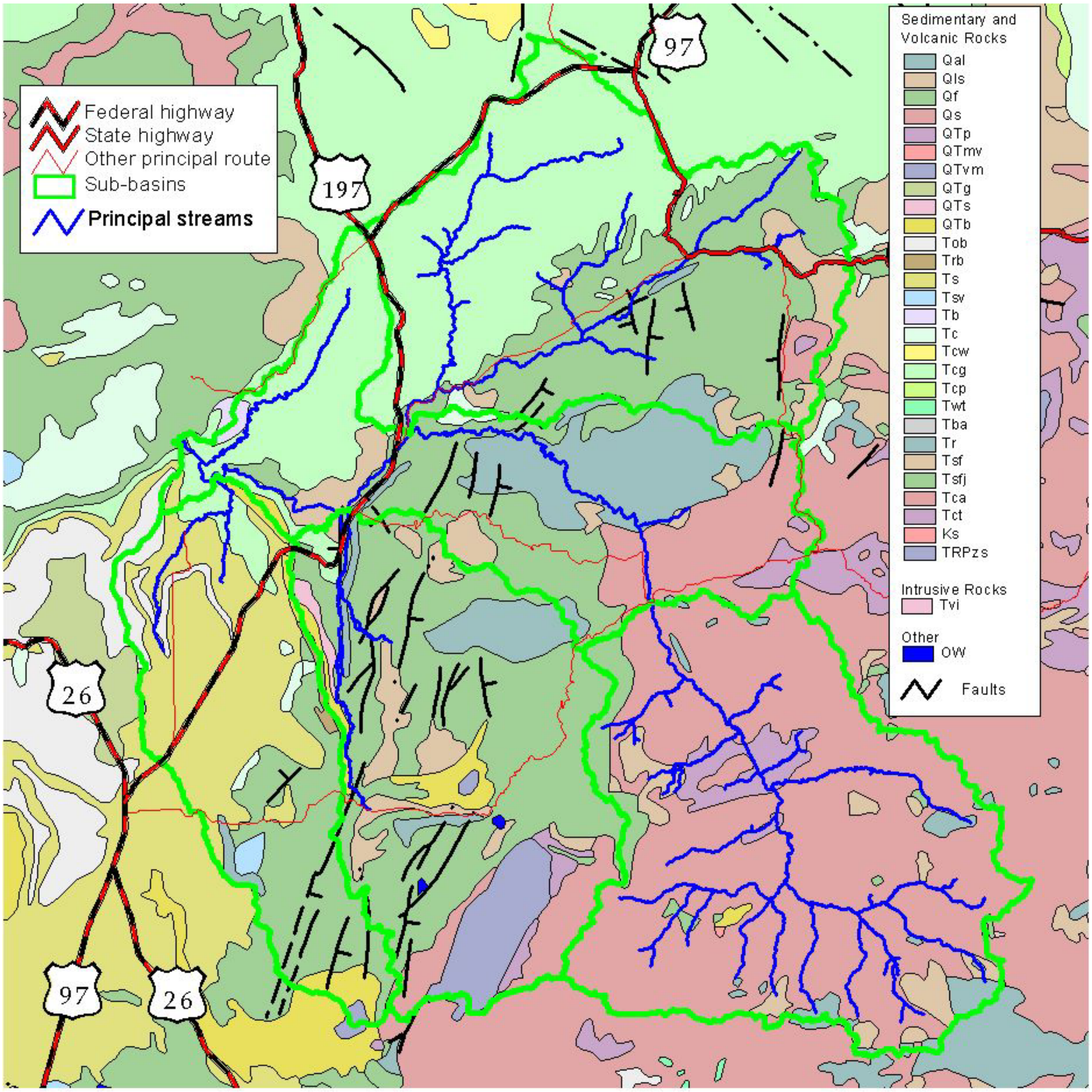


Figure 1-10. Surficial geology within the Trout Creek watershed. Refer to Table 1-6 for summary. Data source: (Walker and MacLeod, 1991).

Table 1-6. Summary of percent sub-basin (and watershed) area by geologic type within the Trout Creek watershed (Walker and MacLeod, 1991).

Map Symbol	Description (Age-Epoch)	Antelope Creek	Mud Springs Ck	Hay Creek	Upper Trout	Lower Trout	Entire Watershed
Sedimentary and Volcanic Rocks							
Qal	Alluvial deposits (Holocene)	0.4%	1.3%	2.2%	0.2%	1.3%	1.0%
QlS	Landslide & debris-flow deposits (Holocene & Pleistocene)	5.5%		8.9%	5.7%	7.0%	5.7%
QTmv	Mafic vent complexes (Pleistocene, Pliocene, & Miocene?)				0.1%		0.01%
QTvm	Mafic vent deposits (Pleistocene, Pliocene, & Miocene?)		0.5%	0.3%			0.1%
QTg	Terrace and pediment gravels (Pleistocene & Pliocene)		0.1%				0.01%
QTs	Sedimentary rocks (Pleistocene & Pliocene)			1.0%			0.2%
QTb	Basalt (Pleistocene & Pliocene)		4.7%	4.1%	0.3%	0.5%	1.6%
Tob	Olivine basalt (Pliocene & Miocene)		5.3%			0.1%	0.7%
Trb	Ridge-capping basalt & basaltic andesite (Pliocene & upper Miocene)		0.9%	0.2%			0.2%
Ts	Tuffaceous sedimentary rocks & tuff (Pliocene & Miocene)		48.2%	0.02%		0.4%	6.5%
Tsv	Silicic vent complexes (Pliocene, Miocene, & upper Oligocene)		1.2%				0.2%
Tb	Basalt (upper & middle Miocene)					0.6%	0.1%
Tc	Columbia River Basalt Group & related flows (Miocene)	0.9%	1.6%			0.6%	0.5%
Tcg	Grande Ronde Basalt (middle & lower Miocene)	47.4%	5.2%	1.1%		23.5%	16.0%
Tr	Rhyolite & dacite domes & flows & small hypabyssal intrusive bodies (Miocene to upper Eocene?)	1.9%		5.7%	3.2%	22.7%	6.6%
Tsfj	John Day Formation (lower Miocene, Oligocene, & uppermost Eocene?)	42.0%	30.6%	57.2%	4.3%	23.1%	30.4%
Tca	Clastic rocks & andesite flows (lower Oligocene?, Eocene, & Paleocene?)	1.7%	0.2%	8.4%	81.9%	18.2%	26.3%
Tct	Predominantly tuffaceouse facies of Clarno Formation (lower Oligocene? & Eocene)	0.2%		1.9%	4.5%	1.8%	1.9%
TRPzs	Sedimentary rocks, partly metamorphosed (Triassic & Paleozoic)			8.8%			1.8%
Intrusive Rocks							
Tvi	Mafic vent & intrusive rocks (Eocene?)				0.01%	0.1%	0.01%
Other							
OW	Open Water			0.2%			0.04%

1.2.7 Soils

Information on soils in the Trout Creek watershed is available from four separate sources (Figure 1-11). The majority of the watershed is covered by the 1975 Soil Survey of the Trout Creek-Shaniko Area (NRCS, 1975), and the 1999 Soil Survey of Upper Deschutes River Area (NRCS, 1999). Soil information for U.S. Forest Service (USFS) lands is available from the Ochoco National Forest Soil Resource Inventory (SRI) database (USFS, 1977). Soil information for the remaining area was obtained from the NRCS State Soil Geographic Database (NRCS, 2001a). Soils in the Trout Creek watershed are predominately loam in texture

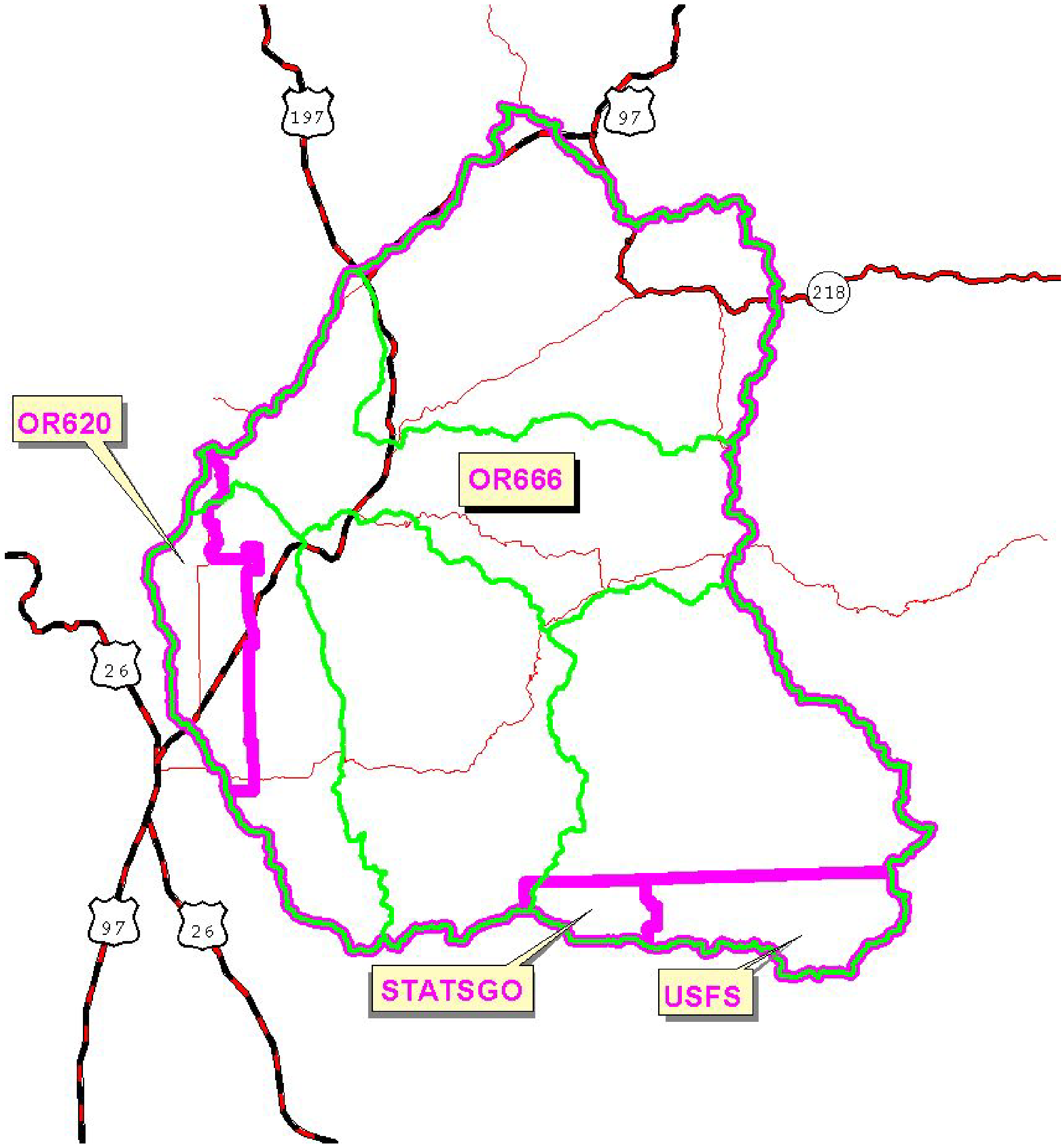


Figure 1-11. Sources of soil information for the Trout Creek watershed. The area shown as "OR620" is covered in the Soil Survey of Upper Deschutes River Area (NRCS, 1999). The area shown as "OR666" is covered in the Soil Survey of the Trout Creek-Shaniko Area (NRCS, 1975). The area shown as "USFS" is covered in the US Forest Service Soil Resource Inventory (SRI) database (USFS, 1977). The area shown as "STATSGO" is covered in the State Soil Geographic Database (NRCS, 2001a).

1.2.8 Climate

The Trout Creek watershed experiences interior climatic conditions typical of central Oregon. Climate data from several climate stations in and around the watershed (Figure 1-12, Table 1-7) was used to characterize conditions in the area.

Air temperatures vary throughout the area with elevation. Mean minimum air temperatures (Figure 1-13) occur in the months of December and January, and range from 20-25^{0}F. Mean maximum air temperatures (Figure 1-14) occur in the months of July and August, and range from the mid 70's to the mid 90's.

The Trout Creek watershed is located within the relatively dry region of Oregon east of the Cascade Mountains. Wintertime air masses moving over the Cascades warm as they descend in elevation, increasing their ability to retain moisture, resulting in less precipitation east of the Cascade crest than is seen on the west side (orographic effect). The Oregon Climate Service (1998) has published digital maps of mean annual and monthly precipitation for the State of Oregon, based on available precipitation records for the period 1961-1990. The Oregon Climate Service (OCS) maps were produced using techniques developed by Daly and others (1994), which use an analytical model that combines point precipitation data and digital elevation model (DEM) data to generate spatial estimates of annual and monthly precipitation. As such, the precipitation maps available from the OCS incorporate precipitation data from the local stations shown in Figure 1-12 and Table 1-7. For further information on how these maps are produced the reader is referred to Daly and others (1994), or the on-line overview available at http://www.ocs.orst.edu/prism/overview.html.

Mean annual precipitation within the watershed generally increases as elevation increases (Figure 1-15). Mean annual precipitation ranges from 8-10 inches near the mouth of the watershed to approximately 28 inches in the headwaters of Trout Creek (Figure 1-15).

Mean monthly precipitation for each subbasin was also estimated using data available from the OCS (1998) (Figure 1-16). Variation in mean monthly precipitation values are reflected in elevational differences among the subbasins. Mean monthly precipitation is lowest in the month of July for all subbasins (Figure 1-16), having a value of 0.3 inches for all subbasins except Upper Trout where the mean July precipitation is 0.6 inches. November has the highest values of mean monthly precipitation in all subbasins, ranging from 1.5 inches in the Mud Springs Creek subbasin to 2.2 inches in the Upper Trout subbasin.

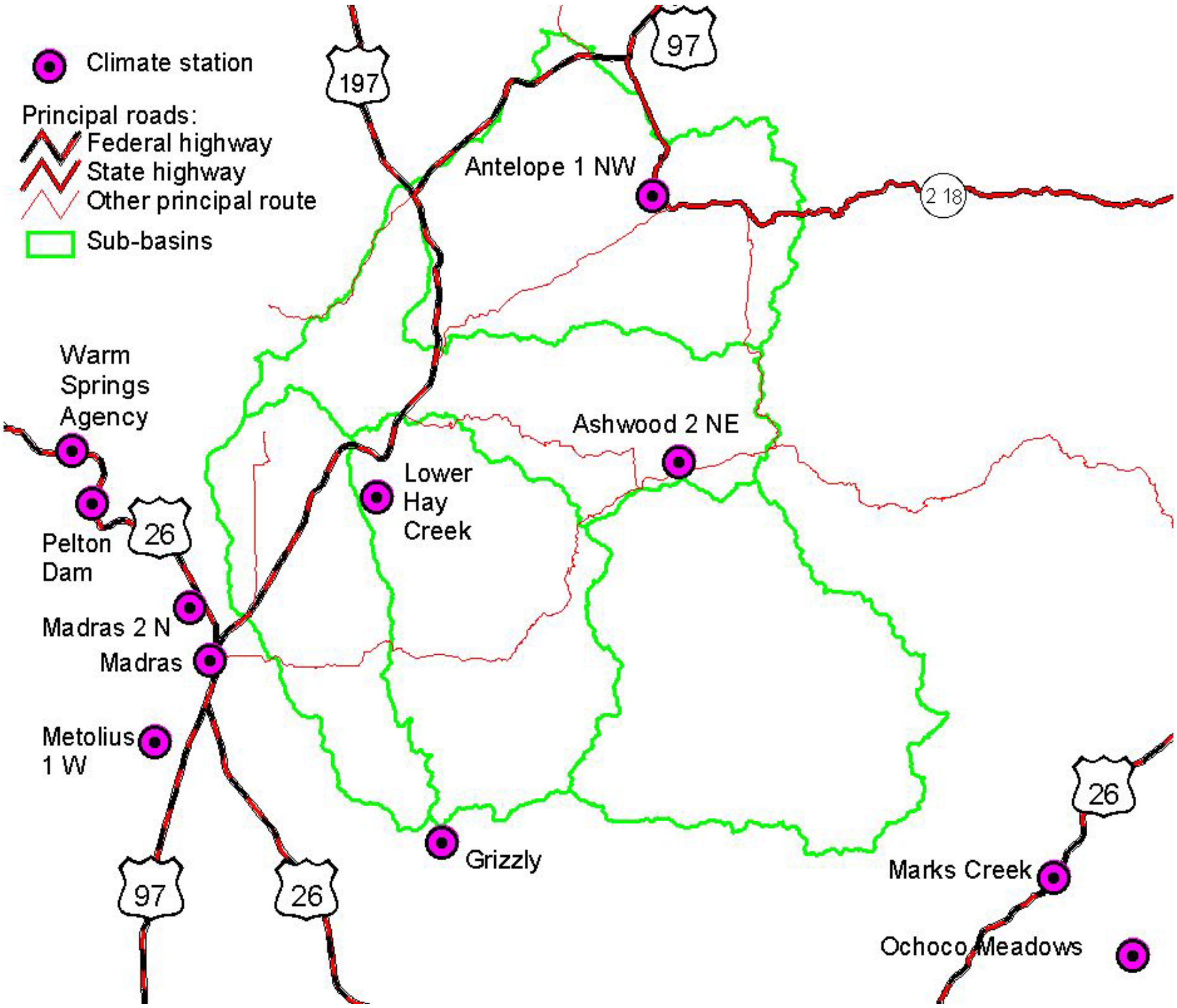


Figure 1-12. Climate stations in the vicinity of the Trout Creek watershed. Data sources: EarthInfo (1996), NRCS (2001b). There is a climate station near Foley Creek. The National Climate Data Center does identify a "Foley Butte" station, but because they do not collect data for this location it was not included with the list of sites.

Table 1-7. Station information for climate stations in the vicinity of the Trout Creek watershed. Data sources: EarthInfo (1996), NRCS (2001b).

Station Name	Elevation (feet)	Latitude	Longitude	Parameter:	Period of record	% cov.
Antelope 1 NW	2,839	44°55'N	120°44'W	Temperature: Snowfall: Precipitation:	1/1/1931 to 12/31/1995 1/1/1931 to 12/31/1995 1/1/1931 to 12/31/1995	(90%) (92%) (92%)
Ashwood 2 NE	2,819	44°45'N	120°43'W	Temperature: Snowfall: Precipitation:	1/19/1979 to 12/31/1981 7/1/1948 to 12/31/1995 7/1/1948 to 12/31/1995	(2%) (94%) (95%)
Grizzly	3,634	44°31'N	120°56'W	Temperature: Snowfall: Precipitation:	7/1/1948 to 12/31/1995 7/1/1948 to 12/31/1995 7/1/1948 to 12/31/1995	(90%) (93%) (93%)
Lower Hay Creek	1,887	44°44'N	120°58'W	Snowfall: Precipitation: (100%)	7/1/1948 to 12/31/1995 7/1/1948 to 12/31/1995	(97%)
Madras	2,229	44°38'N	121°08'W	Temperature: Snowfall: Precipitation:	1/1/1928 to 12/31/1995 1/1/1928 to 12/31/1995 1/1/1928 to 12/31/1995	(97%) (98%) (98%)
Madras 2 N	2,439	44°40'N	121°09'W	Temperature: Snowfall: Precipitation:	2/20/1952 to 12/31/1995 2/20/1952 to 12/31/1995 2/20/1952 to 12/31/1995	(63%) (63%) (63%)
Metolius 1 W	2,502	44°35'N	121°11'W	Temperature: Snowfall: Precipitation:	8/4/1948 to 11/30/1993 9/1/1948 to 11/30/1993 9/1/1948 to 11/30/1993	(95%) (97%) (97%)
Pelton Dam	1,411	44°44'N	121°14'W	Temperature: Snowfall: Precipitation: (100%)	8/4/1958 to 12/31/1995 8/1/1958 to 12/31/1995 8/1/1958 to 12/31/1995	(98%) (93%)
Warm Springs Agency	1,503	44°46'N	121°15'W	Temperature: (100%) Snowfall: (100%) Precipitation: (100%)	11/1/1948 to 5/31/1949 11/1/1948 to 5/31/1949 11/1/1948 to 5/31/1949	
Marks Creek Snow course	4,540	44°29'N	120°24'W	First-of-month Snowpack:	1/1/1938 to 5/1/2000	
Ochoco Meadows SNOTEL	5,200	44°26'N	120°20 W	Temperature: Precipitation: (100%) Snowpack: (100%) (100%)	6/15/1989 to 9/30/2000 10/1/1980 to 9/30/2000 10/1/1982 to 9/30/1983 10/1/1984 to 9/30/2000	(98%)

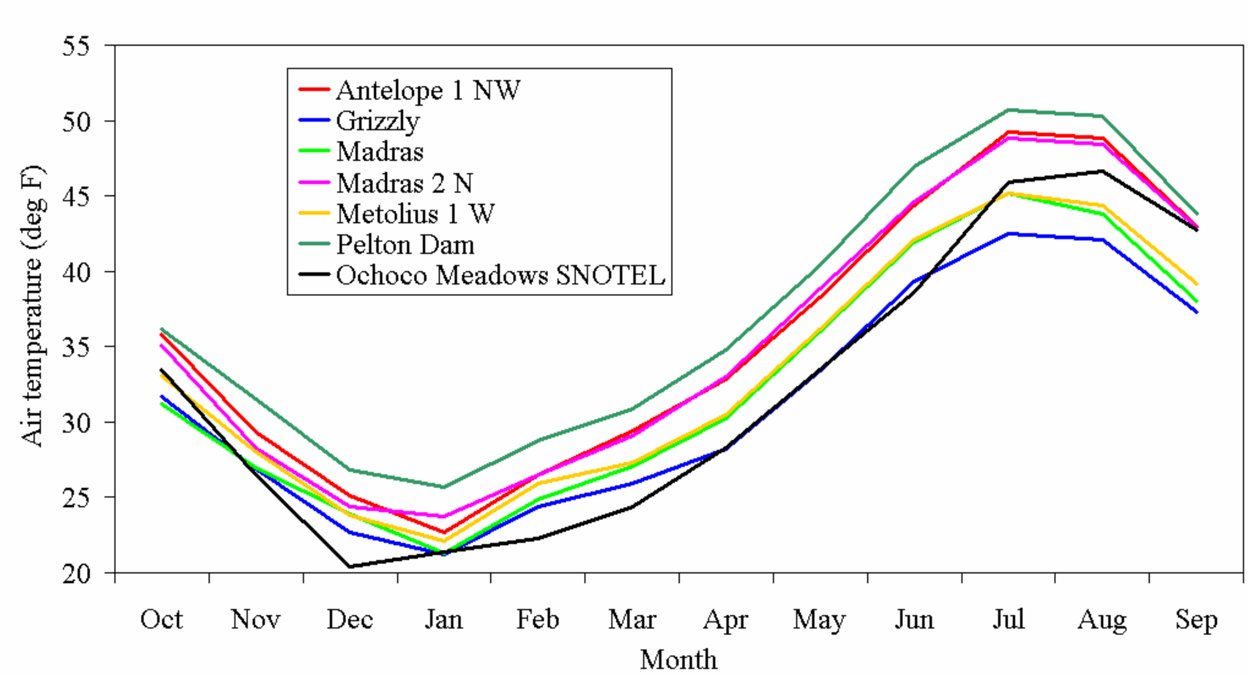


Figure 1-13. Mean minimum air temperatures for climate stations in the vicinity of the Trout Creek watershed. Refer to Figure 1-12 and Table 1-7 for location and data availability.

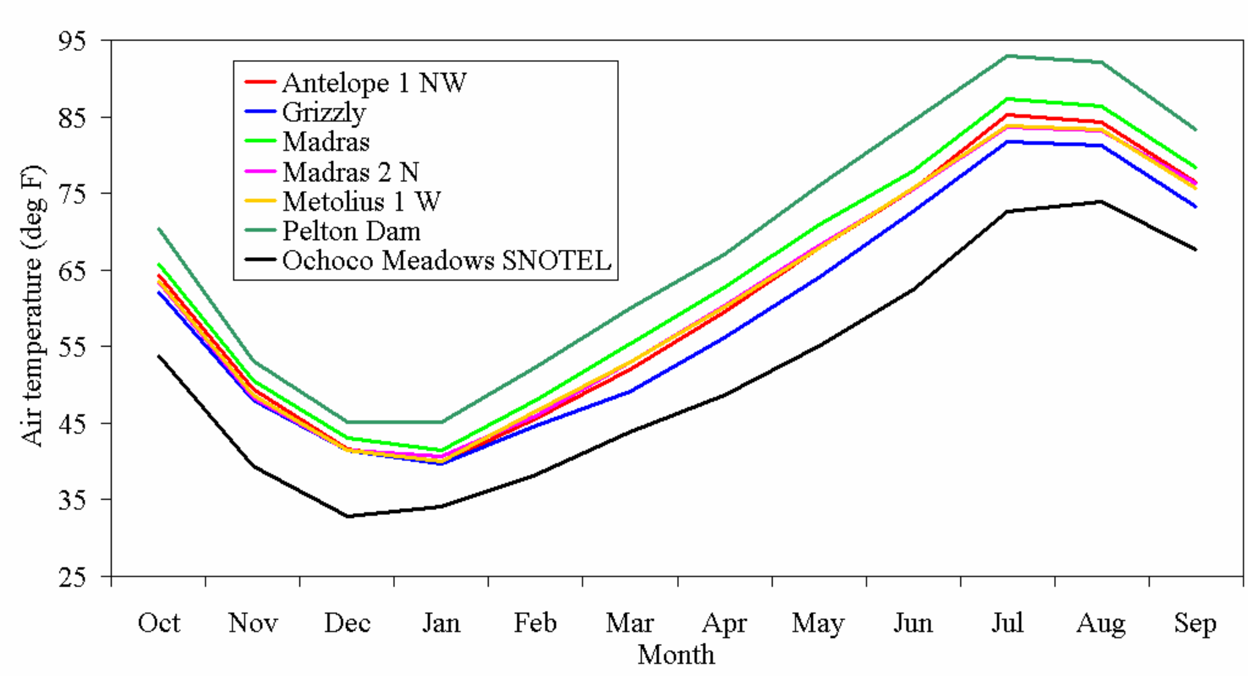


Figure 1-14. Mean maximum air temperatures for climate stations in the vicinity of the Trout Creek watershed. Refer to Figure 1-12 and Table 1-7 for location and data availability.

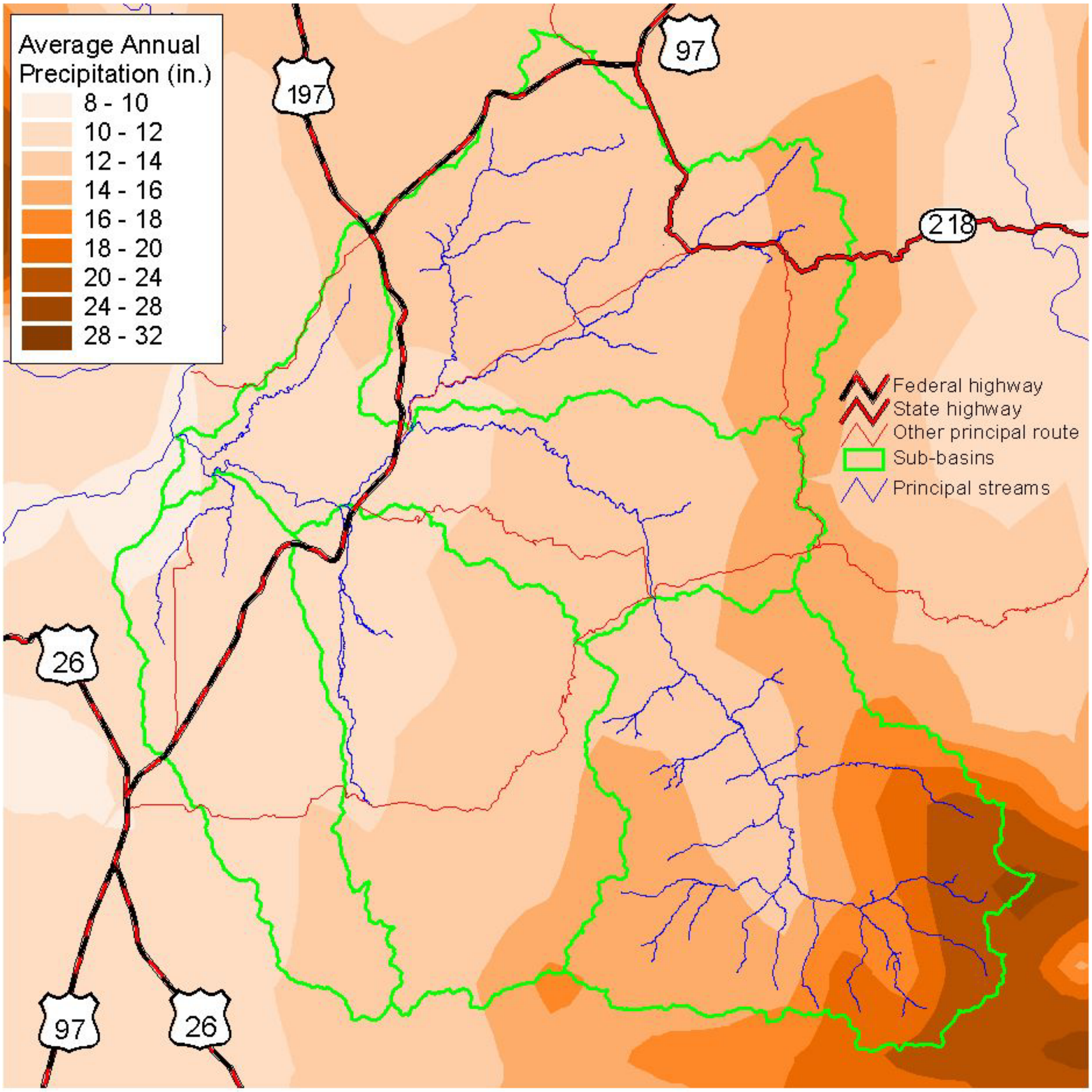


Figure 1-15. Average annual precipitation in the Trout Creek watershed. Data source: Oregon Climate Service (1998).

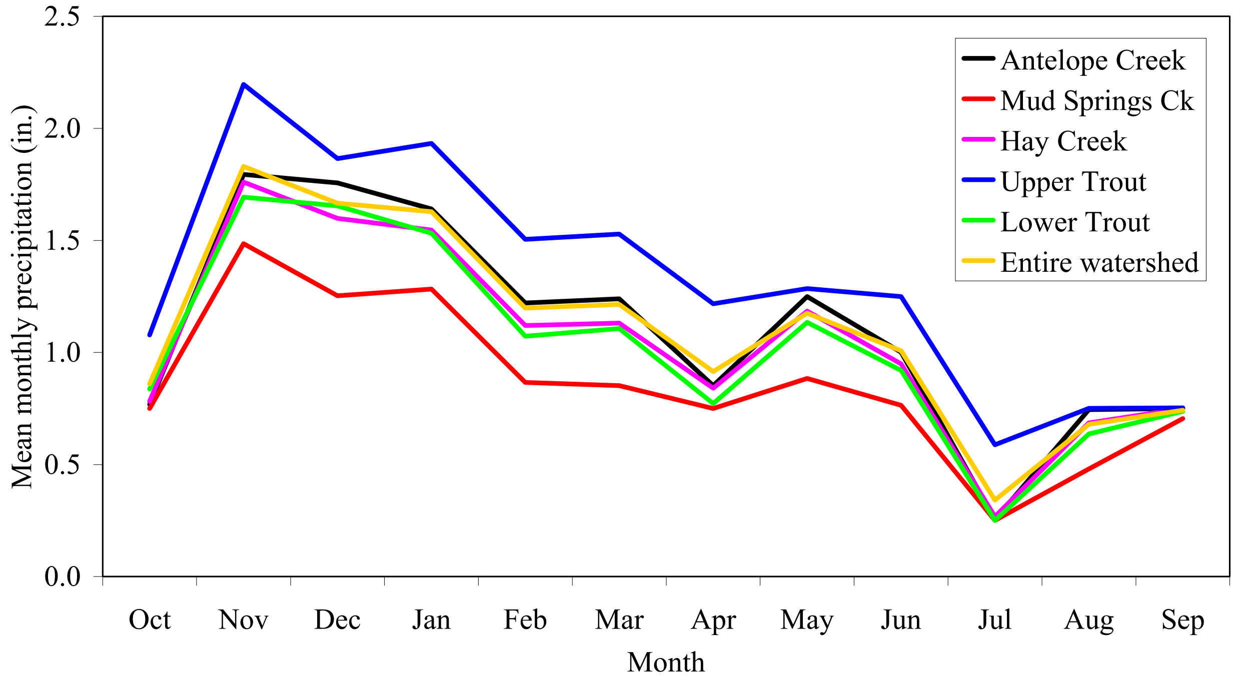


Figure 1-16. Mean monthly precipitation by subbasin within the Trout Creek watershed. Data source: Oregon Climate Service (1998).

Year-to-year variability in precipitation was assessed using long-term precipitation records from the Madras climate station (Figure 1-12, Table 1-7). Total monthly precipitation data available from the OCS (2001) was used to calculate total precipitation by water year (Figure 1-17). Missing values were estimated from Metolius 1W climate station data (Figure 1-12, Table 1-7) which correlated well with the Madras station data (monthly precip. @ Madras = 0.9155 * monthly precip. @ Metolius 1W) + 0.0632; $r^2 = 0.90$).

The two primary patterns of climatic variability that occur in the Pacific Northwest are the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). The two climate oscillations have similar spatial climate fingerprints, but very different temporal behavior (Mantua, 2001). One of the primary characteristics distinguishing these trends are that PDO events persist for 20-to-30 year periods, while ENSO events typically persist for 6 to 18 months (Mantua, 2001). Several studies (Mantua et al., 1997; Minobe, 1997; and Mote et al., 1999) suggest that five distinct PDO cycles have occurred since the late 1800's (Table 1-8). Changes in Pacific Northeast marine ecosystems have been correlated with PDO phase changes. Warm/dry phases have been correlated with enhanced coastal ocean productivity in Alaska and decreased productivity off the west coast of the lower 48 states, while cold/wet phases have resulted in opposite patterns of ocean productivity (Mantua, 2001).

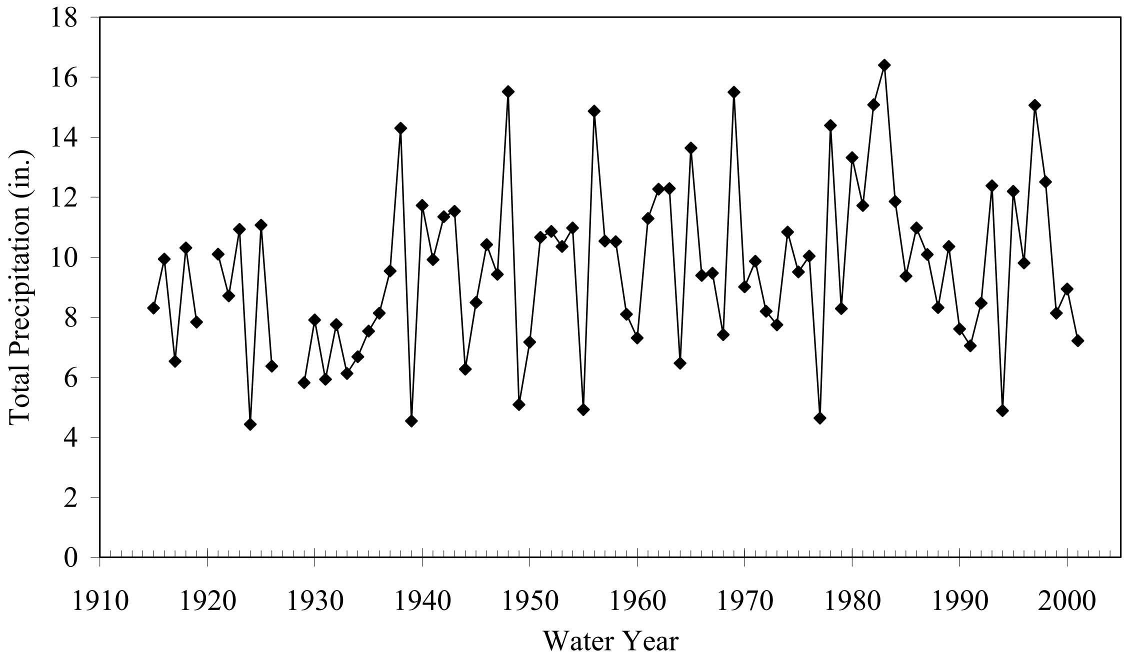


Figure 1-17. Annual precipitation at the Madras weather station.

Table 1-8 Recent Pacific Decadal Oscillation (PDO) cycles in the Pacific Northwest Data Sources: Mantua et al. (1997), Minobe (1997), Mote et al (1999).

PDO cycle	Time period
Cool/wet	1890-1924
Warm/dry	1925-1946
Cool/wet	1947-1976
Warm/dry	1977 –1995
Cool/wet	1995 – present (estimated)

Statistical techniques were applied to the annual precipitation record available from the Madras climate station to understand whether local trends follow the documented PDO cycles. Data from this station was processed in the following manner:

1. The mean and standard deviation was calculated for the annual precipitation at each station over the period of record

2. A standardized departure from normal was calculated for each year by subtracting the mean annual precipitation from the annual precipitation for a given year, and dividing by the standard deviation

3. A cumulative standardized departure from normal was then calculated by adding the standardized departure from normal for a given year to the cumulative standardized departure from the previous year (the cumulative standardized departure from normal for the first year in a station record was set to zero).

This approach of using the cumulative standardized departure from normal provides a way to better-illustrate patterns of increasing or decreasing precipitation over time by reducing year-to-year variations in precipitation, thus compensating for the irregular nature of the data set. Values for the cumulative standardized departure from normal increase during wet periods and decrease during dry periods. Results for the Madras station are given in Figure 1-18.

Precipitation patterns from the Madras station (Figure 1-18) generally follow the documented regional trends (Table 1-8). The warm/dry phase that is regionally reported to have lasted until 1946 appears to have ended sometime around 1937, and the following cool/wet phase appears to have lasted from 1937 to 1987. A short-warm/dry phase appears to have occurred from approximately 1987 – 1994, and we currently appear to be in a cool/wet phase, however, data are not conclusive.

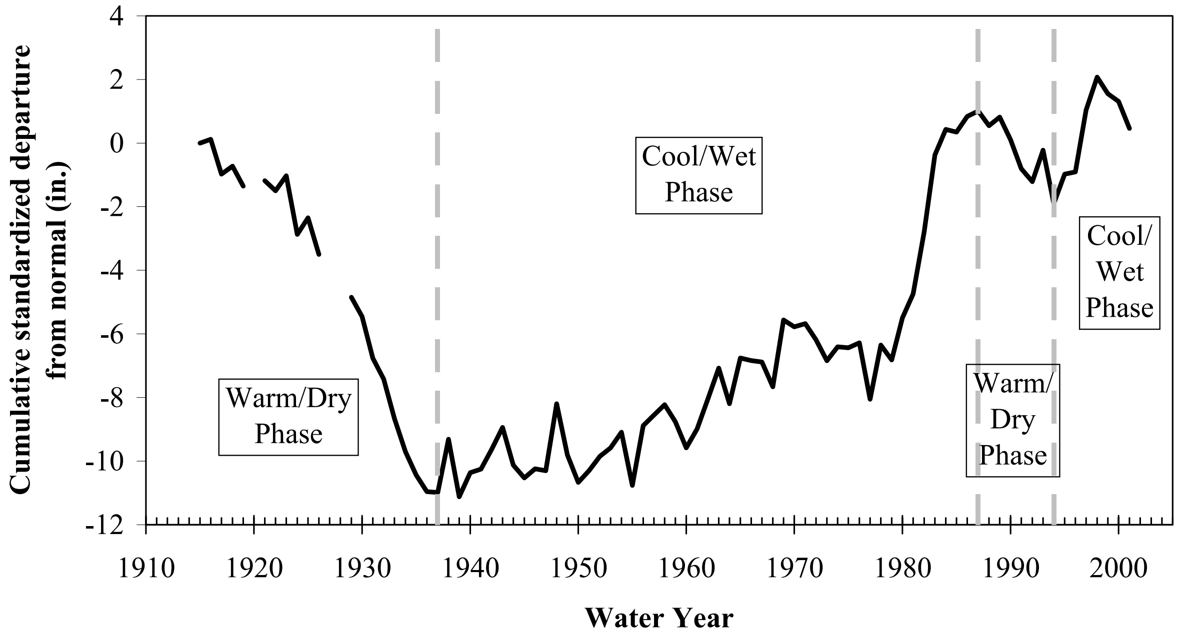


Figure 1-18. Cumulative standardized departure from normal of annual precipitation for the Madras weather station. Local PDO cycles are shown as vertical dashed lines.

Data on snowfall (i.e., depth of snow independent of snow density) and snowpack (i.e., depth of snow on the ground, expressed in terms of snow water equivalent or SWE) are available from several stations in the vicinity of the Trout Creek watershed (Figure 1-12, Table 1-7). Mean monthly snowfall is shown in Figure 1-19, and snowpack is shown in Figure 1-20. Unfortunately, snowfall data are not available for the higher elevation areas, and snowpack data are unavailable for lower elevation areas. Consequently, a direct comparison of the two data sources is not possible. However, several points can be made based on the data presented in Figure 1-19 and Figure 1-20: The amount of snowfall is proportional to elevation, and occurs from the month of October to June, with the highest snowfall occurring in the month of January. On average, snowpack increases through the winter months, reaching maximum values during the month of March, after which snowpack decreases. Snowpack is generally gone sometime during the month of May.

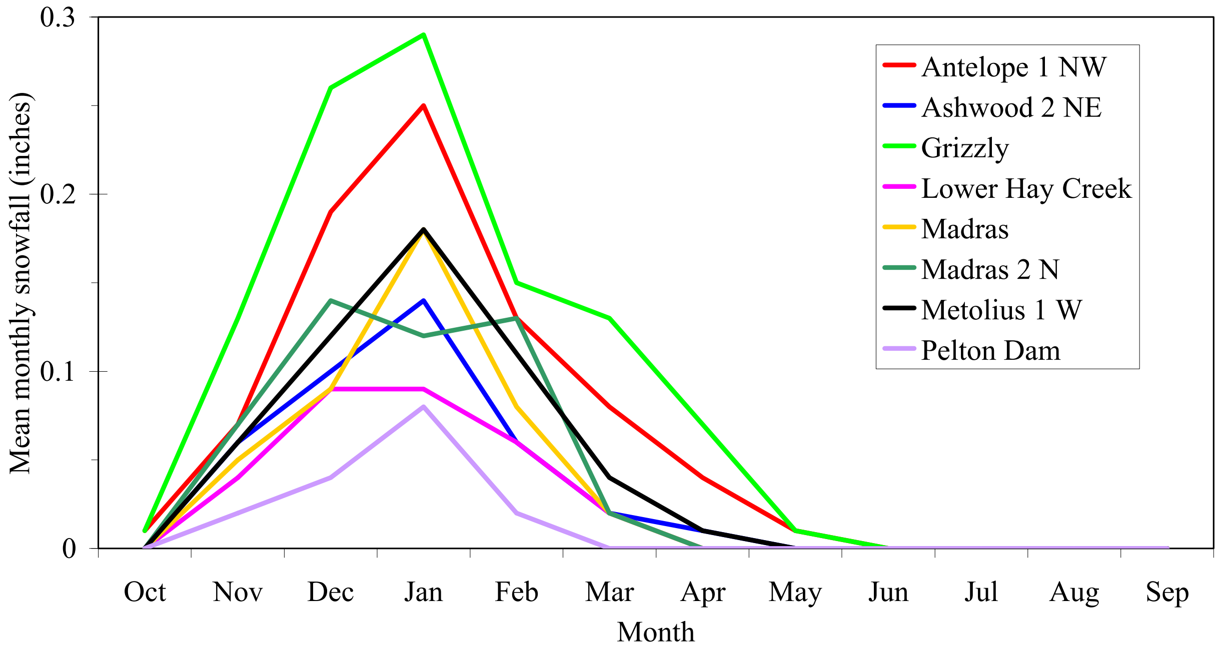


Figure 1-19. Mean monthly snowfall for climate stations in the vicinity of the Trout Creek watershed. Refer to Figure 1-12 and Table 1-7 for location and data availability.

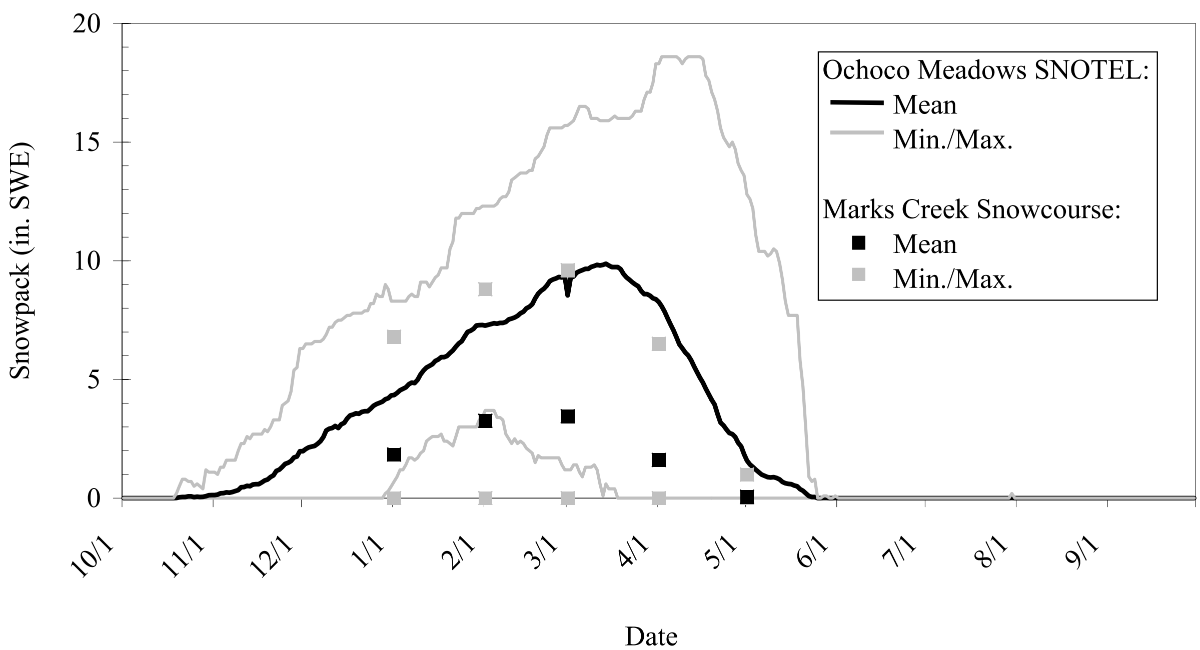


Figure 1-20. Snowpack (in inches of snow-water equivalent) at climate stations in the vicinity of the Trout Creek watershed. Refer to Figure 1-12 and Table 1-7 for location and data availability.

1.2.9 Previous Studies

The following is a partial list of previous studies pertaining to the watershed that were used as information sources for this assessment. The study name and the geographical extent of the study are presented in Table 1-9. A short description of each study, and the study components that were found to be useful in this assessment, follows Table 1-9. Other sources of information are cited within the individual assessment components.

Table 1-9. Summary of previous studies available for the Trout Creek watershed.

Study Name (references)	Geographical extent
A reconnaissance report on the Trout Creek watershed (Wheeler, 1969):	Trout Creek Watershed upstream of Antelope Creek
Trout Creek Riparian Rehabilitation (Northwest Biological Consulting, 1983; 1984)	Entire watershed (limited to the downstream portions of principal tributaries)
Trout Creek Survey Summary (Farthing, 1987):	Approximately 10 miles of the Trout Creek mainstem, and approximately 13 miles of tributary streams all located in the Upper Trout Creek subbasin.
Trout Creek Watershed Analysis Report (USFS, 1995):	The portions of the Upper Trout Creek watershed upstream of Foley Creek, and the Foley Creek drainage itself.
Trout Creek Watershed Resource Inventory, Problem Assessment and Treatment Alternatives (Edlund and Penhollow, 1996):	The Antelope subbasin, Upper Trout subbasin, and the portion of the Lower Trout subbasin upstream of Antelope Creek. Also included is the mainstem Trout Creek corridor downstream to the mouth.
Trout Creek Watershed Stream Habitat Surveys (Oregon Department of Fish and Wildlife, 1998)	Stream channel habitat inventories for selected reaches of Trout Creek and tributary streams (See section 8.0, Fisheries).
Trout Creek Wetlands and Stream Restoration Study (USBR, 1999):	The Upper Trout Creek subbasin

1.2.9.1 A reconnaissance report on the Trout Creek watershed (Wheeler, 1969):

This report is an evaluation of the potential for development of irrigation storage reservoirs in Trout Creek upstream of Antelope Creek. The report provides a brief description of the watershed, a discussion of water-related problems, and an evaluation of its water supply. The report provides analysis of two potential reservoir sites upstream of Ashwood; the “Cow Camp” site, located upstream of Boardtree Creek, and the “Hillgrade” site, located approximately four miles upstream of Ashwood.

Information from this report that was useful in the present analysis included results of a channel loss survey along the mainstem of Trout Creek

1.2.9.2 Trout Creek Riparian Rehabilitation (Northwest Biological Consulting, 1983; 1984):

These reports were part of a three-phase enhancement plan for Trout Creek and its principal tributaries. Phase 1 (Northwest Biological Consulting, 1983) consisted of a preliminary study including air photo interpretation of stream, riparian, and upland conditions, as well as a compilation of watershed characteristics (e.g., climate, geology, hydrology, etc.). Phase 2 (Northwest Biological Consulting, 1984) presented results of field inventories and conceptual habitat enhancement plans. The Phase 2 report makes mention of a forthcoming Phase 3 document that was to include landowner participation for development of a final enhancement plan, however, this document was not provided to our assessment team, and it is not clear if it was ever completed.

Information from this report that was useful in the present analysis included summaries of riparian vegetation conditions, stream shading, upland vegetation conditions, and hydrologic conditions in the watershed.

1.2.9.3 Trout Creek Survey Summary (Farthing, 1987):

This unpublished report is a compilation of field data collected during the summer of 1987 using the same methodologies as described in Northwest Biological Consulting (1983). These surveys cover streams that are all located in the Upper Trout Creek subbasin, and include the Trout Creek mainstem from river mile (RM) 35.75 to 45.2; Barber Creek from RM 0.0 - 2.0, Board Hollow Creek from RM 0.0 - 3.50; Beaver Creek from RM 0.0 - 1.0, Poison Hollow from RM 0.0 - 0.50; Amity Creek from RM 0.0 - 6.25; and Studhorse Ck from RM 0.0 - 0.25.

Information from this report that was useful in the present analysis included summaries of riparian vegetation conditions and stream shading.

1.2.9.4 Trout Creek Watershed Analysis Report (USFS, 1995):

This report, published by the Ochoco National Forest, covers watershed conditions in the portions of the Upper Trout Creek watershed upstream of Foley Creek, and within the Foley Creek drainage itself. Although this document was prepared as a management tool for National Forest lands in the watershed it does, to the extent possible, include conditions on private lands in the assessment area. The document summarizes historic, current, and desired future conditions for vegetation (both upland and riparian), water quantity and quality, and fisheries.

Information from this report that was useful in the present analysis included background information on the watershed, evaluations of riparian and upland vegetation conditions, summaries on water quality conditions (primarily temperature), and some analysis of hydrologic conditions in the watershed.

1.2.9.5 Trout Creek Watershed Resource Inventory, Problem Assessment and Treatment Alternatives (Edlund and Penhollow, 1996):

This document, created with landowner input, and assembled by the Jefferson County SWCD, is a compilation of historic and current resource conditions in the Antelope subbasin, Upper Trout subbasin, and the portion of the Lower Trout subbasin upstream of Antelope Creek. Also included is the mainstem Trout Creek corridor downstream to the mouth.

Information from this report that was useful in the present analysis included the historical overview (including damage from the 1964 flood); a compilation of land ownership in the area; general vegetation descriptions; descriptions of climatic conditions and soils; overviews of crop production; descriptions of forest, livestock, wildlife and fish resources; a summary of noxious weeds; an analysis of peak flow changes attributable to land use for 10 subwatersheds; and a summary of water use. The document includes objectives for future watershed management, a list of problems and concerns, and a series of proposed treatments to address these concerns.

1.2.9.6 Oregon Department of Fish and Wildlife Stream Habitat Inventories, 1998:

Stream channel habitat inventories were conducted on selected reaches of Trout Creek (where there was landowner approval) and tributaries. See Section 8.0, Fisheries, for description of habitat inventories and map of locations.

1.2.9.7 Trout Creek Wetlands and Stream Restoration Study (USBR, 1999):

This document was created to address late summer stream flows in the Upper Trout Creek subbasin. The document identifies a series of potential opportunities for capturing early-season stream flows for storage in wetlands and stream bank aquifers, and subsequent release during the late summer period.

Information from this report that was useful in the present analysis included a description of the project area (including streamflow measurements), generic descriptions of potential enhancement projects, specific locations where projects could be applied, and considerations for project implementation (e.g., maintenance, costs, monitoring, etc.).

2.0 HISTORICAL CONDITIONS

CONTRIBUTED BY MARIE HORN, JEFFERSON COUNTY SOIL AND WATER CONSERVATION DISTRICT

2.1 INTRODUCTION

This chapter summarizes available information on historic and current land use effects on the natural watershed of Trout Creek. While the Trout Creek watershed has been altered and restoration to pre-settlement is not an option, knowledge of historic and current conditions and the cumulative effects of land use can help guide restoration actions and improve chances for success.

Documentation for this chapter is a summarized account of the information found in the Confederated Tribes of Warm Springs, re-licensing application, summarized accounts from the "Jefferson County Reminiscences"; "The History of Jefferson County" and "Shaniko".

Historical Timeline

Period	Event
10,000 B.P.	Native Indians resided in the land and used the Trout Creek watershed for hunting, foraging and Gathering
5,960 BP	An very early pithouse found in the Willowdale area, dated between 5,000 and 5,960 BP
1820's	First European fur trappers and traders from Hudson Bay Co. entered the area. Later Peter Skene Ogden, Finan McDonald, Nathaniel Wyath's party, John C Fremont and Kit Carson all came through the area.
1856	Hostilities escalated between the area Indian tribes and the new settlers coming into the area. The Government issued an order for no settlement east of the Cascades.
1858	Gen Harney revoked the restriction to settle East of the Cascades
1866-1868	Gen. George Cook, for whom Crook County was named, engaged the troops against Indians
1862	Felix and Marion Scott punched a freight road into the territory and built the first cabin in the territory as a winter camp to care for the livestock
1868	First documented ranch was settled at Willowdale by Bidwell Cram. It was also believed to be a part of the original holdings of the early cattle barons Teal and Coleman
1868	It is believed that the stockmen began to use Trout Creek in earnest after this year. Water and forage was abundant in the area

1873	Dr David Baldwin of Oakland, Calif established the Hay Creek Ranch, touted worldwide as the "greatest Merino sheep breeding station in the world. Wool became a major economic commodity
1874	Tom Hamilton was the first to breed, raise and introduce Shorthorn cattle to this part of Oregon. Once he grazed 7,500 head of sheep and 200 head of cattle
1890	In 1890 Charles Durham built the second sawmill in the Trout Creek area at Blizzard Ridge. The mill produced lumber used by settlers to build cabins, and other buildings in Madras, Hay Creek, Shaniko, Antelope and Ashwood
1896	Gold was discovered in Trout Creek and the first mining company was formed
1898	Ashwood post office was established and named for the local ash buttes and Whitfield T Wood, a settler from the 1870s
1897	Silver discovered by sheepherder Thomas Brown
1899	Ashwood was platted as a town by James Woods to accommodate gold/silver miners, it had 15 blocks. It boomed as the cinnabar (mercury) and silver mines around it flourished.
1902	4,000,000 pounds of wool, 400 railroad cars of cattle and 1,688,00 bushels of wheat were shipped from Shaniko
1910	The railroad was built that passed thru Gateway to Madras and points south, that served an important stockyard at Gateway
1914	Jefferson County was carved out of Crook County
1908-1916	There was a rush for homesteading in Trout Creek
1923	Modern paved highway completed
1934-1940	Mercury mining was at its peak.
1964	Major flooding event over a vast region of Jefferson County. Corps of Engineers “straightened” the channel along portions of Trout Creek. (500 yr + event)
1972	Major flood event
1973	Agate beds become a popular attraction and business venture
1996	Major flood event
1996	Major fire event 25,000-30,000 acres of rangeland (August)
1997	Major flood event (May)
1998	Major flood event (May)

2.2 HISTORICAL NARRATIVE

Much of the Trout Creek history has been lost for lack of recording and in the passing of many of the early settlers who actually lived the history. A lot of the creeks, springs, hills, and canyons are named for early settlers.

2.2.1 Prehistoric: (summarized from the Confederated Tribes of Warm Springs re-licensing study)

These summaries are from Jefferson County, as there is little pre-historic information available on Trout Creek alone. It is agreed among the landowners and the Confederated Tribes of Warm Springs that tribal hunting, fishing, and gathering tasks were conducted in the Trout Creek watershed for many, many years.

North Central Oregon has been inhabited for at least 12,000 years, but only very recently has archeological research begun to reveal the rich patterns of pre-European contact human life. Because of its links with adjacent areas, the prehistory of central Jefferson County is best interpreted within the framework of archaeological data from north-central Oregon in general.

Early inhabitants were probably mobile foragers, following herds of now extinct herbivores, such as mammoth. Evidence points to small bands of people organized as to kinship ties. Their dependency was largely on prey animals, with less specialized knowledge of other animals, plants, and mineral resources in the territory.

A later age shows sparse habitation with the economy of the inhabitants depending less on large animals and more on a broader range of animals and plants. Historical sites are usually found in direct association with streams, ponds, and marshes and generally show short terms of inhabitation. Foraging territories shrank, meaning the groups traveled less. Human populations increased substantially only where fresh winter foods were available in large quantities.

Historical site locations apparently were chosen for their proximity to a variety of resources, particularly mammals, (such as deer, elk and big horn sheep), anadromous fish, and roots that could be gathered efficiently in extensive rocky soil on the hillslopes and the flat ground in between canyons.

2.2.2 Pre-European Settlement

A key find of a very early pithouse in the Willowdale area, dated between 5,000 and 5,960 BP. This house apparently reflects the new land use strategy of diminished residential mobility of past trends. This also reflects the elevated reliance of stored foods. The strategic change of land use accommodated the growth of the population of these peoples. Population peaked initially at Willowdale because the locality was blessed with the best variety of plant and animal foods, some well suited to storage. Local game resources were insufficient to feed residential groups in the winter. Hunting and gathering was probably within a days walk, and residential moves were most likely to have occurred as the resources were depleted. Additional proof of the presence of Indian culture can be found in and around the Currant Creek area, with pictographs, arrowheads and other artifacts having been found over a large range of the watershed.

2.2.3 First Euro-American Contacts: (summarized from the Confederated Tribes of Warm Springs re-licensing study) (Excerpts from Jefferson County Reminiscences and History of Jefferson County)

Fur traders from the Hudson's Bay Company were the first Euro-Americans in the Deschutes region arriving in the 1820s. Early explorers included Peter Skene Ogden who led one group south from the Columbia River, while Finan McDonald crossed the Cascades from the west. The two met around the confluence of the Deschutes, Metolius, and Crooked rivers near the present day town of Metolius. From here they proceeded up the Crooked River. In 1826, Ogden ventured downstream along the Deschutes. John C Fremont of the U S Army started from The Dalles and followed the Deschutes River to its headwaters. Kit Carson served as guide on this expedition. Due to the rugged canyons of the Deschutes River, transportation corridors remained undeveloped. Nathaniel Wyath's party made a detour into the Trout Creek region in 1834. Early settlement was limited to miners and cattlemen until after the 1860s.

It is hard to determine when the earliest settlers first came to Trout Creek, but it appears the inland community did not begin to settle extensively until 1868.

Indians along the Columbia River, including the Wasco Chinookans and the Sahaptin speaking people later referred to as Tenino or Warm Springs, signed an 1855 treaty with the United States. Known collectively as the Tribes and Bands of Middle Oregon, these groups settled upon the Warm Springs Reservation prior to treaty ratification by Congress in 1859. The Paiutes were placed onto the reservation in approximately 1879. The treaty tribes ceded over 10 million acres to the United States in exchange for exclusive use of their reservation lands, and hunting, fishing, pasturing, and gathering rights on their ceded and aboriginal lands. An 1865 supplemental treaty attempted to limit their access off the reservation and impose a farming lifestyle on the Indians. This latter treaty was never implemented, enforced, or observed by any government. Overall, most of the reservation land is not conducive to agriculture, with lands favorable for crop production located on small parcels along the creeks and rivers. Through subsistence farming, ranching, traditional food gathering, and the exercise of off-reservation rights, the tribes garnered enough resources during the early years on the reservation for survival.

2.2.4 Historic Land Use: (summarized from the "Jefferson County Reminiscences", Jefferson Co. Library Association (1957); "The History of Jefferson County") and "Shaniko", Helen Rees 1982.

One early settler was Bidwell (Bud) Cram, it was the first place owned and developed on Trout Creek and most likely the first in Central Oregon. This place was also the original holdings of the large cattle barons of early history, Teal and Coleman. It was said that at one time, Cram owned and operated 20,000 acres, besides his cattle roaming over a vast portion of the country.

Trout Creek enters a deep gorge and opens out to meadows and hay land that is the backbone of cattle production. At Cow Canyon, settlers could rest overnight for an early start up the steep grades. A toll gate located half way up the canyon allowed all freight and travel to pass through to reach areas of Trout Creek and beyond.

The first road was punched in Trout Creek by Felix and Marion Scott in 1862 for moving freight wagons and cattle to the Salmon River Mines in Idaho. They also built the first cabin in the territory as a winter camp to care for the livestock. Because of the abundance of available grasses in the Trout Creek watershed, it was a popular place to hold cattle, sometimes as overwintering grounds. Some of the first to hold cattle in the territory were Scotts, Cunsil, Richie, and John B. Evans. John B Evans described the land in Trout Creek as having grass that grew high and rank. Hay could be cut anywhere in the Trout Creek/Blue Mountains. Wild timothy, pea vine, grew 3 ft high and pine grass 18 inches high. Bunch grass would make a ton an acre. There were only a few settlers in the area and practically all were engaged in hunting. The game was plentiful and the skins and dried meat was sold in The Dalles. The chief game was deer, elk, and bear. In pioneer days an enormous amount of deer, both mule and whitetail were killed for market within the territory (which afterwards became Crook County) for the hides and hams alone. Sage hens, antelope, prairie chickens, and grouse were plentiful, as was trout. He stated his brother caught 50 trout in one day of fishing the Deschutes.

Dr. David Baldwin of Oakland, Calif established the Hay Creek Ranch in 1873, touted worldwide as the "greatest Merino sheep breeding station in the world." Wool from the Trout

Creek area moved slowly by freight wagons up the Little Trout Creek, through Antelope to Shaniko for shipping. The original ranch started with 160 acres and grew to several thousand acres. Dr. Baldwin used his fields to grow the some of the first alfalfa in Oregon. The Parrish family settled above the Baldwin ranch and grew vegetables and fruit to sell to neighbors. Over the years, special breed of sheep were developed and sold world-wide. They proved to be a heavy wool bearing breed. Besides the large flocks of sheep, the ranch at one time supported up to 2000 head of cattle. Hay Creek was the first ranch to install a sheep shearing plant. In its first year of operations, 42,000 sheep were sheared. By 1910, government land was being withdrawn from free range activities and the Hay Creek Ranch began to sell off large numbers of sheep. Wool from the Trout Creek area moved slowly by freight wagons up the Little Trout Creek, through Antelope to Shaniko for shipping. Tom Hamilton settled above Ashwood on Trout Creek and was the first to breed and raise purebred Shorthorn cattle in this part of Oregon. At one time it is estimated he grazed as many as 7,500 sheep and 200 head of cattle. Several families settled Trout Creek in the 1870's.

In the 1870s all traffic into central Oregon, east to Burns, and south to Lakeview passed through Antelope. Charles Durham built the second sawmill in the Trout Creek area at Blizzard Ridge in 1890. The mill produced lumber used by settlers to build cabins, and other buildings in Madras, Hay Creek, Shaniko, Antelope, and Ashwood. Gold was discovered in 1896 by a sheepherder named Wilson who was herding sheep on the Jones Ranch. Gold discovery prompted the establishment of the Oregon King Mining Co which operated off and on again over a long period of time, due to litigation and changes in ownership. Over the years, hundreds of mining claims were filed, but no rich fields were ever developed. Even before Wilson found the quartz float, as early as 1884, W.T Wood discovered sulphate ores containing valuable minerals and was one of the leaders in opening the Ashwood mines. There were no rich fields discovered, despite the fact that the sulphate ores held gold and silver. Silver was discovered in 1897 by a sheepherder named Thomas Brown.

During 1908-1916 there was a rush of homesteading in the Ashwood area. Every 160 acres were filed upon in that era, with springs and creeks placed under fencing. The homesteaders were people from all parts of the 48 states. Thornton, Johnson, Nartz and Swanson are still names that reside and take care of the land in the Pony Creek area. Water was a real problem for the homesteaders. In many instances water had to be hauled in barrels for household use as well as for livestock. Ward Farrell built the first dam on Pony Creek, and so had an abundance of water for cattle and irrigation on a garden scale.

New settlers coming to the Pony Butte area found a vast amount of rangeland. First, land was cleared of sagebrush, juniper, and rocks. Many times they brought livestock, prepared to stay. A few came only with the intention of "proving up" on the homestead in compliance with government regulations and then selling to the cattlemen. Several landowners ran large bands of sheep in the watershed.

The Ashwood post office was established in 1898 and named for the local ash buttes and Whitfield T Wood, a settler from the 1870s. The post office served 85 persons. James Wood was the first postmaster of Ashwood and also developed mines around the area.

No passable road appeared in the community until 1919 when the county constructed a road through the Pony Creek Canyon, which came out at the foot of Pony Butte and then joined the Ashwood-Gateway market road. In 1910, the railroad was built up through the canyon into Gateway on through to Madras and points south. A railroad depot was located here and used by stockmen. 1903 saw settlers in the northwest end of the Gateway boundary. Gateway shows signs of a time in history where a large lake formed and was eventually filled with brown sediment, signs of which are still visible today. Mud Springs derived its name from springs up in the hills where, in the early days, livestock were watered. The early 1900's found settlers coming to the area to homestead. By 1905 most of the land had been filed on at the land office in The Dalles.

Homesteaders found the land covered with sagebrush, bunch-grass, and juniper trees. Lumber for housing was hauled from the mills at Grizzly. Homesteaders hauled water in barrels, covered with canvas, later many dug cisterns and hauled water in tanks. Water came from Sage Brush Springs, and the Perry Henderson place. With the coming of the railroad, a well was developed one mile north of Madras and homesteaders used this source for a time. About 1912, C.V. Duling put down a well and sold water to the neighbors. Trout Creek was first used for irrigation in 1877.

"Shaniko:" In the early days large amounts of wool were shipped from Shaniko, it was the largest shipping port for wool in the US. In 1902, it was estimated that 4,000,000 pounds of wool, 400 railroad cars of cattle, along with an estimated 1,168,866 bushels of wheat were shipped from Shaniko. It was estimated that one sheep yielded 10-18 pounds of wool. The major sheep raising ranch was Hay Creek Ranch, with an estimated flock of 50,000 head. Twelve to fifteen thousand ewes were bred each year at Hay Creek Ranch, with four thousand rams being sold annually. At one time, the ranch employed 70-100 men to care for the sheep and to put up hay. In the early 1900s, the ranch consisted of approximately 27,000 acres. Hay Creek Ranch also ran 1500-2000 head of cattle. The ranch grew approximately 6,000 tons of alfalfa in meadows that produced large yields. Hay Creek Ranch provided the first sheep shearing plant, with 42,000 head sheared the first year. Large bands of wild horses were also shipped from Shaniko to Portland refineries.

At one time rabbits were so prolific that rabbit drives were conducted by local ranchers and Indians; rabbits were driven into corrals and slaughtered. Even before gold and the silvery metal (mercury) were discovered in the Ashwood area, its rich history largely concerned livestock raising. Stockmen were naturally attracted to the southwest area due to the grassy, green hills and abundant water from timbered mountains. The first stockmen in the area used it as an over-winter stop.

Discovery of an outstanding mercury mine in 1934 in the Horse Heaven region was a viable operation up until the 1940s, when there was a drastic drop in the market. In 1954, the mining resumed as the price for mercury soared.

2.3 CHANNEL MODIFICATION (SUMMARIZED FROM THE TROUT CREEK WATERSHED RESOURCE INVENTORY)

A large accumulation of snow over frozen ground, followed by rapid warming and heavy rains caused widespread flooding throughout eastern Oregon in December 1964. Trout Creek completely inundated the Willowdale valley and dropped the streambed by 10 feet in places due to headcutting and channel widening. Many of the cut banks are visible today. A major channelization project by the Corps of Engineers followed the 1964 flood and the resultant berms have interfered with stream function by disconnecting streams from the floodplains. The berms were constructed in 1965, reaching from the mouth of Trout Creek to Degner Canyon, from Degner Canyon to Boardhollow Creek.

Major flooding occurred in the Trout Creek Watershed after heavy winter rains in late December 1996 and spring of 1997.

3.0 CHANNEL HABITAT TYPE CLASSIFICATION AND CHANNEL MODIFICATION

3.1 INTRODUCTION

This section of the watershed analysis presents the results of the classification of stream channel habitat types (CHT) within the Trout Creek Watershed. The type, magnitude, and location of modifications to the channel network are also presented. Finally, some recommendations are given with respect to improvement in channel and aquatic habitat conditions. Channel typing is a key component in any watershed analysis as it can be used as a guide to understanding aquatic habitat conditions and directions for possible restoration activities. Typing is based on the widely held assumption that stream channels possess specific physical characteristics resulting from the interaction of geologic, climatic, and vegetative inputs (Montgomery and Buffington, 1993). Based on the processes that define the channel, it is possible to classify the complex array of channel types found within a watershed. As channel types are defined by similar geomorphic processes, they can be expected to possess similar physical characteristics and respond in a similar manner to changes within the watershed. Watershed changes affect channels primarily through the natural or man caused alteration of the supply of water, sediment, or wood. While it may not be possible to quantify the precise nature of channel response, the similarity in geomorphic processes does allow for some degree of predictive capability with respect to channel change.

3.2 METHODS

The methods employed to complete this portion of the watershed analysis are found in the Oregon Watershed Assessment Manual (OWEB, 1999). Due to the large size of the watershed, some changes to the methodology presented in the manual are necessary.

The channel typing methods outlined in the manual rely heavily on the stream attributes of gradient, confinement, and stream size. Confinement is defined as the relationship of the bankfull channel width to that of the floodplain. Primary sources of information to aid in channel typing and modification assessment include 1:24000 USGS topographic maps, data and reports from the US Forest Service (USFS) and 1998 habitat surveys form the Oregon Department of Fish and Wildlife (ODFW), miscellaneous reports on watershed condition and history, and discussions with agency personnel and landowners familiar with current and past watershed conditions. Due to budget constraints and private land access, only limited checking of field conditions was undertaken.

3.3 CRITICAL QUESTIONS

In order to guide the assessment, a number of critical questions were developed during project scoping.

- What are the dominant channel forming and maintenance processes in different parts of the watershed?
- What is the distribution of channel habitat types in the watershed?
- What is the location of channel habitat types most sensitive to changes in the watershed?
- What portions of the channel network are likely sites for restoration?
- What are the locations and relative magnitude of channel modifications?

3.4 RESULTS

The results of the channel investigation are organized to address the critical questions.

3.4.1 What are the dominant channel forming and maintenance processes in different parts of the watershed?

The Trout Creek Watershed contains a wide variety of channel types ranging from steep headwater streams to low gradient, wide floodplain channels. The following paragraphs describe by subbasin general channel types as well as channel forming and maintenance processes.

In the Antelope Creek subbasin, approximately 54% of the channel network is composed of moderate gradient (2-8%), confined channels. Very few high gradient channels exist in the basin. As such, much of the channel network acts as a transport system for small to medium sized sediment. Soils tend to be shallow, resulting in low infiltration rates and high runoff rates during snowmelt and high intensity storms.

Channels converge to form a low gradient, moderately confined channel set in a wide alluvial valley. Given the low gradient of the valley, this area likely acted as a sediment deposition zone with the channel migrating laterally across the valley floor. Over time, the channel has been confined through various modifications, and the channel has downcut, becoming entrenched and isolated from the floodplain. Elsewhere in the Antelope subbasin, channels are moderate gradient very tightly confined systems flowing through bedrock canyons. This relatively unreactive channel type is common in much of the lower Ward Creek drainage.

In the Hay Creek and Mud Springs subbasins, much of the channel network is composed of moderate gradient confined channels that have entrenched into a subtle landscape underlain by deep loam soils. Stream power is very low, with most of the channel network dry during the summer months. Deep soils and the subtle terrain likely promote lower runoff rates than elsewhere in the basin. In addition, a significant amount of the channel network has been channelized to control flow or aid in irrigation. This is especially true in the Mud Springs basin.

Much of the Upper Trout Creek subbasin contains moderate to high gradient (>6 %) headwater streams that act as source and transport areas for small, medium, and occasionally large size sediment. This region is forested, with large woody debris (LWD) playing a significant role in the formation and maintenance of aquatic habitat features such as pools and sorted spawning gravel. Streams flow through soils derived from volcanic flows and ash deposits. As such, there is an abundant supply of fine-grained material available for transport. Short, low gradient reaches where channels flow through wetland meadows are also present, such as those in the Foley Creek drainage. In these low energy systems, deposition of all sizes of sediment fosters channel splitting and highly sinuous channels with beaver ponds.

These upper Trout Creek tributaries converge to form the mainstem of Trout Creek approximately 12 miles above Ashwood. Through the Ashwood valley to the top of Degner Canyon, the channel is a low gradient (about 2%) stream set in a wide alluvial valley. The stream is moderately confined, and historically likely possessed a wider floodplain than present today. Short reaches of bedrock canyon are present in this area as well. Deposition and transport of sediment both occur in this reach, with numerous lateral bars present. Berms placed in the mid 1960's have greatly influenced channel form, although erosion of the berms has occurred as the stream tries to reestablish a functional floodplain. In many places, significant downcutting and bank erosion in response to the berms and alteration of riparian conditions and flow regimes has occurred. This type of channel also exists in the Willowdale area below the bedrock confined transport reaches of Degner Canyon. The smaller streams that flow into the central and lower portions of Trout Creek drain moderate to steep basins underlain by shallow volcanic soils. Runoff rates are fairly high for these lands, and transport of fine sediment is significant during runoff events.

3.4.2 What is the distribution of channel habitat types in the watershed?

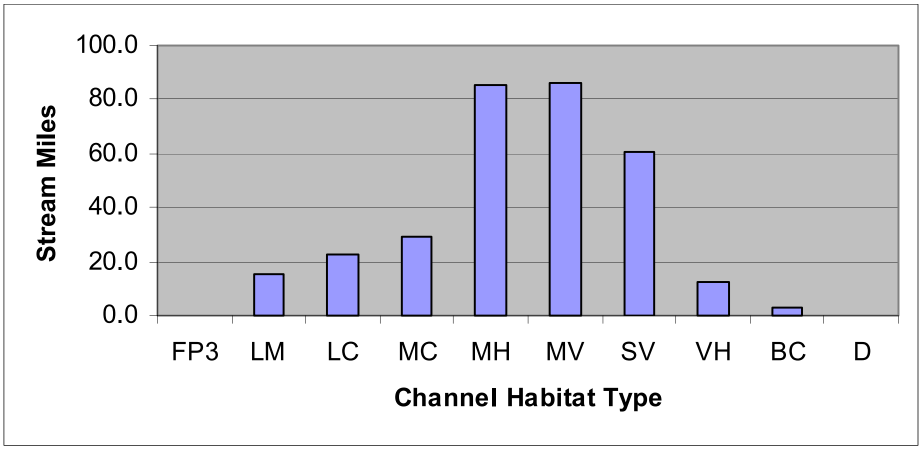
The channel network is divided into channel types as described in the OWEB Watershed Assessment Manual (OWEB, 1999). Channel types have been assigned based on the current channel condition. presents by subbasin the distribution of the various channel types followed by Figures 3-1 through 3-5 displaying this information in graphic form. Maps displaying the location of all channel types are available in GIS format at the Jefferson County Soil and Water Conservation District office in Redmond, Oregon. Figure 3-6 presents the location of the LM channel types as they are identified as likely locations for preservation or enhancement (see Section 3.4.4). In addition to the standard channel types presented in the manual, the Table lists a number of channel "types" not identified in the Manual. These include type D (channelized stream sections) and type IRR D (constructed irrigation ditches). These types are listed in order that all water features are accounted for in terms of mileage totals in the watershed. The IRR D channels are not discussed further with respect to channel process, sensitivity, or restoration potential.

Table 3-1. Trout Creek watershed channel habitat type distribution (miles).

Channel Habitat Type Code	Channel Habitat Type Description	Rosgen Channel Type	Antelope Creek	Mud Springs Creek	Hay Creek	Upper Trout Creek	Lower Trout Creek
FP3	Low gradient small floodplain	C	0	0	0	1.0	0
LM	Low gradient moderately confined	C,E	15.4	0	0	15.0	13.5
LC	Low gradient confined	F,B,G	22.5	19.3	31.0	4.0	11.6
MC	Moderate gradient confined	B,G	29.0	49.5	32.4	39.0	36.9
MH	Moderate gradient headwater	B,C	85.3	43.2	16.8	22.4	20.7
MV	Moderately steep narrow valley	A,B	85.9	60.9	105.4	72.3	86.7
SV	Steep narrow valley	A,B	60.3	22.4	62.7	127.2	47.7
VH	Very steep headwater	A	12.6	7.7	8.5	57.0	11.3
BC	Bedrock canyon	A1,G1	2.7	0	0	2.0	19.3
D	Channelized stream		0	16.7	7.4	0	0.5
IRR D	Constructed irrigation ditch		0	41.6	0	0.5	5.8

As is evident from the data in 3-1, approximately 55% of the channel network is composed of moderate gradient (2-8%) relatively confined channels. The vast majority of steep (>8%) headwater channels are located in the Upper Trout Creek subbasin.

Figure 3-1. Antelope Creek channel habitat type distribution.



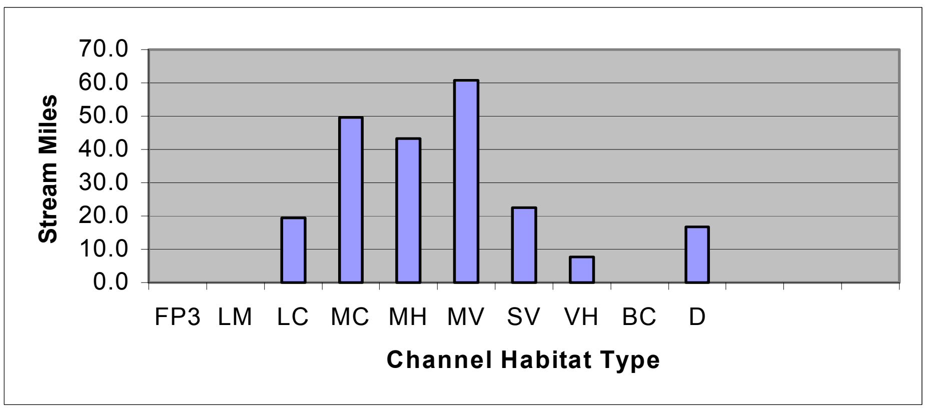


Figure 3-2. Mud Springs Creek channel habitat type distribution.

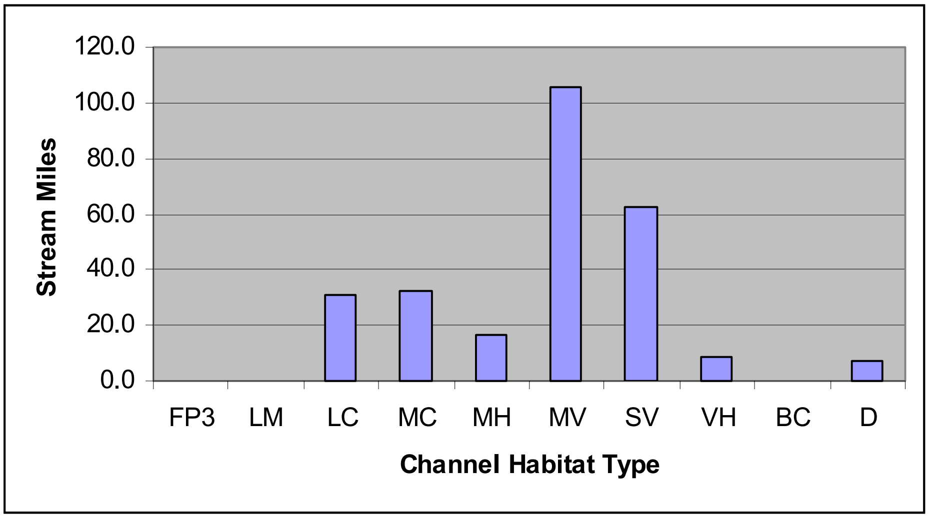


Figure 3-3. Hay Creek channel habitat type distribution.

Figure 3-4. Upper Trout Creek channel habitat type distribution.

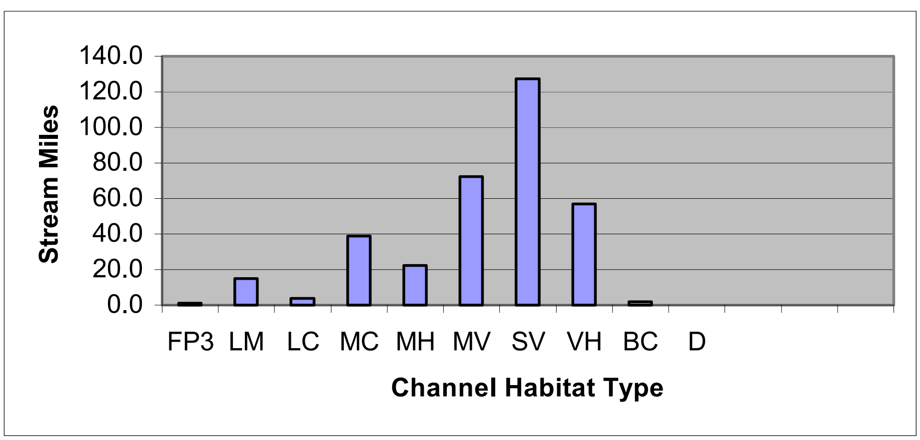


Figure 3-5. Lower Trout Creek channel habitat type distribution.

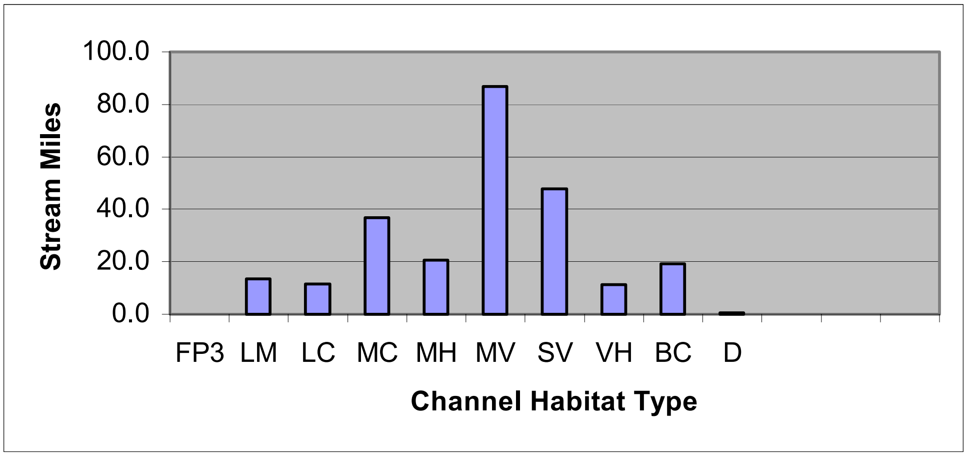
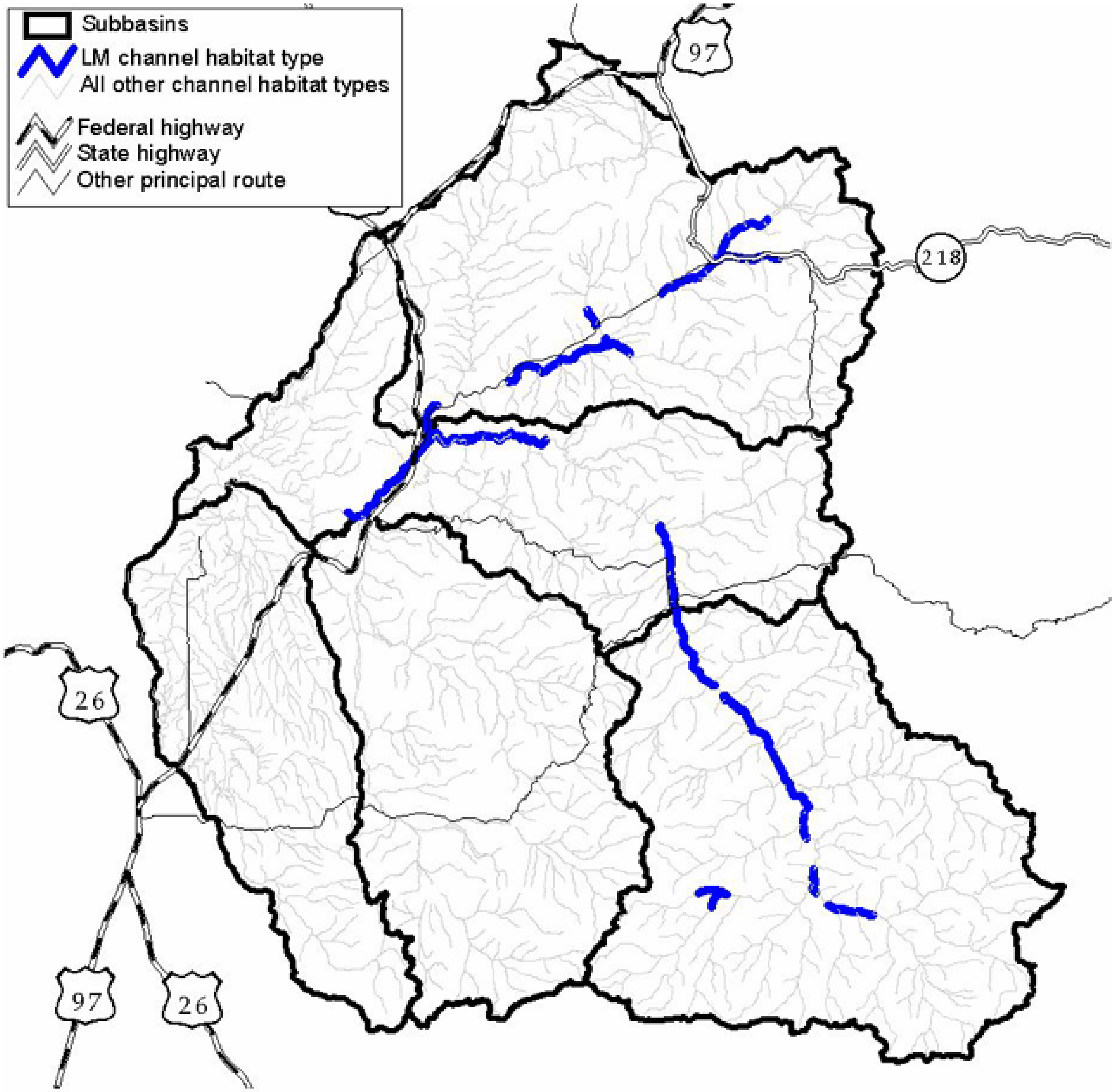


Figure 3-6. Channel habitat type low gradient moderately confined (LM) distribtion.



3.4.2.1 FP3- Low gradient small floodplain

This channel type encompasses approximately one mile of stream in the Foley Creek drainage. In this reach, the stream flows through a 1000 foot wide wetland meadow. This section is a deposition zone for sediment and wood delivered from steeper upstream areas. The stream is highly sinuous, and prone to lateral migration during periods of high flow. The floodplain is well developed and is at least four times the width of the bankfull channel. Substrate consists of organic material, sand, and small gravel. Beaver activity has affected channel form, creating pools and split channels

3.4.2.2 LM- Low gradient moderately confined

These low gradient (<2 %) reaches possess a narrow floodplain approximately two to four times the width of the bankfull channel. They are located in the Antelope Creek, lower Trout Creek, and upper Trout Creek subbasins. The channels are usually single thread with occasional split channels and islands and are set in a wide valley bound by low terraces or hillslopes. Both deposition and transport of sediment and wood can occur in these dynamic systems. Because of the variety of morphologic processes which define these channels, channels often display a diversity of aquatic habitats. As many of the channels in the watershed appear to be downcutting, it is possible that many of the channels mapped as low gradient confined (LC) have evolved from these more moderately confined channels.

3.4.2.3 LC- Low gradient confined

These channels are single thread systems with a narrow floodplain less than twice the width of the bankfull channel. They are confined by hillslopes, bedrock outcrops, or terraces, and often display areas of significant bank erosion. As they are low gradient, they tend to be located in the central and lower portion of the main Trout Creek system, but are also scattered throughout the lower elevation subbasins such as Hay and Mud Springs Creeks. The larger systems possess enough energy to route fine sediment, gravel, and cobble downstream despite the low gradients.

3.4.2.4 MC- Moderate gradient confined

These channels possess gradients between 2% and 4%, but may contain short reaches up to 6%. They possess a limited floodplain whose width is usually less than twice that of the bankfull width. Channels are confined by hillslopes or steep valley walls. All subbasins contain a significant amount of this channel type, with the majority being intermittent streams in the Mud Springs subbasin. The larger of these channels are transport systems capable of routing sediment and where present, wood, downstream.

3.4.2.5 MH- Moderate gradient headwater

These small confined channels drain gentle hillslopes and are mostly above the anadromous fish zone. Gradients range from 2% to about 6%, but short reaches with lower gradients may exist. Due to their small size and moderate gradient, streams possess limited power to route material downstream except for periods of intense runoff associated with thunderstorms. They are dry for much of the summer and fall.

3.4.2.6 MV- Moderately steep narrow valley

Gradients in this channel type are commonly between 4% and 8%, with the channels confined by hillslopes or high terraces. In places, a narrow floodplain less than twice the width of the bankfull channel exists. Streams are generally small in size and most become dry by mid summer. They are considered transport reaches for small to medium sized sediment, and are capable of delivering spawning size material to the larger channels downstream. They are the most common channel type in the watershed, and make up about 28% of the channel network. Nearly 40% of the Hay Creek channel network consists of this channel type. Given their position between steeper headwater channels and lower gradient mainstem reaches, they are particularly vulnerable to channel erosion.

3.4.2.7 SV- Steep narrow valley channel/VH- Very steep headwater

These high gradient (8%-16%) channels are small headwater streams located near ridgetops or are incised into steep valley walls. Channels over 16% gradient are mapped as VH, while those between 8 and 16 percent are mapped as SV. They are discussed together here, as channel processes are similar. Both are considered source and transport reaches with respect to sediment and are tightly confined with little or no floodplain development. Channel form consists of a series of steps or cascades interrupted by short pool reaches. The majority of these channels (44% by channel length) are located in the Upper Trout Creek subbasin, with the Mud Springs Creek subbasin possessing the least amount of this channel type.

3.4.2.8 BC- Bedrock Canyon

The bedrock canyon stream channels are located in the Ward Creek drainage of Antelope Creek, the mainstem of Trout Creek through Degner Canyon and a number of small tributaries in that area, and short sections of the mainstem of Trout Creek above Ashwood. Gradients in this channel type vary, with the larger bedrock channels possessing gradients between 1% and 4% while some of the smaller channels flowing into the mainstem in Degner Canyon having gradients of up to 10 %. These channels are strictly transport systems for sediment, wood and water, and consist of a series of cascades interspersed with pools

3.4.2.9 D- Channelized Stream

These "channels" are sections of natural streams that have been realigned, straightened, or placed in a constructed channel. They are usually without a floodplain and consist of one continuous glide with minimal habitat features such as pools or sorted gravel deposits. Periodic dredging to maintain flow capacity is common. Much of the Mud Springs Creek system has been channelized, as well as portions of Lower Trout Creek and Hay Creeks. Short sections of stream in the Antelope Creek subbasin have also been realigned.

3.4.3 What is the location of channel habitat types most sensitive to changes in the watershed?

As changes occur within the watershed, channel types differ in the type and magnitude of their response. Channels are constantly adjusting their physical characteristics in response to natural or man caused landscape changes. Channel changes may benefit or harm aquatic resources as well as residents of a watershed. The response can be positive or negative. In general, channels that are most sensitive to changes are low gradient (<2%) reaches with a developed floodplain (Montgomery and Buffington, 1993). These channels often lack geomorphic controls such as bedrock, boulders, or confining terraces or hillslopes and are often considered deposition zones for sediment and wood. At the other end of the sensitivity spectrum are channels such as bedrock canyons. Channel response is limited, and material delivered to these confined channels is usually routed through to downstream reaches without significant change to channel form or aquatic habitat features.

Channel changes are usually brought about by alterations of the input factors sediment, wood, or water to the stream system. Given this, each of the channel habitat types is rated high, moderate, or low with respect to the anticipated response to changes in these factors (Table 3-2). It should be noted that these are general ratings, and the response of any particular reach of stream may vary from the assigned rating. The purpose of the rating is to provide understanding as to the spectrum of responses of channel types within the watershed.

Table 3-3 presents a definition for these ratings in terms of anticipated response. Fine sediment refers to material smaller than gravel, while coarse sediment refers to gravel, cobble, and boulders. Obviously, some of the channels in the lower portion of the watershed have limited opportunity for wood to play a role in channel response.

Table 3-2. Channel habitat type sensitivity ratings.

Channel Habitat Type	Description	Fine Sediment	Coarse Sediment	Wood	Water
FP3	Low gradient small floodplain	High	High	High	Moderate
LM	Low gradient moderately confined	High	High	High	Moderate
LC	Low gradient confined	Moderate	Moderate	Moderate	Moderate
MC	Moderate gradient confined	Low	Moderate	Moderate	Moderate
MH	Moderate gradient headwater	Moderate	High	Moderate	Moderate
MV	Moderately steep narrow valley	Low	Moderate	Moderate	Moderate
SV	Steep narrow valley	Low	Moderate	Moderate	Moderate
VH	Very steep headwater	Low	Moderate	Moderate	Moderate
BC	Bedrock canyon	Low	Low	Low	Low
D	Channelized stream	Low	Moderate	Moderate	Low

Table 3-3. Channel habitat type rating explanation.

Rating	Fine Sediment	Coarse Sediment	Wood	Water
Low	Fine sediment is readily transported out of the system. Temporary storage of fines in sheltered areas	Sediment stored temporarily before transported downstream. Little change in overall channel morphology	Not a primary roughness element, and when present does not significantly contribute to pool formation or gravel sorting	Little or no change in channel characteristics expected. High flow pass without channel adjustment
Moderate	Minor accumulations in pools and along channel margins. A large, persistent source would result in loss of pool volume and increased embeddedness	Minor adjustments in channel width and depth, and bar configuration	Contributes to pool formation, sediment trapping and sorting. Often works with other roughness elements to form habitat features	Minor increases in bedload transport, bank erosion or scour. Very large flood events could result in significant change in channel dimension
High	Large accumulations in pools forming sand pillows, gravel interstices filled	Significant alteration of basic channel geometry. Pool filling, channel aggradation, and split channel formation is likely	Critical for pool formation and maintenance, gravel retention and sorting. May be vital to dissipation of stream energy	Significant increase in bedload transport, possible channel widening or scour as well as coarsening of bed material

As expected, the floodplain and moderately confined channels are considered the most sensitive channel types within the watershed. The floodplain channel type (FP3) is limited to a short (1 mile) reach in the central portion of Foley Creek. The stream channel consists of multiple unconfined channels set in a wide valley. In 1995, 27 beaver dams were noted in this reach (ODFW, 1998). Due to the low gradient and unconfined nature of the channel, the addition of fine or coarse sediment would result in pool filling and lateral channel migration. The reduction of woody debris delivery to the channel, would likely result in loss of habitat diversity, as stream energy could not be focused to maintain pools or trap gravel.

The other highly sensitive channel type found within the Trout Creek watershed is the low gradient moderately confined channel (LM). These channels occupy about 44 miles within the lower and upper Trout Creek subbasins as well as portions of Antelope Creek. With the exception of a portion of Foley Creek adjacent to the floodplain channel, this channel type consists of mainstem portions of both Trout and Antelope Creeks. While these channels are not as responsive as the floodplain channel type, the presence of the limited floodplain allows for channel adjustment given a change in the input factors of sediment, wood, and water. Not surprisingly, the responsive nature of these channels attracted the attention of the Corps of Engineers following the flood of 1964, resulting in the construction of berms to control flooding and lateral channel migration and protect farmland.

3.4.4 What portions of the channel network are likely sites for restoration?

When considering a site for fish habitat restoration, a number of themes need to be thoroughly evaluated. The first is whether an area needs to be restored and the second is the likelihood of success of any restoration effort. One of the primary purposes of the watershed analysis is to evaluate conditions throughout the watershed so that restoration efforts can be prioritized and coordinated.

Numerous studies have identified degradation of aquatic habitat and channel conditions within the Trout Creek watershed (Northwest Biological Consulting, 1984; USFS, 1995; and Edlund and Penhollow, 1996). The need for improvement in habitat conditions is clear. While it is beyond the scope of this watershed assessment to identify precise locations for recommended restoration activities, the grouping of channel types allows for some predictive power with respect to the likely success of restoration efforts.

In general, those channel sections that are the most sensitive to changes within the watershed also have the potential to respond to restoration efforts. Given this general statement, the FP3 and LM channels would likely respond to efforts to improve habitat conditions. The FP3 channels are the most sensitive and it may be more difficult to predict the response of the channel to restoration efforts. In addition, field observation and ODFW data indicate that habitat conditions in this section of stream are good relative to elsewhere in the basin. Given this, other areas in the basin may be better candidates for restoration activities.

In particular, the LM channels offer considerable opportunity to restore some of the processes that would lead to improvement in aquatic habitat conditions. It must be emphasized that for any improvement in habitat conditions to occur, efforts that focus on the processes in and adjacent to the targeted reach must be coupled with efforts in upland areas to improve range, road, and runoff conditions. Perhaps the primary change that has occurred to the LM channels is the removal of the link between the active channel and the floodplain. This has resulted from a number of causes, ranging from the obvious such as the berming, to the more subtle such as change in runoff patterns due to soil compaction. Specific actions that could be undertaken to restore geomorphic processes in these and other channels can be found in the Recommendations section (section 3.6) of this Chapter.

In addition to the LM channels, a number of the LC channel reaches could be likely candidates for restoration. Although confined channels are generally not thought of as prime restoration candidates, a number of these channels may have been LM type channels historically and have incised to the point where they have become disconnected from their floodplains. In doing so, banks have become oversteepened and are actively eroding. Given the extent of eroded channels in the watershed (see Sediment Source Chapter, 6), it is highly likely that opportunities for restoration exist. These channels are located in the lower portion of the Trout Creek mainstem, in Antelope Creek, and upper Ward Creek. Locating specific channel reaches would require field investigation to determine the magnitude of incision and the likely success of any restoration efforts.

3.4.5 What are the locations and relative magnitude of channel modifications?

Trout Creek has a long history of human activity. By the 1860s, stockmen had been utilizing the Trout Creek Watershed, starting a legacy of ranching that continues today. The 1880's established farming in the lower portions of the Trout Creek Watershed. Eventually, road building and timber harvest occurred in the watershed. These activities, as well as natural occurrences such as floods, have affected channel conditions in a number of ways. The following discusses some of the more obvious channel modifications and their impact to channel and aquatic habitat conditions. The major source for this information came from watershed reports, landowners and agency personnel, primarily Tom Nelson from the ODFW, as well as limited field verification.

Perhaps the greatest "modification" to channel conditions over time has not resulted from the specific actions detailed below. Changes to overall channel condition have been brought about by a combination of on-going, sometimes subtle land management activities in the watershed. This issue is addressed in the Discussion section (section 3.5) that follows this Channel Modification section.

3.4.5.1 Channelization

This modification involves channel straightening, relocation, and excavation. These activities were done for a number of reasons, including flood control, water delivery for irrigation purposes, and realignment to ease agricultural operations. As the data source for identifying these channels are existing digital coverage (BLM, 2001; REO, 2001; USGS, 2001), it is highly probable that additional reaches of channelized streams occur in the watershed, particularly short reaches too small to appear on the map. It is apparent that the greatest amount of channelized stream is in the Mud Springs subbasin. Channeliztion has occurred over the last 100 years, with the precise dates of most of the work unknown. The greatest amount of channelization in the Hay Creek subbasin was thought to have occurred during the 1950's when the stream in the lower portion of the basin was realigned (Nelson, pers. comm.). Obviously, channelization has a direct affect on habitat conditions in the affected reach. Simplification of aquatic habitat is the primary impact, as the stream structure that produced pools, riffles, and steps is removed. In addition, downstream reaches can be affected as flow velocities increase and sediment delivery rates and timing are altered.

3.4.5.2 Berms/Dikes

This modification involves the placement of berms, dikes, and levees along one or both sides of the stream channel. Although this often results in channelized stream reaches, generally no excavation within the channel has occurred. This is the primary difference between this modification and those discussed in the previous section. Table 3-4 presents by subbasin the amount of channel affected while Figure 3-7 displays the location of these modifications. The majority of central and lower Trout Creek was bermed by the U.S. Army Corps of Engineers in the mid 1960's in response to the large flood in December of 1964. Bulldozers were used to push material from the stream and adjacent riparian areas to create flood control berms on one or both sides of the channel. These berms have had a significant impact on channel condition. The channels have been isolated from their floodplain, riparian vegetation removed, side channels have been cutoff, and some channels have been straightened. This action has altered flow velocities, sediment movement and deposition, and bed morphology and the diversity of aquatic habitat in general has been greatly reduced.

The majority of these berms are still in place, but their effectiveness in terms of the intended flood control effort has been reduced. Subsequent high flows have eroded portions of the berms, with flow moving around the berms as the channels attempt to reestablish their floodplain and meander patterns. In general, the berms along the Trout Creek mainstem between Mud Springs Creek and Hay Creek are the most continuous, while berms in the Willowdale and Ashwood areas have become less functional in terms of channel containment. (Nelson, pers. comm.). In addition to the original destruction of the riparian vegetation caused by berm construction, regrowth on the berms has been slow in many areas due in part to the soil compaction from the heavy machinery working at the channel edge. Due to the magnitude of the berming projects, as well as the location with respect to suspected areas of key habitat for anadromous species, these dikes have had a significant affect on channel condition and processes. The Army Corps is planning to modify the berms within the next few years to improve geomorphic processes (Middle Deschutes Local Advisory Commission, 2001).

3.4.5.3 Dams

Historically, a common practice within the watershed to provide water for irrigation and livestock was the construction of gravel push-up dams in the channel. This practice is not nearly as common today as infiltration galleries are constructed. A few dams, however, still exist in the watershed. In addition, hundreds of small sediment and stock watering dams exist on tributary streams. Obviously, the impact of these structures is significant at the site of their construction. Fish blockage, water temperature increases, and potential sediment production during construction are all associated with these structures. In addition, downstream habitat conditions are affected as flows are disrupted and sediment movement patterns are altered. Impacts can be positive as well, through trapping of sediment and reducing peak flow velocities during high intensity storm events. The location and overall impact to the aquatic resources of all of these structures are unknown.

3.4.5.4 Instream Habitat Projects/Fencing

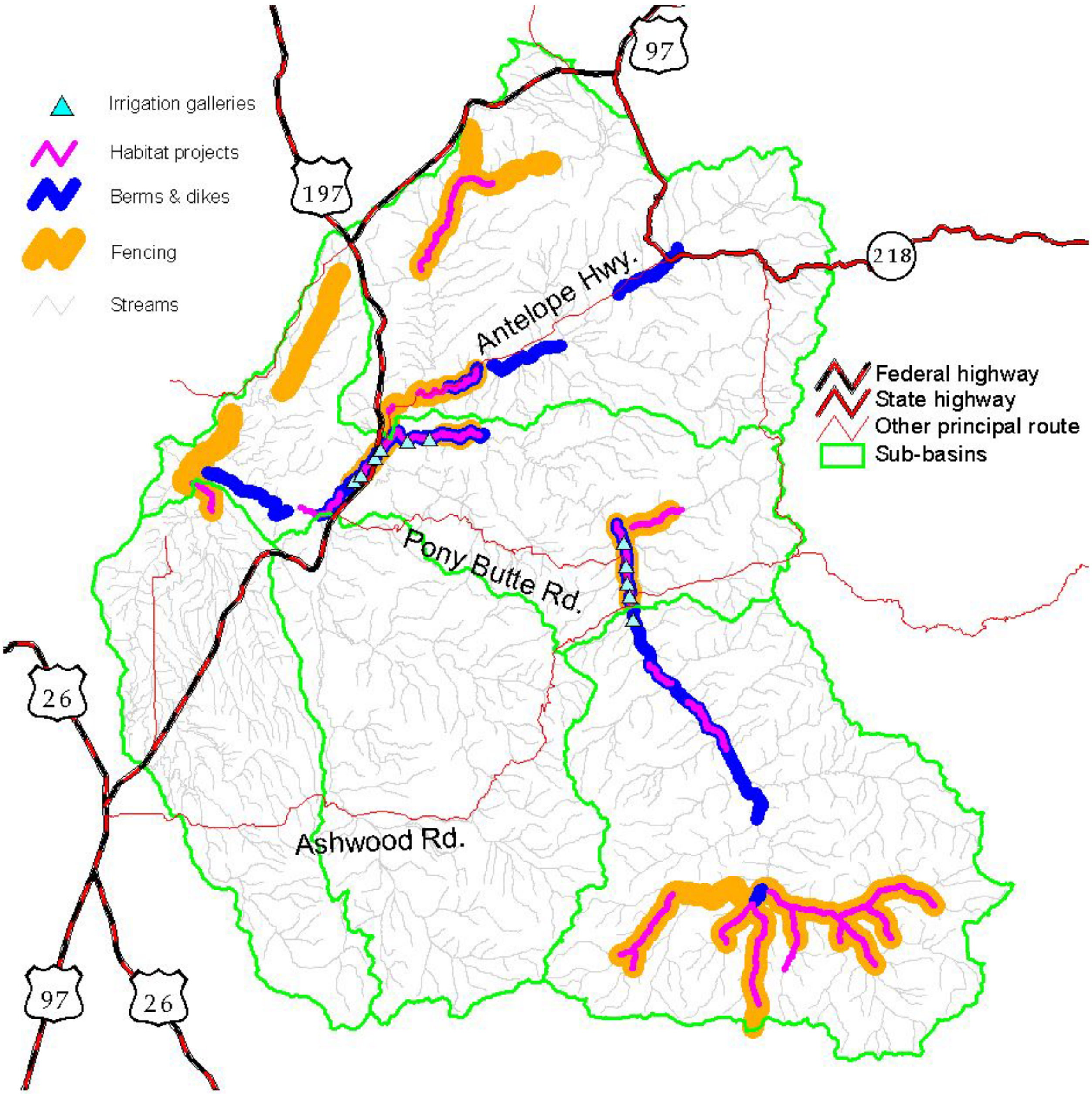
Starting in early 1984, the Bonneville Power Administration in cooperation with the ODFW began a Trout Creek Stream Habitat Enhancement Project (Edlund and Penhollow, 1996). This project assisted land owners with projects meant to improve stream and riparian conditions. Between 1986 and 1994, BPA installed a total of 132 miles of riparian fencing, placement of 4764 instream habitat log and rock structures such weirs and jetties, stabilizing 20,923 feet of streambank, primarily through placement of juniper riprap, development of off-stream stock watering facilities, and screening of irrigation facilities. The USFS has also actively engaged in instream habitat projects, riparian planting (Potlid Creek and tributary), and riparian fencing. Figure 3-7 displays the location of the reaches where facilities are known to exist today while Table 3-4 presents the miles of stream currently affected by these activities.

Quantification of the impact of these improvements on channel morphology and aquatic habitat is not possible. In most cases, the impact of the fencing and structures has not been monitored, and only a qualitative assessment concerning the impact can be made. Investigations have concluded that control of livestock through riparian fencing offers the greatest recovery for degraded riparian vegetation and function (Kauffman et al, 1993). In the Upper Trout Creek subbasin, riparian conditions have improved since the 1960's with the alteration of grazing practices and riparian fencing (USFS, 1995).

Table 3-4. Channel habitat modifications (stream miles).

Channel Modification	Antelope Creek	Mud Springs Creek	Hay Creek	Upper Trout Creek	Lower Trout Creek
Channelization	0	16.7	7.4	0	0.5
Berms/Dikes	7.4	n.d.	n.d.	10.6	16.1
Riparian Fencing	13.1	1.4	n.d.	27.5	15.8
Instream Habitat Projects	8.2	1.4	n.d.	27.1	13.4

Figure 3-7. Channel modification locations



3.4.5.5 Miscellaneous Projects

A number of projects have been undertaken by landowners (often with assistance from ODFW, NRCS, or the Conservation District) that have likely improved channel conditions. For example, 11 irrigation galleries have been installed in the basin, with more planned within the next year. These galleries eliminate the need for push dams and associated damage within the channel. Gallery locations are shown on Figure 3-7.

In order to control peak flow events, sediment and improve upland range and pasture conditions, the majority of land owners (75%) along the mainstem of Trout Creek are working with the Conservation District or the NRCS in the development of Farm Plans (Peplin, pers. comm.). Changes in land management practices such as grazing and watering schedules should improve upland conditions. In addition, over 50 sediment and flow control basins have been installed in the watershed to control peak flows and subsequent erosion. About 5600 acres in the watershed are enrolled in the Conservation Reserve Program that promotes the establishment of perennial vegetation on highly erodible lands (NRCS, 2000). These lands are located mostly in the Lower Trout Creek and Antelope Creek subbasins.

Watershed Council members have stated that landowners in the watershed are continually striving to improve land management practices to benefit not only their personal operations, but also the health of the Creek (Trout Creek Watershed Council, pers. comm.). These practices include reduced grazing, off-site watering, fencing and other management strategies

3.5 DISCUSSION

Trout Creek possesses a wide variety of channel types with varying responses to the changes that have occurred in the watershed. Previous reports addressing channel conditions in the Trout Creek Watershed have all identified significant changes over time with respect to increased sedimentation, bank erosion, channel widening or downcutting (USFS, 1995; Edlund and Penhollow, 1996; Kauffman et al, 1993; Northwest Biological Consulting, 1984).

On Forest Service land in the Upper Trout Creek subbasin, 8% of the channels sampled were labeled as Rosgen (1996) Type F or G channels (USFS, 1995). These are erosional channel types indicative of channel alteration. The Forest Service anticipated that less than 1% of the sampled channels would be of this channel type. They attributed the higher than expected percentage of these erosional channels to changes in the watershed such as beaver removal, grazing, flooding, fire, and logging and road construction.

Unfortunately, there is very little data that quantifies how channels have changed over time. Most of the statement in the reports dealing with channel condition are qualitative in nature and do not give the magnitude or precise causal mechanism responsible for specific channel changes. Changes in upland vegetation appear to be a major cause for increases in peak flows (Middle Deschutes Plan, 2001). The dramatic increase in juniper and subsequent decrease in perennial grasses and soil infiltration capacity are a primary concern throughout much of the non-forested portion of the watershed (Peplin, pers. comm.). These changes, as well as loss of riparian vegetation due to historic grazing practices, wildlife impacts, and flooding are dominant factors with respect to channel degradation. Watershed Council members have also identified the 1964 flood and timber harvesting in the upper reaches of Trout Creek in the 1950's and 1960's as important factors relative to channel changes (Trout Creek Watershed Council, pers. comm.).

In general, channels have responded to these changes in two ways. Many channels have likely widened and become shallower as bank cohesion is lost due to vegetation removal. Increased sediment deposition often aggrades channel bed, forcing the stream to expand laterally. These wide shallow channels are susceptible to increased temperatures and evaporation.

In other channels, focused stream energy from increased peak flows has helped establish a headcut or knick point in the stream. These often migrate upstream, causing severe downcutting and gullying.

In developing strategies for improvement of channel conditions, it is emphasized that we consider not only the in-channel processes responsible for the changes listed above, but also the hillslope and riparian processes which are equally influential. Without addressing high runoff and erosion rates from hillslopes, the success of many of the in channel activities is questionable.

3.6 DATA GAPS / RECOMMENDATIONS

- Fill in the data gaps with respect to channel condition

The primary data gap with respect to the channel network is the lack of information for certain stream reaches. The Council should encourage land owners to allow assessment of stream channel condition information for reaches where no or limited data are available. Some of the key areas where data are unavailable are below Ashwood and below Amity Creek on the mainstem of Trout Creek. Based on information gathered from maps and aerial photos, these areas may be appropriate sites for restoration activities. Land owners should be reminded that geomorphic processes, upstream conditions, and fish use, rather than their specific land management activities, dictate to a large degree the location of appropriate restoration sites.

- Protect channels which are in good condition

Due primarily to limited access, certain channels such as portions of Ward Creek and Degner Canyon possess relatively good riparian and aquatic habitat conditions. The Council should continue working with landowners to identify additional areas and encourage appropriate land management practices.

- Restore natural geomorphic processes, starting with LM channel types

In many of the mainstem and larger tributaries, damage from high flows and loss of riparian vegetation has combined to change the physical attributes of the stream, resulting in aquatic habitat degradation. Many streams have likely widened and become shallower, with a loss of pool habitat. In other streams, particularly smaller channels, streams have downcut and become isolated from their floodplains. Through a combination of reducing peak flows and sediment transport as well as promoting riparian recovery, the geomorphic processes that dictate channel conditions will begin to improve aquatic habitat.

With respect to riparian recovery, fencing to control livestock access to the stream channel has proven to be one of the most successful land management activities (Magilligan and McDowell, 1997). Research across the west, including tributaries to the Crooked River draining similar landforms and soil types to Trout Creek has found that improvement in channel and habitat conditions following riparian fencing is quickest and most pronounced in relatively unconfined channels such as those mapped as LM (Magilligan and McDowell, 1997). Typical changes following fencing include an increase in pool frequency, increased sinuosity and increased flow depth. Fencing should allow for lateral channel migration and the establishment of a functional floodplain (Hupp and Simon, 1991). This would mean removal or breaching of berms that limit channel movement. Negotiations with landowners, as well as investigation of site specific geomorphic conditions, would allow establishment of protected riparian zones which are functional but not overly restrictive from a land management perspective.

- Identify and address site specific problems within the channel network

While the emphasis of this entire recommendation section is to coordinate upland activities that influence runoff with riparian and channel activities, there are likely specific sites that would benefit from immediate action. Acute bank erosion, headcutting, and road failures that affect channel movement are types of problems which should be identified and targeted.

- Identify small tributaries suffering from high flow damage

While channel projects such as fencing and juniper riprap are important to improve habitat conditions, excessive peak flows and sediment transport can negate in-channel efforts. Roads, soil compaction, and vegetation changes have increased peak flows from many streams in the watershed (Middle Deschutes Local Advisory Committee, 2001) causing bank erosion and downcutting. An effort should be undertaken to identify and prioritize tributary channels that continually deliver excessive flow and sediment to the channel network. Obviously, the Council should consider not only the tributaries themselves, but prioritize the receiving waters with respect to beneficial human uses and aquatic habitat.

- Undertake measures to reduce peak flow/sediment damage in tributary channels

After the most degraded tributaries have been identified, measures aimed at reducing peak flow volume and velocity as well as sediment should be undertaken. This could include juniper control, establishment of perennial vegetation (Conservation Reserve Program), increasing the number of sediment/flow control basins in upland areas, refining road maintenance practices, or improving grazing management practices. Without improvement in upland conditions, in channel improvements may not yield intended results.

- Extend 15 year leases on currently protected riparian areas

Improvement of channel and habitat conditions has occurred in the riparian areas currently fenced (Nelson, pers. comm.). As many of these leases will be ending soon, it is important to take advantage of these improvements by extending these leases. Research has shown that while improvement in riparian vegetation conditions may be evident within the first years of protection, reestablishment of geomorphic processes appropriate for the stream in question may take decades (Clifton, 1989).

- Monitor the effectiveness of restoration actions

While much has been done in the watershed to improve channel and habitat conditions, many of these efforts have not been monitored. Without monitoring, identifying and implementing those activities that yield the greatest benefit can not be done. This should begin with an inventory of those improvements that are already in place.

4.0 HYDROLOGY AND WATER USE

The Hydrology and Water Use assessment generally followed the methodology as outlined in the Oregon Watershed Assessment Manual (WPN, 1999). The assessment methodology outlined in the manual is designed around a series of critical questions which form the basis of the assessment. For the Trout Creek assessment some of the critical questions given in the manual were replaced or modified through communication with the client. The critical questions that were addressed in this assessment were:

1. What is the flow regime (flood history and annual hydrograph) of the watershed?

2. What is the distribution springs in the watershed, and where are the likely locations of measurable groundwater inflows in Trout Creek?

3. What are the locations of water withdrawals in the watershed and the estimated withdrawal rates?

4. What is the likely relationship between current land uses in the watershed and the current flow regime (peak and low flows) in the major creeks in the basin?

5. What is the estimated unregulated and regulated bankfull flows at selected locations in the watershed?

6. What are the opportunities for development of off channel live stock watering facilities?

Each of the critical questions given above is addressed in the subsequent sub-sections of this report.

4.1 FLOW REGIME

4.1.1 Streamflow information

Few data are available to characterize streamflow within the Trout Creek watershed. Stream flow records that are available for the area are of short duration and discontinuous. The locations of all available stream flow data are shown in Figure 4-1 and summarized in Table 4-1.

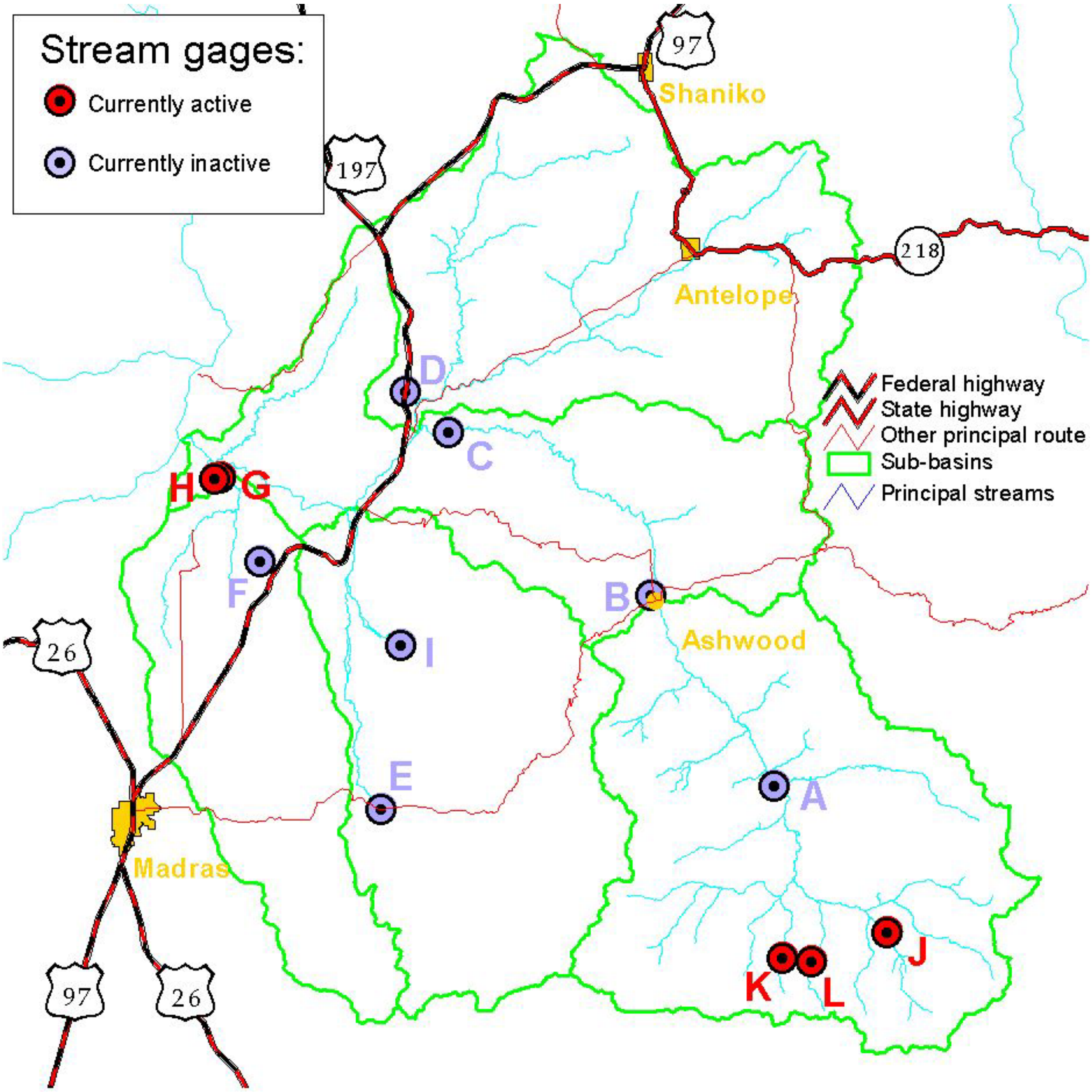


Figure 4-1. Stream gages within the Trout Creek watershed. Refer to Table 4-1 for gage information. Data sources: OWRD (2001b), USFS (2002), USGS (2001b), USGS (1958).

Table 4-1. Stream gages within the Trout Creek watershed. Refer to Figure 4-1 for gage locations. Data sources: OWRD (2001b), USFS (2002), USGS (2001b), USGS (1958).

Map ID	Gage number: name	Area (mi^2) [Elev. (ft)]	Period of record: Mean daily flow	Period of record: Peak flows (Water Year[4])	Notes
A	14093600: Trout Cr Below Amity Cr near Ashwood	120 [2,900]	12/20/1965 – 9/30/1991	1966-74; 1976; 1978; 1981-1991	Gage maintained by OWRD. Record ended when gage washed out in 1991 flood. Numerous gaps in flow record
B	14093700: Woods Hollow at Ashwood	1.42 [2,530]	n/a	1960-63; 1965-66; 1968-72; 1974-75; 1978-79	Gage maintained by USGS. No mean daily flow data
C	14094000: Trout Creek near Antelope	220 [1,820]	n/a	n/a	Gage maintained by USGS. Only mean monthly flow data is available: 4/1915 - 8/1915; 3/1916 - 6/1917
D	14094300: Cow Canyon Creek near Antelope	2.71 [2,160]	n/a	1961; 1963-66; 1970-72; 1978-79	Gage maintained by USGS. No mean daily flow data
E	14095000: Hay Creek near Hay Creek	78 [2,800]	n/a	n/a	Gage maintained by USGS. Only mean monthly flow data is available: 4/1915 - 9/1915; 3/1916 - 7/1916
F	14095200: Sagebrush Creek Trib. near Gateway	7.4 [1,920]	n/a	1957-58; 1961; 1963; 1965-67; 1969-70; 1976; 1979-1981	Gage maintained by USGS. No mean daily flow data
G	14095250 (SBCO): Sagebrush Creek near Gateway	92.7 [1,410]	12/3/99 – present	n/a	Gage maintained by OWRD. Some gaps in data. Data only available through 4/25/01
H	14095255 (TRGO): Trout Creek at Clemens Drive near Gateway	666.8 [1,405]	10/1/99 – present	n/a	Gage maintained by OWRD. Data only available through 4/25/01
I	99000230: Wilson Creek near Madras	7.5 [2,100]	4/20/1950-9/30/1950	n/a	Gage maintained by OWRD.
J	Trout Ck above USFS boundary	10.7 [3,645]	11/1997 - present	11/1997 - present	Gage maintained by USFS. Some gaps in data. Data not included in this assessment.
K	Dutchman Ck at 2720 road	2.7 [3,840]	11/1997 - present	11/1997 - present	Gage maintained by USFS. Some gaps in data. Data not included in this assessment.
L	Cartwright Ck at 2720 road	1.9 [3,920]	11/1997 - present	11/1997 - present	Gage maintained by USFS. Some gaps in data. Data not included in this assessment.

[4] Water year is defined as October 1 through September 30. The water year number comes from the calendar year for the January 1 to September 30 period. For example, Water Year 1990 would begin on October 1, 1989, and continue through September 30, 1990. This definition of water year is recognized by most water resource agencies.

Oregon Water Resources Department (OWRD) stream gage #14093600 (Trout Creek below Amity Creek near Ashwood) provides the longest-term record of stream flow conditions within the Trout Creek watershed. Minimum, average, and maximum mean daily stream flows over the period of record for this gage are shown in Figure 4-2. Also shown in Figure 4-2 is the magnitudes and month/day of occurrence of the annual peak flows.

The middle graph in Figure 4-2 shows minimum, average, and maximum mean daily stream flows over the period of record expressed on a logarithmic scale. This graph shows that, on average, stream flow is less than 1 cfs during the months of August and September, and has fallen below 1 cfs in dry years in the months of May – December.

The hydrograph for gage #14093600 (Figure 4-2) displays a mixed rain-on-snow and spring-snowmelt runoff pattern. The occurrence of the majority of the annual peak flows during the early portion of the winter, along with a coincident "spikey" pattern to the hydrograph is indicative of rain-on-snow conditions. However, a large number of peak flows also occur later in the winter. This combined with the slow decline in springtime stream flows that coincides with the decline in the snowpack (Figure 1-20) suggest that peak flows are also influenced by spring snowmelt conditions.

Further analysis was conducted to determine the hydrologic conditions responsible for peak flow generation within the Trout Creek watershed. Determination of the peak flow generating processes is important because the possible land use impacts to peak flows vary by the mechanism(s) that produce peak flows. The peak flow generating processes were assessed for all annual peak flows recorded at gages #14093600 (Trout Creek below Amity Creek near Ashwood, Table 4-1), 14093700 (Woods Hollow at Ashwood), 14094300 (Cow Canyon Creek near Antelope), and 14095200 (Sagebrush Creek Trib. near Gateway). Details on how this analysis was conducted are included in an appendix found in section 10.0. Forty-five separate events[5] were identified using records available from the four stream gages. Of these 45 events, 26 were identified as rain-on-snow events, 15 were identified as rain-only events, and four were identified as having occurred during clear-sky snowmelt conditions. Of the 15 rain only events, at least eight appear to be due to local high-intensity rainfall produced during thunderstorm conditions.

[5] For some years peak flow data was available from more then one gage. In some years the peak flows would occur at all gages on the same day; these records were treated as one storm event. In other years the peak flows might occur at multiple sites within one or two days of each other but clearly within the same set of climatic conditions; these were also treated as one storm period. Peak flows that occurred at multiple sites that were not within a few days of each other, or that occurred during distinctly different climatic conditions were treated as separate events.

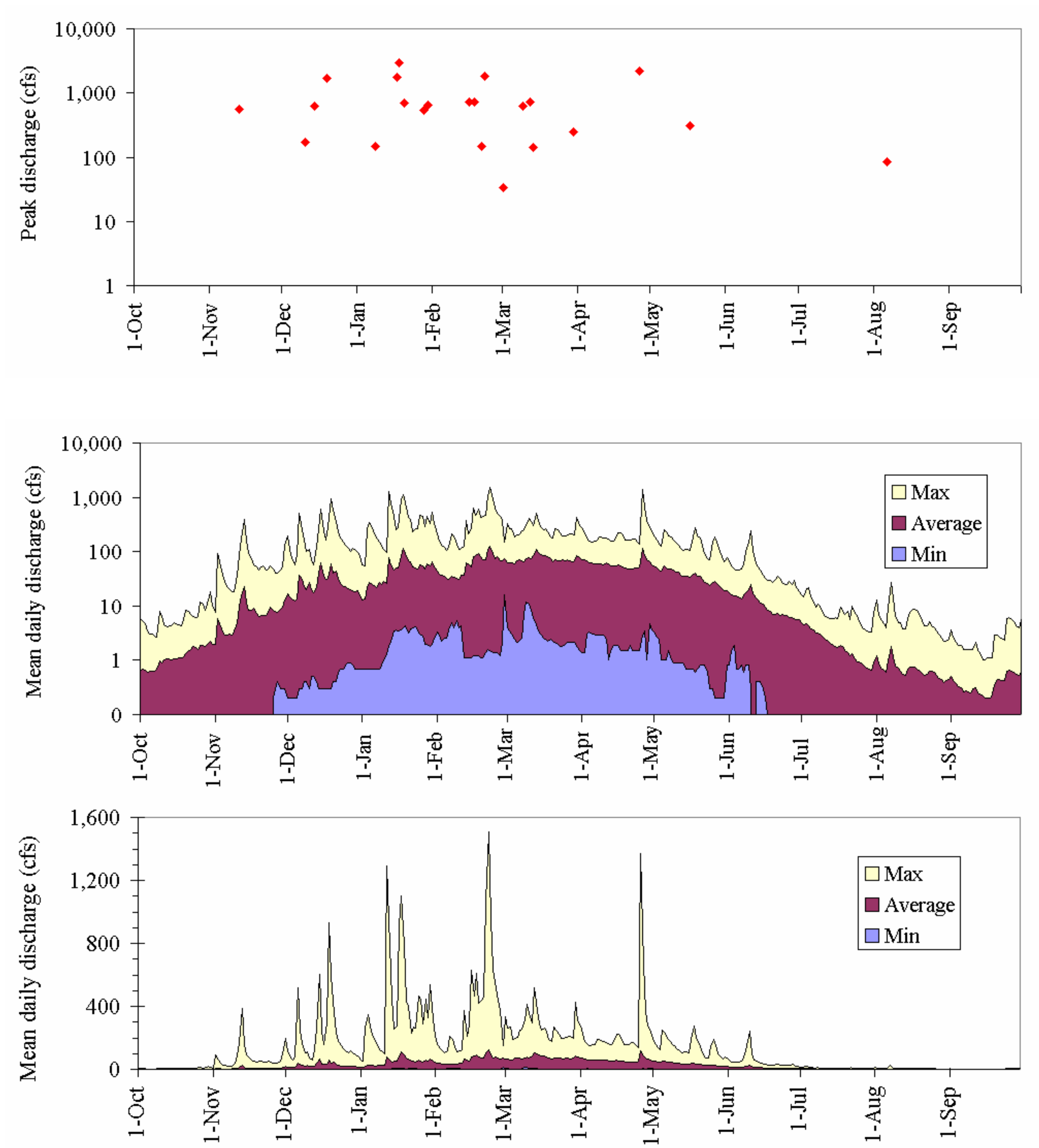


Figure 4-2. Discharge at OWRD stream gage #14093600 (Trout Cr below Amity Cr near Ashwood). Bottom graph shows minimum, average, and maximum mean daily stream flows over the period of record. Middle graph shows same information expressed on a logarithmic scale. Top graph shows annual peak flows. Data source: OWRD (2001b).

The most damaging (in terms of property) peak flow event that occurred in recent times was the flood that occurred on 12/21/1964 during water year 1965, which was a rain-on-snow event (Edlund and Penhollow, 1996). Peak flow records are available for water year 1965 for three of the four stream gages (stream gage #14093600 was not put into operation until the following year). Only two of the three gages identified the 12/21/1964 event as the largest peak flow of that water year; the largest annual event at gage #14095200 occurred on 8/21/1965, and was probably associated with local high-intensity rainfall produced during thunderstorm conditions. Of the two gages where the 12/21/1964 event was recorded, it was ranked as the largest event in the period of record at gage #14094300, but only as the second largest event at gage #14093700 (the largest event at this gage occurred on 2/7/1979; also a rain-on-snow event).

The U.S. Forest Service (USFS) has recently installed three continuous stream gages in the upper portion of the watershed (Table 4-1, Figure 4-1). Only portions of the data were available from two of these gages at the time of this analysis. Mean daily discharge at the Dutchman Creek and Trout Creek gages is shown in Figure 4-3 and Figure 4-4. Water year 2001 was an extremely low flow year; stream flows being approximately 1/2 to 1/3 of average in the area (J. Seymour, USDA Forest Service, pers. comm., 1/14/2002). The top graphs in Figure 4-3 and Figure 4-4 show mean daily stream flows over the period of record expressed on a logarithmic scale. Assuming that water year 1999 was representative of average years, these graphs show that stream flow is less than 1 cfs during the summer months.

The hydrograph for these two headwaters stream gages display a similar streamflow pattern as the Trout Creek below Amity Creek gage (Figure 4-2); with peak flows during the early portion of the winter having a "spikey" pattern that are indicative of rain-on-snow conditions, along with a slow decline in springtime stream flows that coincides with the decline in the snowpack.

The large peak flow seen in the water year 1998 at the Dutchman Creek gage coincided with the Memorial Day flood that occurred in Prineville. Some of the large peaks seen in water year 1999 at the Trout Creek gage may be due to technical difficulties with the gage equipment (J. Seymour, USDA Forest Service, pers. comm., 1/14/2002).

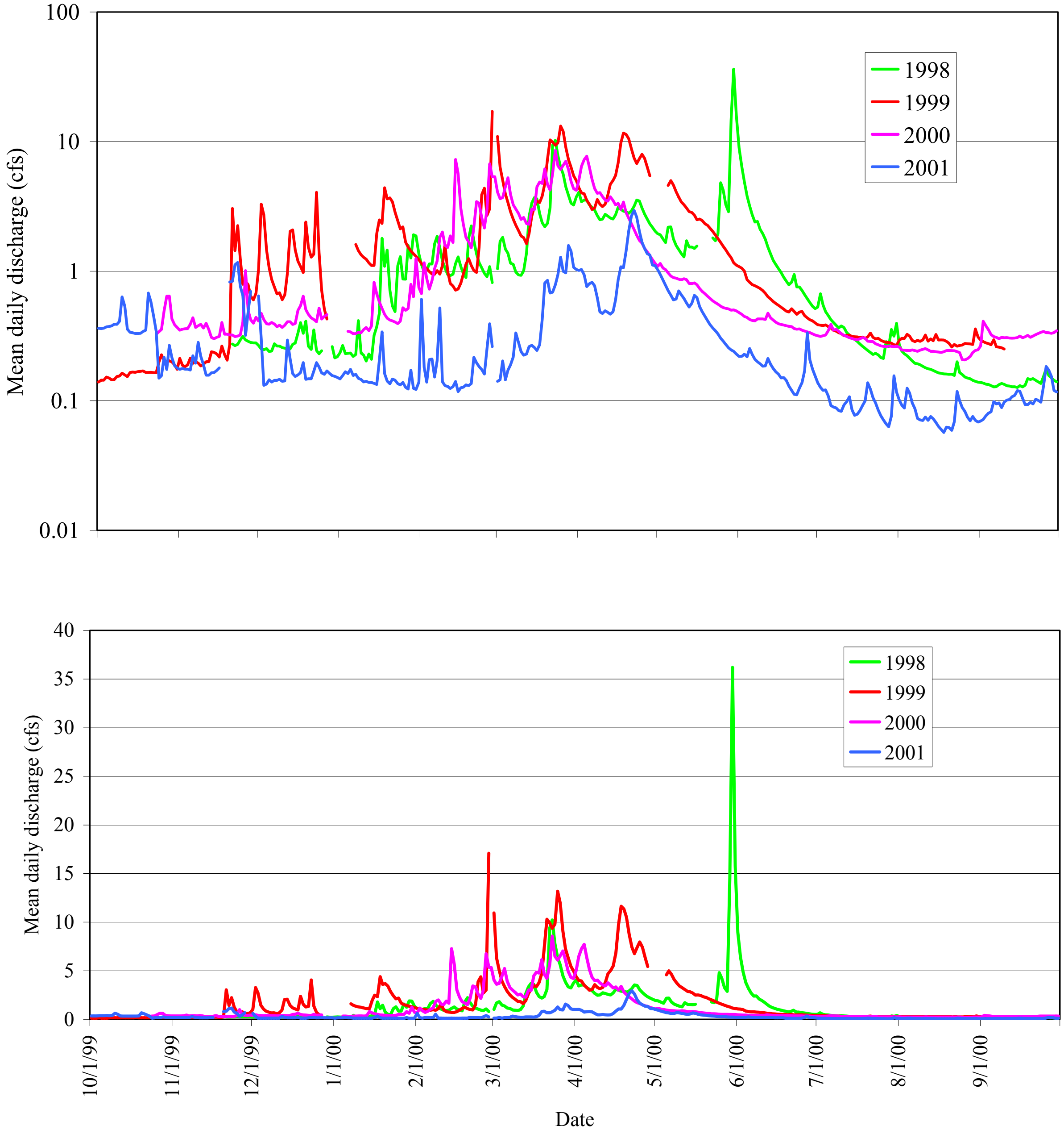


Figure 4-3. Mean daily discharge at the Dutchman Creek gage. Bottom graph shows mean daily stream flows for the four years of record. Top graph shows same information expressed on a logarithmic scale. Data source: USFS (2002).

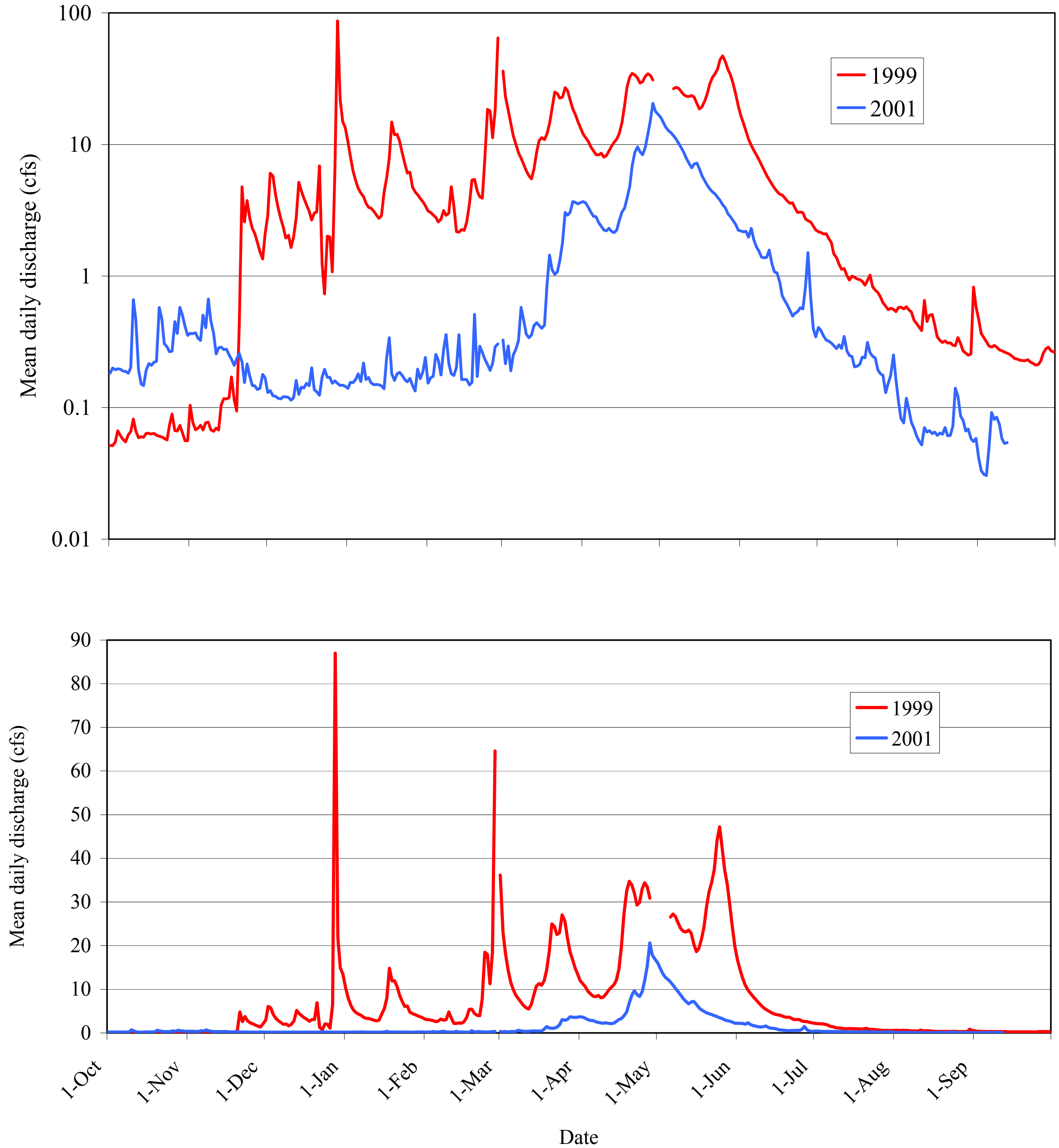


Figure 4-4. Mean daily discharge at the Trout Creek gage. Bottom graph shows mean daily stream flows for water years 1999 and 2001. Top graph shows same information expressed on a logarithmic scale. Data source: USFS (2002).

The OWRD has recently installed two stream gages in the lower watershed; one on Sagebrush Creek immediately upstream from the confluence with Trout Creek (gage #14095250, Sagebrush Creek near Gateway; Table 4-1, Figure 4-1), and the second located on Trout Creek downstream of Sagebrush Creek (#14095255, Trout Creek at Clemens Drive near Gateway; Table 4-1, Figure 4-1). Figure 4-5 shows the discharge at these two stream gages, as well as the streamflow in Trout Creek above Sagebrush Creek, which was calculated as the difference in flow between the two gages.

Although the data, shown in Figure 4-5, are of very short duration several interesting things can be noted. Sagebrush Creek exhibits an unusually constant hydrograph, generally varying no more that 10 cfs in any season. The pattern in the hydrograph of Sagebrush Creek is suggestive of a spring-fed system. Another interesting item in Figure 4-5 is that almost the entire summertime flow in the lower Trout Creek mainstem is from Sagebrush Creek with little contribution from the upper watershed. Finally, it is interesting to note the difference in the winter hydrographs of Trout Creek in water years 2000 and 2001. The wintertime hydrograph for water year 2000 appears similar in shape to the hydrograph from the Trout Creek below Amity Creek gage (Figure 4-2). The wintertime hydrograph for water year 2001 however shows no large flows during the winter months, which is similar to conditions at the USFS gages.

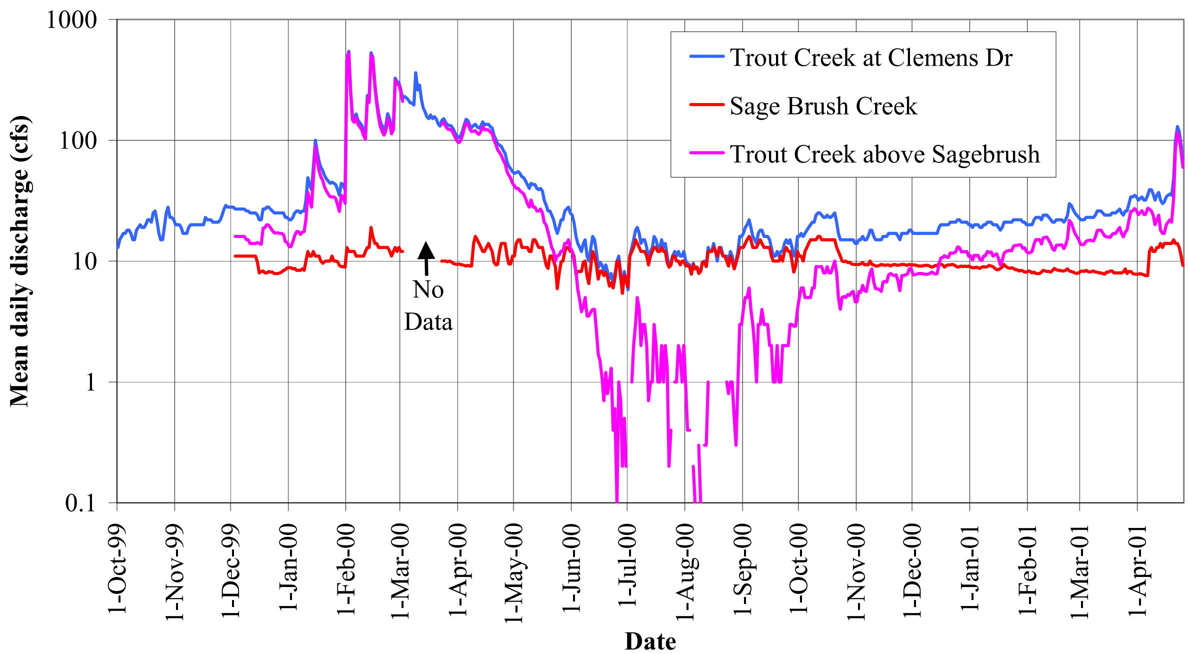


Figure 4-5. Discharge at the stream gages #14095250 (Sagebrush Creek near Gateway) and #14095255 (Trout Creek at Clemens Drive near Gateway). The plot for Trout Creek above Sagebrush Creek was calculated as the difference in flow between gages #14095250 and #14095255. Data source: OWRD (2001c).

Very little is known within the Trout Creek watershed on the interaction between surface and groundwater. Only one study is available that looked at possible losses of streamflow to groundwater aquifers. Wheeler (1969) conducted a channel loss survey along the mainstem of Trout Creek between the location of the gage #14093600 (location "A", Figure 4-1; Table 4-1) and Willowdale (located downstream of the confluence of Antelope Creek), a distance of approximately 26 miles. The survey was conducted over a range of flows from 20 to 40 cfs, and consisted of a series of flow measurements in the mainstem and tributaries. The study identified no significant channel losses in the survey reach.

4.1.2 Flood History

Data on annual peak flows are available for four locations[6] within the Trout Creek watershed (Figure 4-1, Table 4-1). However, these data are of short duration and contain gaps in their records. Data gaps (e.g., 1974) may represent years where particularly large flood events occurred at all or most of the gage stations, and the absence of these data may skew our perception of flood history in the watershed.

The data from the four stream gages within the Trout Creek watershed that have peak flow records are presented in Figure 4-6. For purposes of comparison, the data in Figure 4-6 are presented as unit area stream flows: the peak discharge was divided by the drainage area of the gage. Despite the irregular and short term nature of the data several points can be noted:

- The peak flow response to a given set of storm conditions varies considerably in different areas of the watershed. For example, the 2/7/1979 event differed by an order of magnitude from gage 14094300 (approximately 10 cfs/mi^2) to gage 14093700 (approximately 100 cfs/mi^2)

- Smaller drainages, such as the area draining to gage #14095200, are more vulnerable to local high-intensity rainfall produced during thunderstorm conditions (for example, the water year 1957 event at gage #14095200).

- As has been noted above, the largest peak flow in a given water year does not occur on the same day at all gages within the watershed. Of the 15 storms in Figure 4-6 that have records from two or more gages for the same water year, only seven of the peaks occurred during the same storm event (see section 10.0 for details).

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[6] Data for the three USFS gages listed in Table 4-1 was not available at the time of this analysis, consequently, these data are not included.

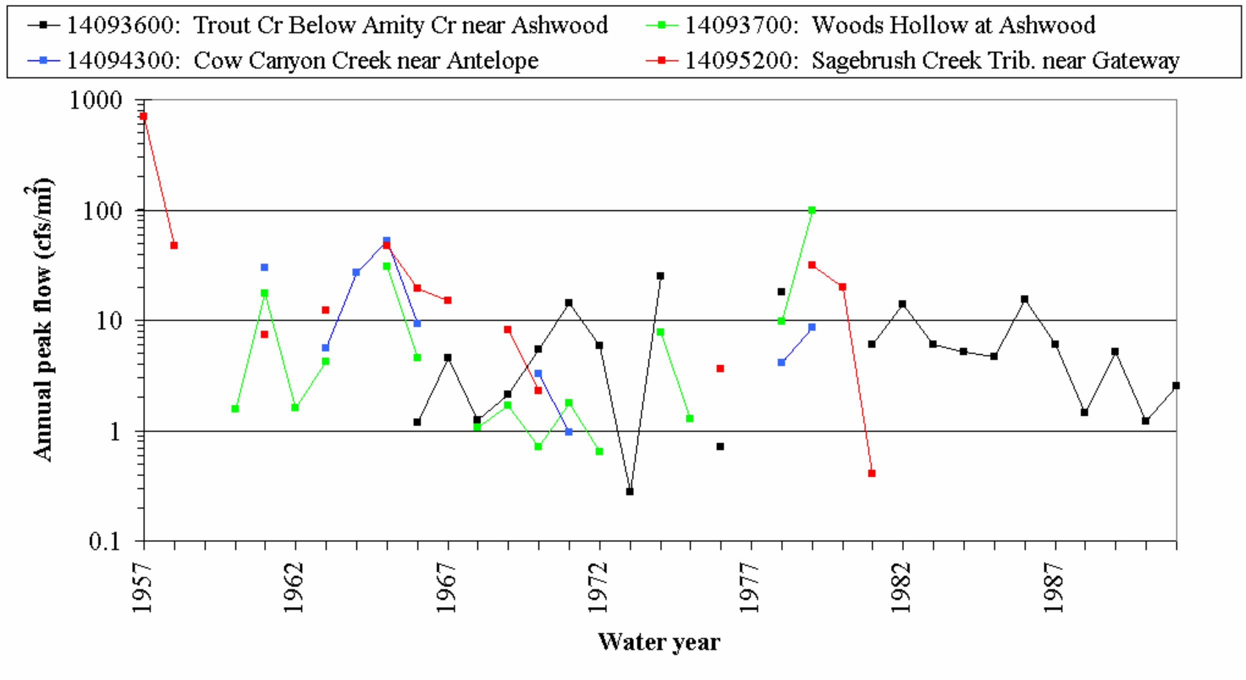

Figure 4-6. Annual peak flows (expressed as cfs/mi^2) at the Trout Creek below Amity Creek (#14093600), Woods Hollow at Ashwood (#14093700), Cow Canyon Creek near Antelope (#14094300), and Sagebrush Creek Tributary (#14095200) stream gages. Refer to Table 4-1 and Figure 4-1 for gage information and locations. Data sources: OWRD (2001b), USGS (2001b).

Despite the spatial variability in peak flow response discussed above, it would still be desirable to extend the record of stream gage #14093600 (Trout Creek below Amity Creek near Ashwood) to provide a better understanding of the peak flow history in the mainstem of Trout Creek. Having a better understanding of the flood history in the mainstem of Trout Creek provides context for interpreting historical channel, riparian, and mass wasting disturbances. The peak flow record for gage #14093600 was extended using regression analysis[7] with long-term peak flow records from other gages in adjacent basins. The stream gages considered for this analysis are shown in Figure 4-7. Two additional gages were considered for this analysis that are not shown in Figure 4-7; gage #14042500 (Camas Creek near Ukiah) and gage #14046000 (North Fork John Day River at Monument). These additional gages were included because they were identified in Northwest Biological Consulting (1983; 1984) as having physiographic watershed characteristics similar to Trout Creek.

[7] Regression analysis is a statistical evaluation of a group of identifiable characteristics which together can predict the outcome of a specific event

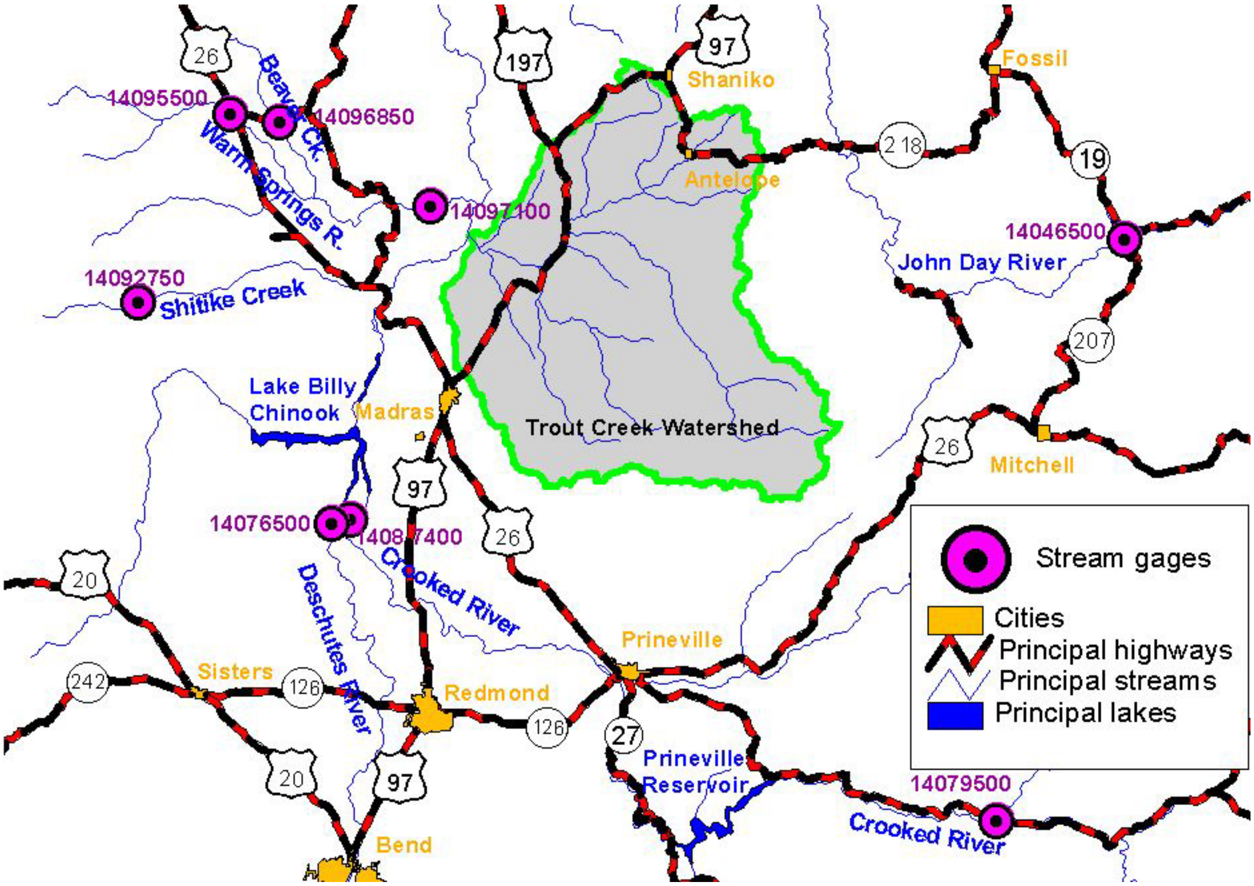

Figure 4-7. Stream gages within the vicinity of the Trout Creek watershed having peak flow information. Gages include #14046500 (John Day River at Service Creek), 14076500 (Deschutes River near Culver), 14079500 (Crooked River at Post), 14087400 (Crooked R below Opal Springs, near Culver), 14092750 (Shitike Cr, at Peters Pasture, near Warm Springs), 14095500 (Warm Springs River near Simnasho), 14096850 (Beaver Ck, below Quartz Ck, near Simnasho), and 14097100 (Warm Springs R. near Kahneeta Hot Springs). Data sources: OWRD (2001b), USGS (2001b).

Of the stream gages considered, gage #14046500 (John Day River at Service Creek), had the best statistical relationship with gage #14093600 (Figure 4-8). This relationship with the John Day gage was used to extend the peak flow record at gage #14093600. The extended annual peak flow record for gage #14093600 is shown in Figure 4-9.

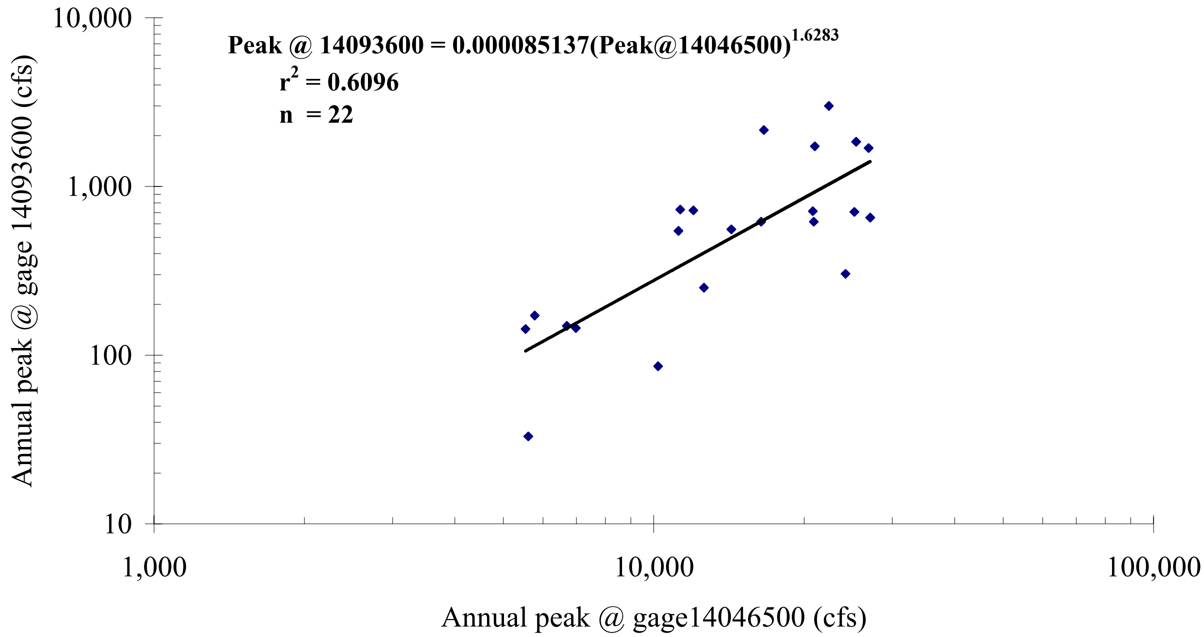

Figure 4-8. Relationship between annual peak flows at USGS gage #14046500 (John Day River at Service Creek) and OWRD gage #14093600 (Trout Cr below Amity Cr near Ashwood).

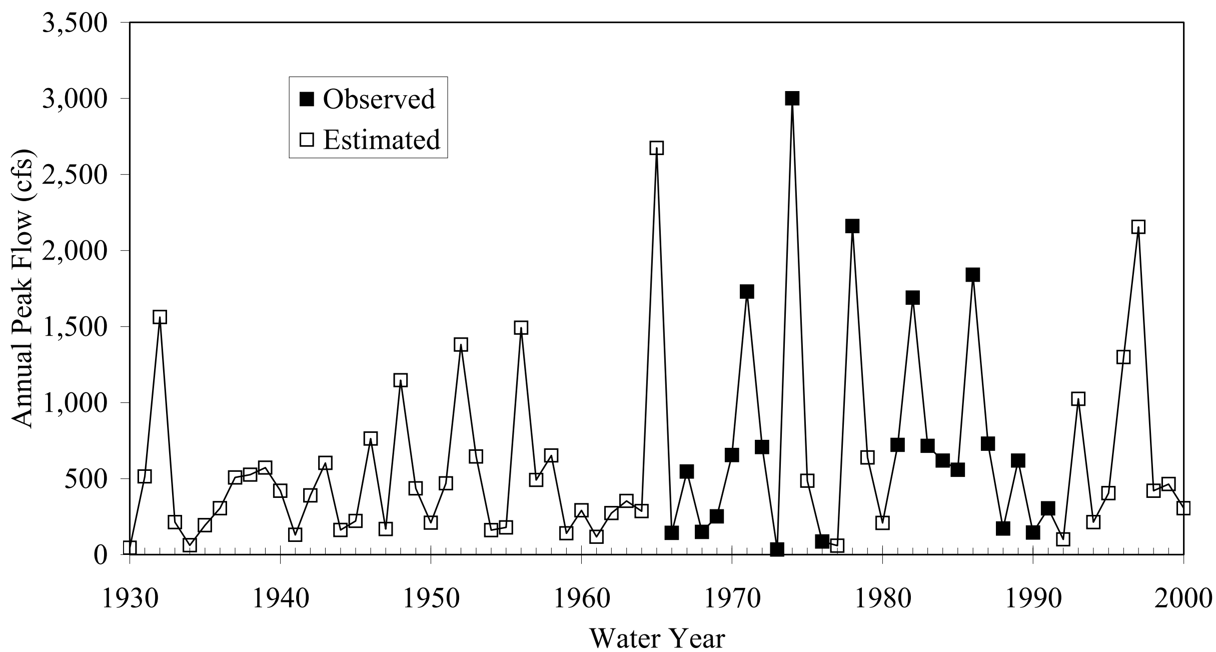

Figure 4-9. Annual peak flows at OWRD gage #14093600 (Trout Cr below Amity Cr near Ashwood). Estimated values were obtained using the relationship developed with USGS gage #14046500 (John Day River at Service Creek; Figure 4-8).

The extended peak flow record shown in Figure 4-9 should be used with caution. Significant unexplained variation exists in the relationship developed with USGS gage #14046500 (John Day River at Service Creek; Figure 4-8). Although the 1974 flood is shown as being larger than the 1965 event, this is contradicted by anecdotal information from Edlund and Penhollow (1996) that suggests that the water year 1965 flood was the largest in the past 40 years. Furthermore, in a discussion of OWRD gage #14093600 included in Edlund and Penhollow (1996), the gaps in the peak flow record for the years 1975, 1979, and 1980 are attributed to significant changes in channel shape due to high water erosion. This further places into question the validity of the synthetic hydrograph presented in Figure 4-9, as these are shown as years having relatively small peak flows.

4.1.3 Mean Monthly Stream Flow

Mean monthly stream flows were calculated for the subbasins of Trout Creek using information available from the OWRD Water Availability Report System (WARS). Natural monthly stream flow values for OWRD stream gage #14093600 (Trout Creek below Amity Creek near Ashwood) are shown in Figure 4-10. Natural Stream Flow is the flow in a stream when there are no consumptive uses[8] or flow regulation. Natural stream flow at gage #14093600 was estimated by OWRD by subtracting out-of-stream consumptive uses from observed monthly flow values.

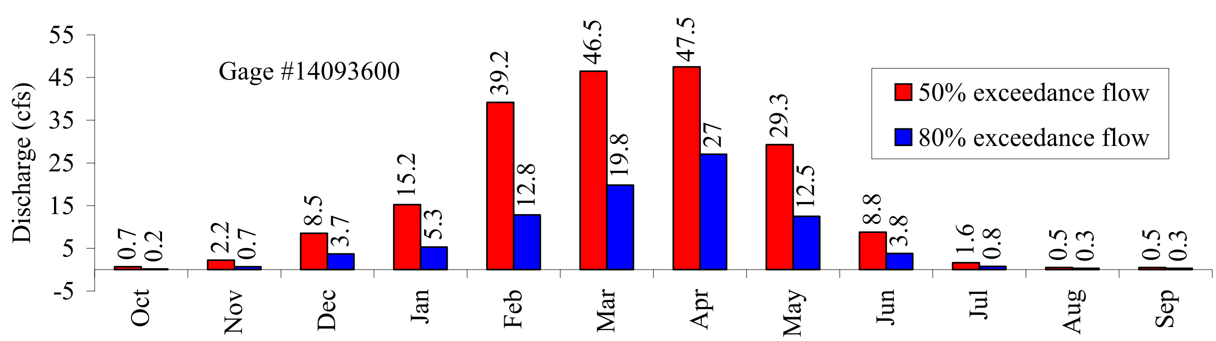

Figure 4-10. Natural stream flow at the OWRD stream gage #14093600 (Trout Cr below Amity Cr near Ashwood) in average and dry years (50% and 80% exceedance flows). Data source: OWRD (2001d).

The monthly stream flows in Figure 4-10 are shown for the 50% and 80% exceedance flows. The 50% exceedance stream flow is the stream flow that occurs at least 50% of the time. Conversely, the stream flow is also less than the 50% exceedance flow half the time. The 50% exceedance flow can be thought of as the average stream flow for that month. The 80%

[8] A consumptive use is any water use that causes a net reduction in stream flow and is usually associated with an evaporative or transpirative loss

exceedance stream flow is exceeded 80% of the time. The 80% flow is smaller than the 50% flow, and can be thought of as the stream flow that occurs in a dry month. These exceedance stream flow statistics are used by the OWRD to set the standard for over-appropriation: the 50% exceedance flow for storage and the 80% exceedance flow for other appropriations (OWRD, 2001d).

Unfortunately, no other gage records are of sufficient length (Table 4-1) to allow for a direct estimate of monthly stream flows at other locations in the watershed. The OWRD has calculated natural monthly exceedance flows for five ungaged locations within the Trout Creek watershed, all but one of which corresponds to the subbasins defined for this assessment. These estimates of natural monthly stream flows were made by the OWRD using statistical models derived from multiple linear regressions.

Figure 4-11 shows the estimated natural stream flow at the mouth of Antelope Creek for average and dry years (OWRD, 2001d). No stream gage records are available for Antelope Creek (Table 4-1), consequently it is impossible to say if the modeled monthly flows presented in Figure 4-11 are accurate or not.

The estimated natural stream flow at the mouth of Mud Springs Creek is shown in Figure 4-12 for average and dry years (OWRD, 2001d). Compare the monthly stream flows shown in Figure 4-12 with the short-term records for the same location presented in Figure 4-5 (gage #14095250, Sagebrush Creek near Gateway). The records from gage #14095250 are of too short a duration to state conclusively, however, it appears that the OWRD monthly estimates do not take into account the apparently unique nature of stream flow (i.e., unusually constant hydrograph, suggestive of a spring-fed system) in the Mud Springs tributary.

Figure 4-13 shows the estimated natural stream flow at the mouth of Hay Creek for average and dry years (OWRD, 2001d). As in the Antelope Creek, no stream gage records are available for Hay Creek (Table 4-1), consequently it is impossible to say if the modeled monthly flows presented in Figure 4-13 are accurate or not.

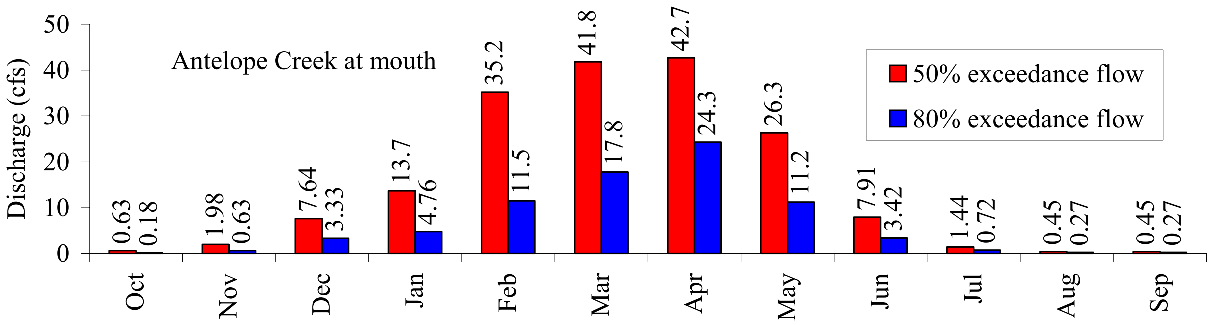

Figure 4-11. Estimated natural stream flow at the Mouth of Antelope Creek in average and dry years (50% and 80% exceedance flows). Data source: OWRD (2001d).

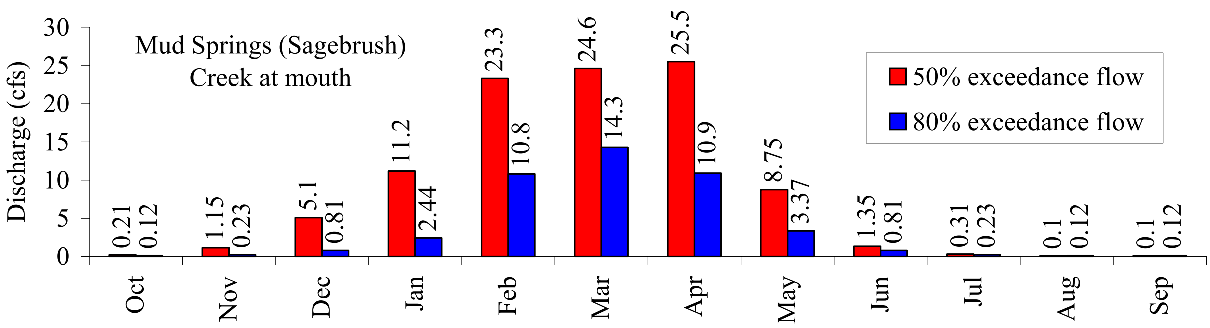

Figure 4-12. Estimated natural stream flow at the Mouth of Mud Springs Creek in average and dry years (50% and 80% exceedance flows). Data source: OWRD (2001d).

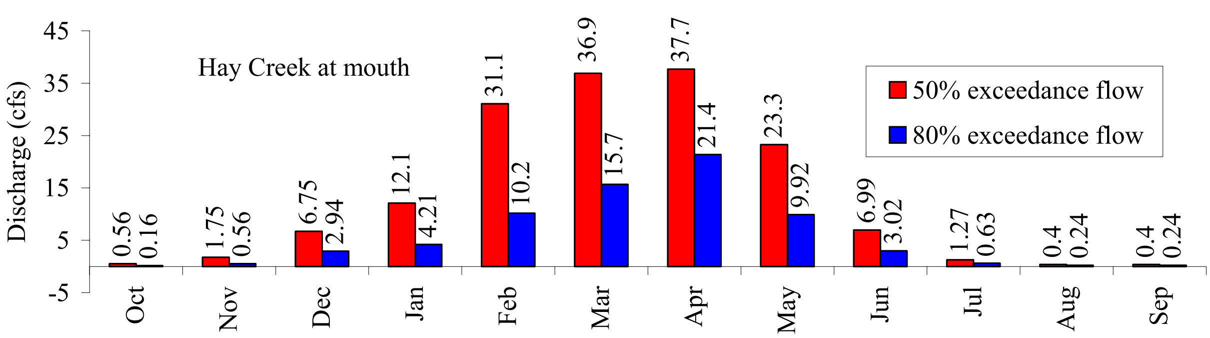

Figure 4-13. Estimated natural stream flow at the Mouth of Hay Creek in average and dry years (50% and 80% exceedance flows). Data source: OWRD (2001d).

The estimated natural stream flow for Trout Creek upstream of Antelope Creek for average and dry years is shown in Figure 4-14 (OWRD, 2001d). Monthly streamflow values for the upper Trout Creek subwatershed would be somewhat less than the values presented in Figure 4-14, and somewhat greater than the values for gage #14093600 (Figure 4-10), which is located upstream of the subbasin outlet (Figure 4-1). The pattern of flows presented in Figure 4-14 are similar to Figure 4-10, and are probably reasonably accurate given the existence of long-term flow records at gage #14093600.

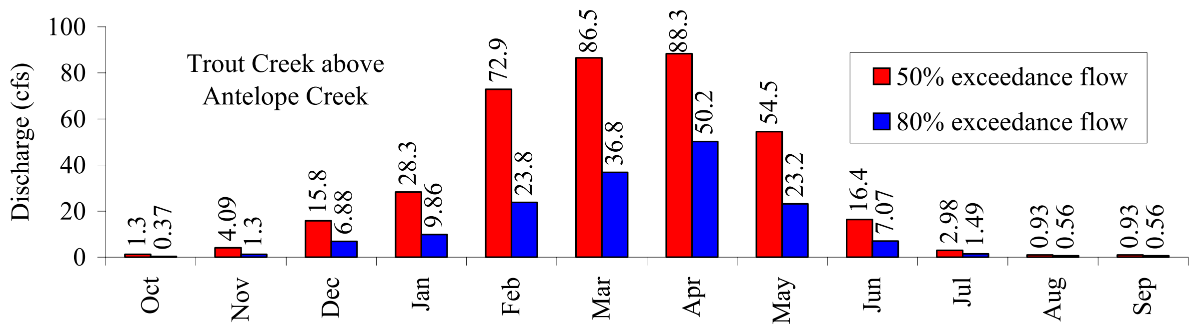

Figure 4-14. Estimated natural stream flow for Trout Creek upstream of Antelope Creek in average and dry years (50% and 80% exceedance flows). Data source: OWRD (2001d).

The estimated natural stream flow at the mouth of Trout Creek for average and dry years are shown in Figure 4-15 (OWRD, 2001d). As with the estimates for Mud Springs Creek, the values shown in Figure 4-15 for the summer months do not compare well with the short-term observations presented in Figure 4-5 (gage #14095255, Trout Creek at Clemens Drive near Gateway). Here also it appears that the OWRD monthly estimates do not take into account the apparently unique nature of stream flow coming from the Mud Springs tributary.

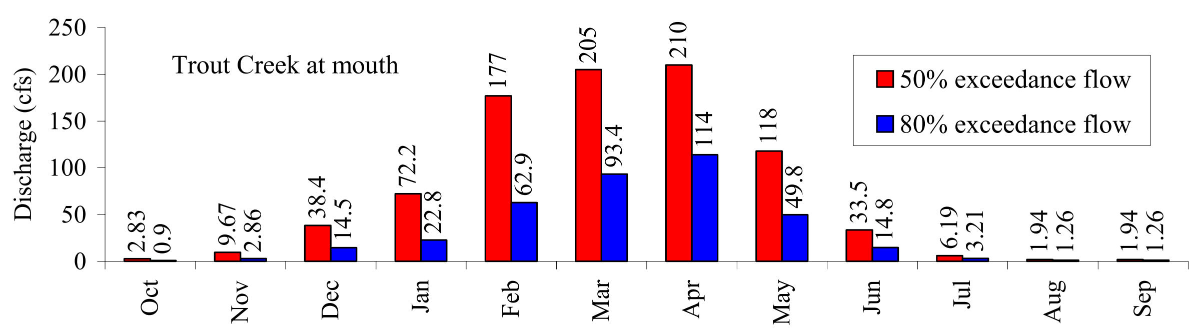

Figure 4-15. Estimated natural stream flow at the mouth of Trout Creek in average and dry years (50% and 80% exceedance flows). Data source: OWRD (2001d).

4.2 DISTRIBUTION OF SPRINGS AND LOCATIONS OF GROUNDWATER INFLOW

The critical question that was asked in this portion of the analysis was "what is the distribution springs in the watershed, and where are the likely locations of measurable groundwater inflows in Trout Creek?" The purpose for asking this question was to identify those areas within the Trout Creek mainstem and tributaries that provide cold-water refugia for salmonid species.

The initial approach taken in this section was to use Forward Looking Infrared (FLIR) thermal photography to measure thermal infrared energy emitted at the water surface along the mainstem of Trout Creek and high-priority tributaries. The FLIR equipment was mounted on a helicopter that was flown at an elevation of several hundred feet along the streams. The flight was conducted on 7/19/2001. Unfortunately, the quality of the imagery was not sufficient to provide any meaningful analysis. Recommendations for future FLIR flights are given in the Data Gaps / Recommendations section of this report. Subsequently, an analysis was undertaken to correlate spring location with geologic factors that may influence the occurrence of springs.

Data on the locations of springs within the watershed were available from two sources. The primary source of data was the Bureau of Land Management's (BLM) Hydrography Points coverage for the BLM Prineville district (BLM, 2001). This data set covered the majority of the watershed. Data on spring locations not covered by the BLM data was derived from USGS 7.5" quad maps (REO, 2001; USGS 2001a).

A total of 421 springs were identified within the watershed (Figure 4-16). Among the subbasins, Upper Trout has the highest density of springs, with one spring for every 1.1 mi^2 of land. The Antelope Creek and Hay Creek subbasins also had relatively high densities of springs with one spring per every 1.2 and 1.5 mi^2 of land respectively. The lowest densities of springs were found in the Mud Springs Ck and Lower Trout subbasins, which had one spring per every 7.7 and 5.3 mi^2 of land respectively. Overall the entire watershed had a one spring per every 1.6 mi^2 of land.

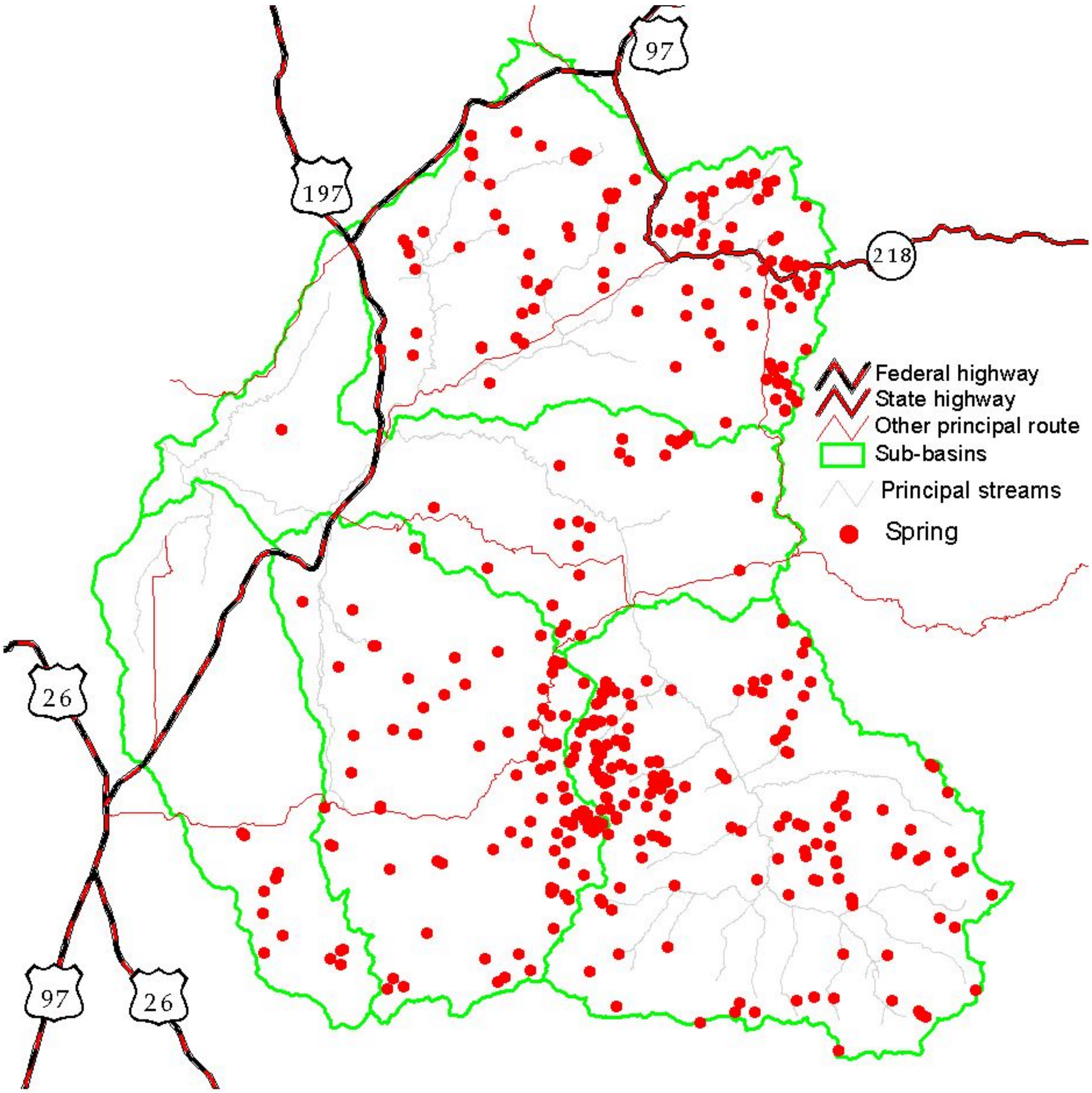

Figure 4-16. Location of springs within the Trout Creek watershed. Data sources: BLM (2001); REO (2001); USGS (2001a).

The density of springs was analyzed by geologic type, using surficial geology information available from Walker and MacLeod (1991) (Figure 1-10, Table 1-6). Springs within the Trout Creek watershed were found within seven of the 20 geologic types that are found within the watershed (Figure 4-17). Collectively, these seven geologic types make up 89% of the watershed area. The greatest density of springs was found in the landslide & debris-flow deposits (QlS; Figure 4-17). Other geologic types that contain springs are (in order of descending density of springs) the Clarno Formation (Tct), John Day Formation (Tsfj), clastic rocks and andesite flows (Tca), Grande Ronde basalt (Tcg), rhyolite and dacite domes and flows (Tr), and partly metamorphosed sedimentary rocks (TRPzs).

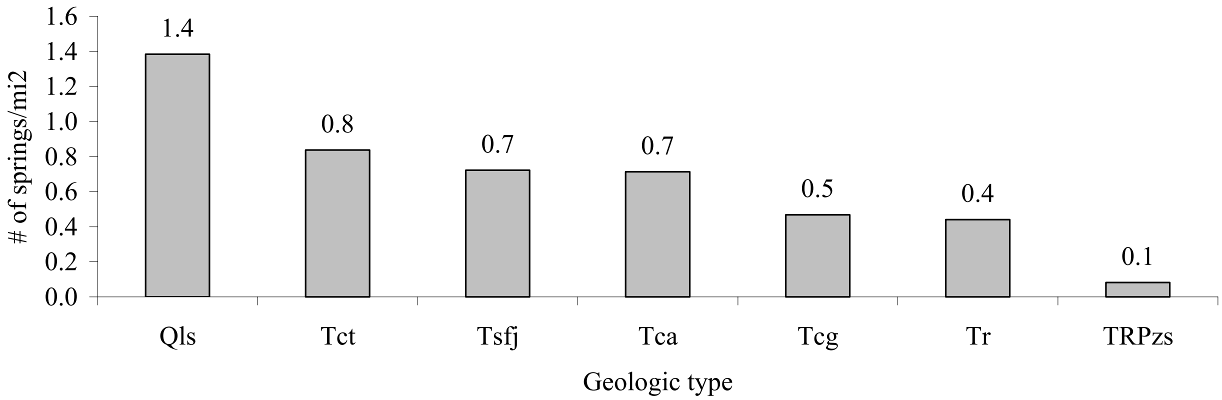

Figure 4-17. Density of springs by geologic type within the Trout Creek watershed. Refer to, Table 1-6 for descriptions of geologic types. (Figure 1-10)

The distribution of springs relative to locations of geologic contacts[9] and faults was also analyzed for the watershed using surficial geology information available from Walker and MacLeod (1991) (Figure 1-10, Table 1-6). The occurrence of springs was highest in areas closest to, and declined with increasing distance from, contacts and geologic faults (Figure 4-18).

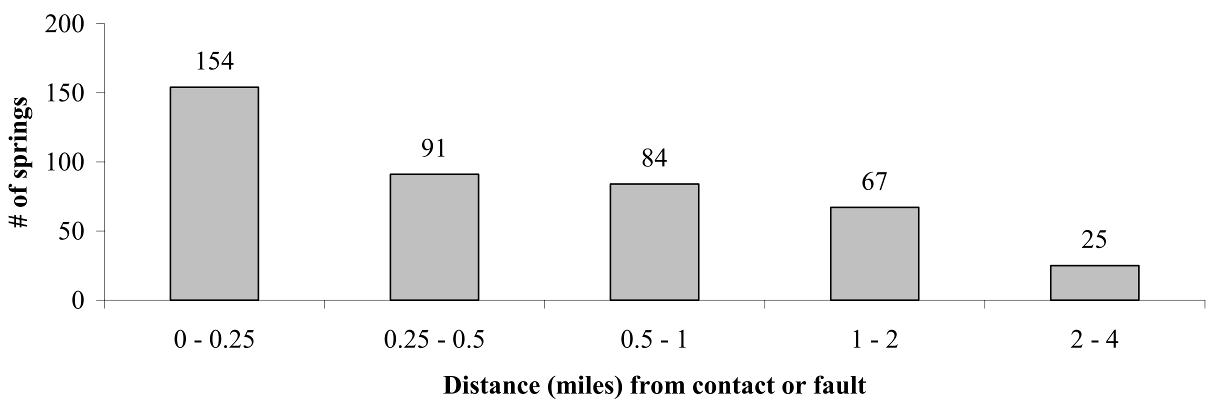

Figure 4-18. Distribution of springs relative to geologic contacts or faults within the Trout Creek watershed.

[9] The boundary between different map units.

4.3 WATER WITHDRAWALS

The critical question that was asked in this portion of the analysis was "where are the locations of water withdrawals in the watershed and what are the estimated withdrawal rates?" Data available from the OWRD (OWRD, 2001a; OWRD, 2002a) were used to identify locations and characteristics of water rights in the Trout Creek watershed[10]. Only those water rights whose current status is given as "non-cancelled" were included in this assessment. An appendix containing a summary of all water rights, listed by subbasin and stream, is included in section 10.2.

4.3.1 Overview of Water Rights in the Trout Creek Watershed

Water rights entitle a person or organization to use the public waters of the state in a beneficial way. Oregon's water laws are based on the principle of prior appropriation (OWRD, 2001e). The first entity to obtain a water right on a stream is the last to be shut off in times of low stream flows. In times when water is in short supply, the water right holder with the oldest date of priority can demand the water specified in their water right regardless of the needs of junior users. The oldest water right within the Trout Creek Watershed has a priority date of 12/31/1870, and the newest a priority date of 1/ 4/2001 (OWRD, 2002).

Certain water uses do not require a water right (OWRD, 2001e). Exempt uses of surface water include natural springs which do not flow off the property on which they originate, stock watering, fire control, forest management, and the collection of rainwater. Exempt groundwater uses include stock watering, less than one-half acre of lawn and garden watering, and domestic water uses of no more than 15,000 gallons per day.

Edlund and Penhollow (1996) include an overview of water rights in the Trout Creek watershed. They note that most of the water rights in the watershed are "decreed" water rights, which refers to an adjudication process applied to water rights that were acquired prior to 1909. The adjudication process confirmed the water rights if it could be proven that the public waters of the state were being used in a beneficial way on certain acreage of land. For water rights after 1909, any entity wanting to use the waters of the state for a beneficial use has had to go through an application/permit process administered by the OWRD. Under this process an entity applies for a permit to use a certain amount of water, and then establishes that the water is being used for a

[10] Of the two sources of data used in this portion of the assessment, the Water Rights Information System data (OWRD, 2002a) is the most accurate and up to date (K. Boles, OWRD, pers. comm., 2/22/2002). The available GIS data (OWRD, 2001a) was used primarily to show locations of diversions and water use and may not accurately reflect current conditions.

beneficial use. Once the beneficial use is established, and a final proof survey is done to confirm the right, a certificate is issued.

In 1980, the state of Oregon withdrew all unappropriated waters of the Trout Creek and its tributaries, except for waters from the Mud Springs Creek subbasin to protect fish spawning (Edlund and Penhollow, 1996). Most recent water-right activity in the watershed involves transfers in place of use, or change in point of diversion.

The OWRD also approves instream water rights for fish protection, minimizing the effects of pollution or maintaining recreational uses (OWRD, 2001e). Instream water rights set flow levels to stay in a stream reach on a monthly basis, have a priority date, and are regulated the same as other water rights. Instream water rights do not guarantee that a certain quantity of water will be present in the stream; under Oregon law, an instream water right cannot affect a use of water with a senior priority date (OWRD, 2001e).

Three stream reaches within the Trout Creek watershed have designated instream water rights for the benefit of fish migration, spawning and juvenile rearing (OWRD, 2001a). These reaches are Trout Creek, from the mouth of Antelope Creek to the confluence with the Deschutes River (Priority date: 3/21/1990), Trout Creek from the mouth of Clover Creek to the confluence with Antelope Creek (Priority date: 5/9/1990), and Antelope Creek from the mouth of Grub Hollow Creek to the confluence with Trout Creek (Priority date: 8/12/1991)

4.3.2 Locations of Water Withdrawals

The OWRD identifies 312[11] points of diversion for water rights within the Trout Creek watershed (OWRD, 2002). The approximate locations of these points of diversion are shown in Figure 4-19 (OWRD, 2001a). Points of diversion for water rights are found within all subbasins, and are predominately from surface water sources (Figure 4-20).

[11] The actual number of physical locations where water is diverted may be less then 312. Diversion points appear to be duplicated in the OWRD GIS coverage in some situations. For example, when more then one water right applies to a physical diversion the number of points may be duplicated.

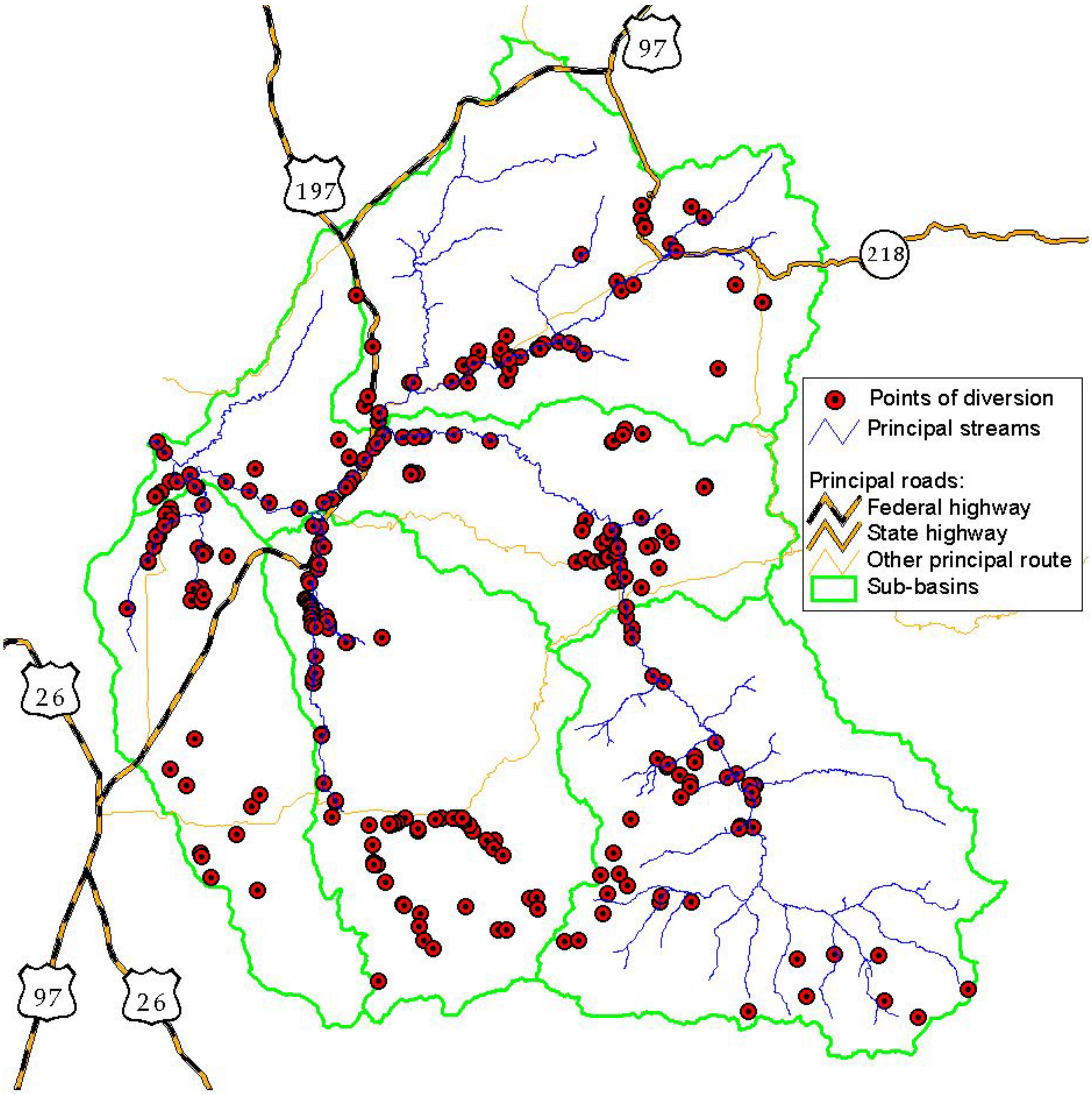

Figure 4-19. Points of diversion for water rights within the Trout Creek watershed. Data source: OWRD (2001a).

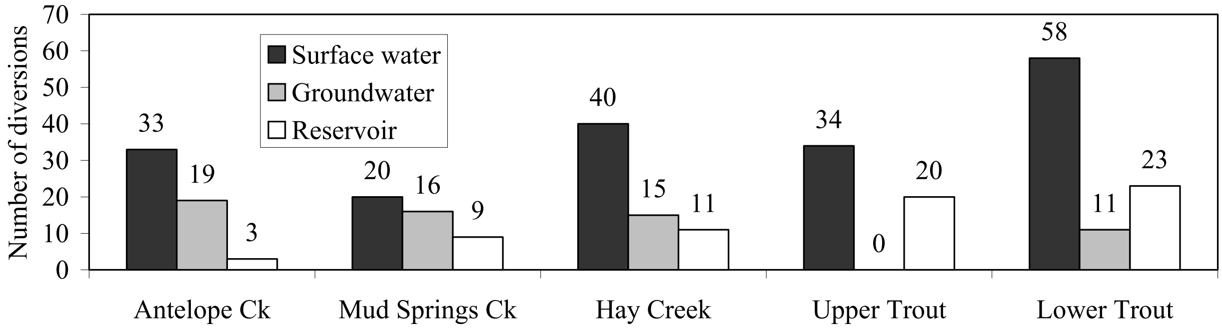

Figure 4-20. Distribution of water right points of diversion by subbasin and water source (i.e., surface water, groundwater, and reservoir) within the Trout Creek watershed. Data source: OWRD (2002).

4.3.3 Withdrawal Rates

Information on withdrawal rates associated with water rights within the Trout Creek watershed is available through the OWRD (2002), and is included in the appendix in section 10.2. Rate of withdrawal given in the OWRD data is expressed either as an instantaneous rate (i.e., cubic-feet per second or gallons per minute) or as a total yearly volume (i.e., acre-feet). Some (but not all) of the water rights whose withdrawal rate is expressed in acre-feet have further restrictions that specify an instantaneous rate that water can be applied (for example, 1/40 cfs per irrigated acre) as well as the maximum volume that can be applied in a given season or over any 30-day period. It would be most convenient, when summarizing the rate of water withdrawals, to be able to express the withdrawal rate in common units of measurement for all water uses within a subbasin. However, this type of estimate is not possible at the current time using the publicly-available information from the OWRD. The OWRD is considering changes to their Water Rights Information System (WRIS) that will allow estimation of instantaneous withdrawals (K. Boles, OWRD, pers. comm., 2/22/2002).

Given the limitations described above, the withdrawal rates for the Trout Creek watershed had to be estimated separately for those water rights whose rate of withdrawal is given as a total yearly volume (acre-feet), and those whose rate are given as an instantaneous rate (cfs). Summaries for these two units of measure are given in Figure 4-21 and Figure 4-22.

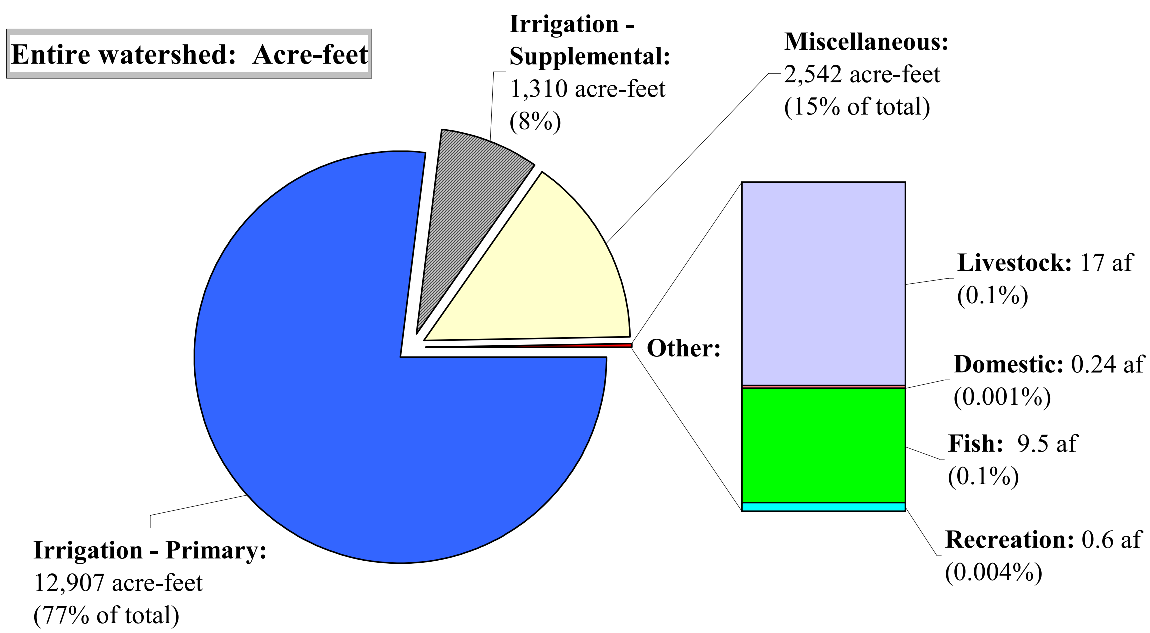

Figure 4-21. Summary of the water rights within the Trout Creek Watershed that are reported in units of acre-feet. Data source: OWRD (2002).

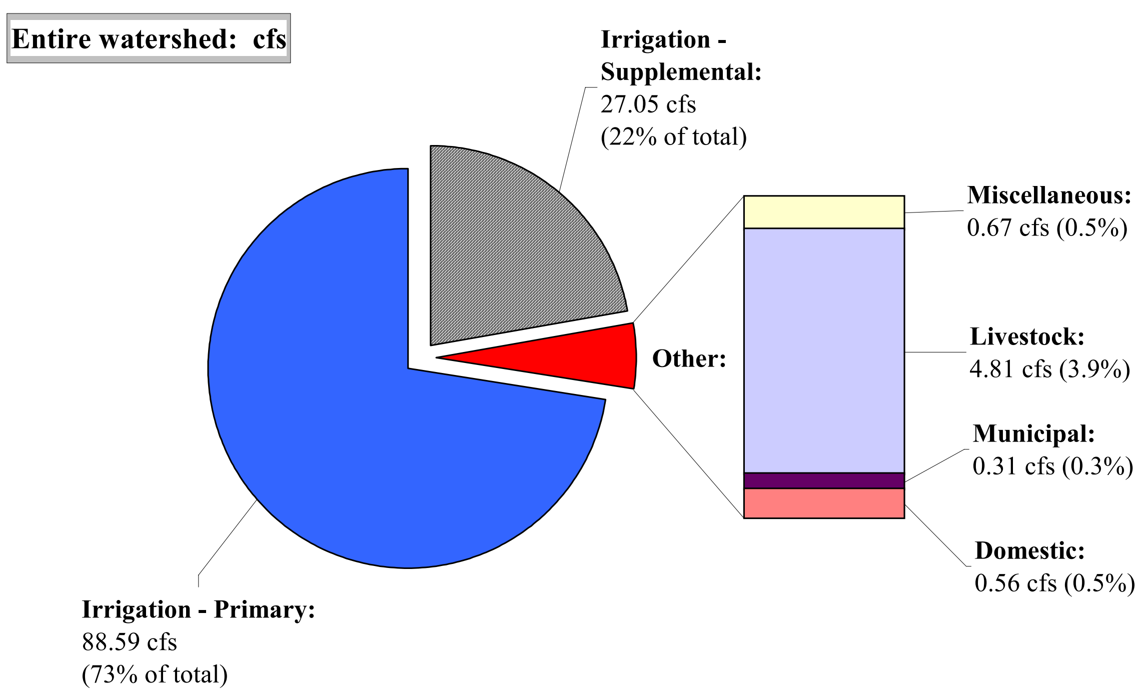

Figure 4-22. Summary of the water rights within the Trout Creek basin that are reported in units of cubic feet per second (cfs). Data source: OWRD (2002).

Despite the difficulty in expressing all water rights in a common set of units, it is clear that irrigation is the primary use of water withdrawals in the watershed, accounting for 85% of the volume reported in units of acre-feet (Figure 4-21), and 95% of the volume reported as an instantaneous rate (Figure 4-22). Additionally, almost all of the water use that is shown as "miscellaneous" is water storage associated with irrigation.

Irrigated areas within the Trout Creek watershed are shown in Figure 4-23 (OWRD, 2001a). The majority of the irrigated lands within the watershed are found in the Hay Creek and Lower Trout Creek subbasins (Figure 4-24).

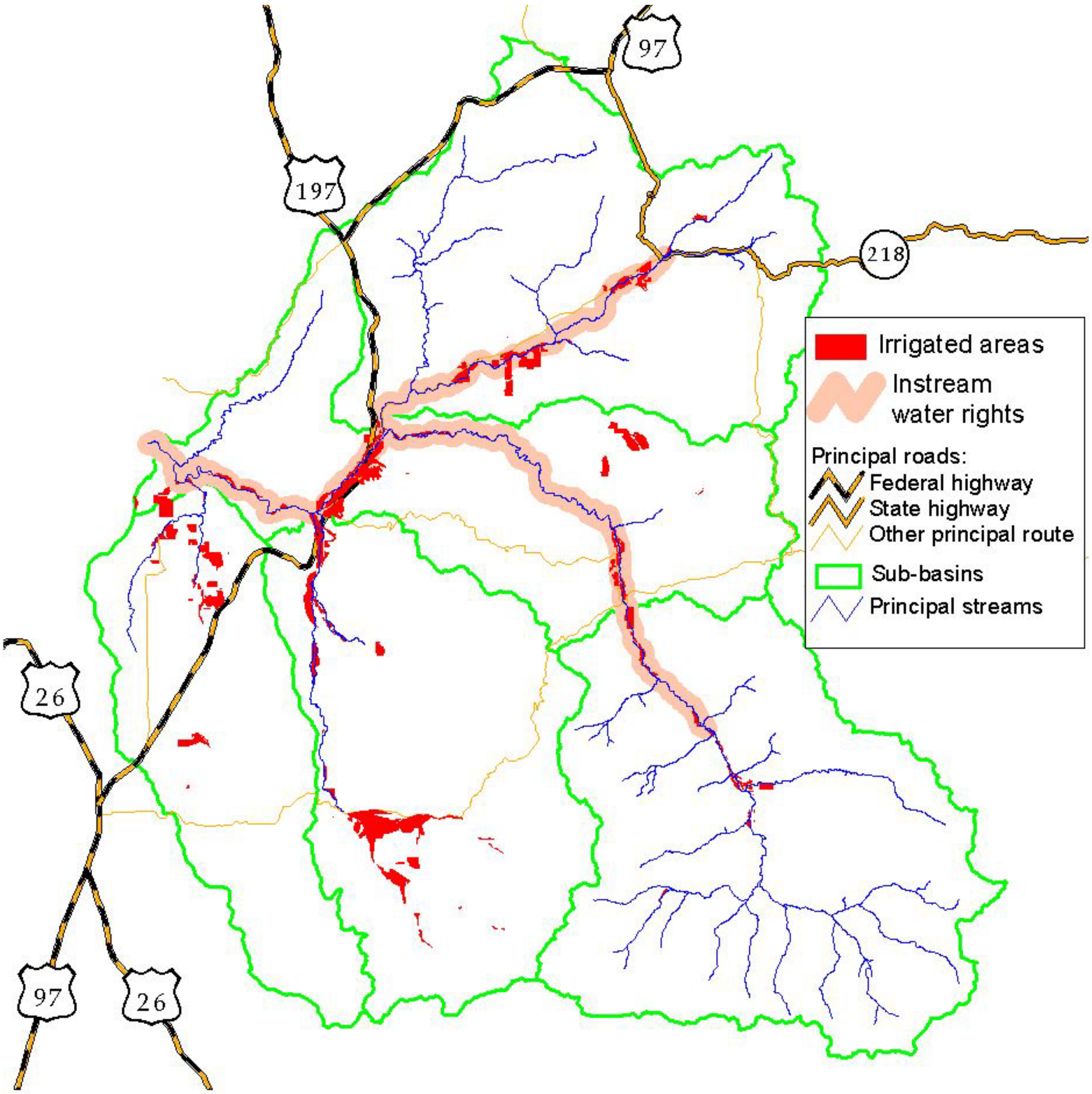

Figure 4-23. Irrigated areas and stream having instream flow rights within the Trout Creek watershed. Data source: OWRD (2001a).

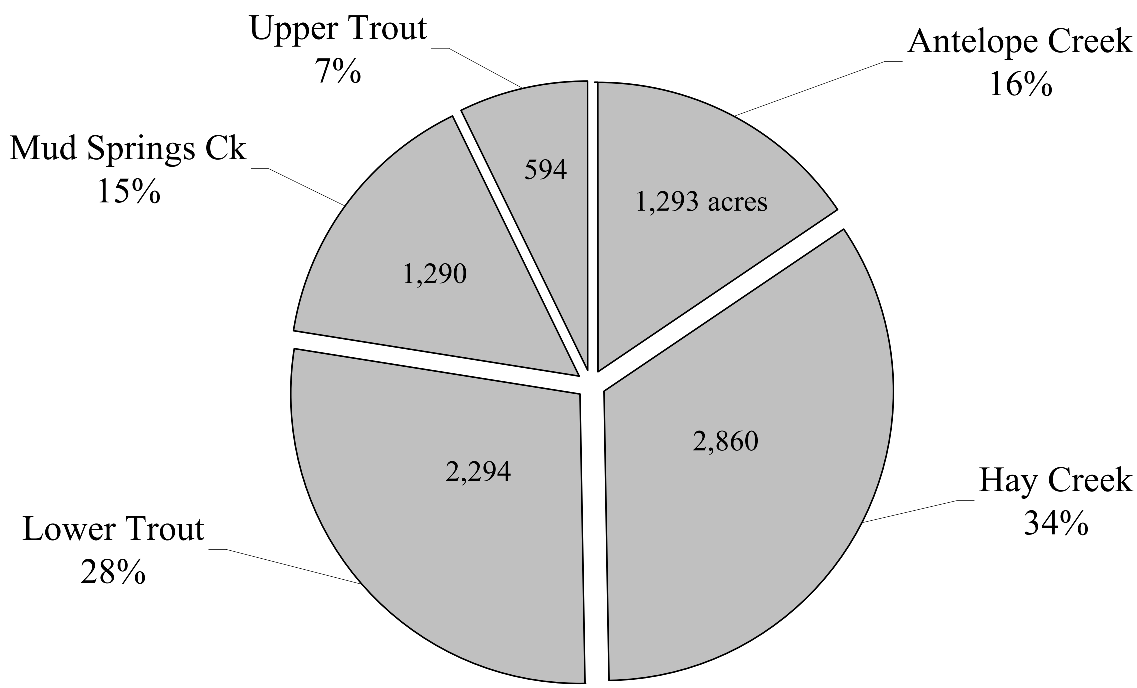

Figure 4-24. Distribution of irrigated acres by subbasin. Data source: OWRD (2001a).

4.4 CURRENT LAND USE EFFECTS ON FLOW REGIME

The critical question that was asked in this portion of the analysis was "what is the likely relationship between current land uses in the basin and the current flow regime (peak and low flows) in the major creeks in the basin?" Information available from several sources was used to estimate land use effects on stream flow; no new analysis was performed as part of this assessment. This portion of the assessment was broken into two main components that reflect the priorities of concern in the watershed; effects due to water withdrawals, and all other land uses.

4.4.1 Water Withdrawals

The OWRD has estimates of the net effects of water withdrawals on monthly stream flows. This information can be extracted from the OWRD Water Availability Report System (WARS) for five locations within the Trout Creek watershed (OWRD, 2001d). The five locations where effects of water withdrawals can be estimated are the same locations that mean monthly stream flow estimates were derived for in section 4.1.3; the mouths of Antelope, Mud Springs and Hay Creeks; Trout Creek above Antelope Creek; and the mouth of Trout Creek.

In estimating the net effects of water withdrawals on monthly stream flows, the OWRD has taken into account the fact that a portion of the water withdrawn from the water source returns to the stream. Only the portion of each withdrawal that is actually consumed (i.e., the consumptive use) is included in the net estimate. A consumptive use is defined by the OWRD as any water use that causes a net reduction in stream flow (OWRD, 2001d). These uses are usually associated with an evaporative or transpirative loss. The OWRD recognizes four major categories of consumptive use: irrigation, municipal, storage, and all others (e.g., domestic, livestock).

The OWRD estimates the consumptive use for irrigation using estimates made by the USGS; including estimates from the 1987 Census of Agriculture, estimates from the OSU Cooperative Extension Office, 1989-90 Oregon Agriculture and Fisheries Statistics, and an OSU Study of Crop Water Requirements (OWRD, 2001d). Irrigation uses are not estimated to be 100 percent consumptive. Consumptive use from other categories of use is obtained by multiplying a consumptive use coefficient (e.g., for domestic use, the coefficient is 0.20) by the maximum diversion rate allowed for the water right. The OWRD assumes that all of the non-consumed part of a diversion is returned to the stream from which it was diverted. The exception is when diversions are from one watershed to another, in which case the use is considered to be 100 % (i.e., the consumptive use equals the diversion rate).

The net effect of water withdrawals on monthly stream flows were estimated at each of these five locations (i.e., the mouths of Antelope, Mud Springs and Hay Creeks; Trout Creek above Antelope Creek; and the mouth of Trout Creek) in the following manner:

1. The estimated monthly natural stream flows for average and dry years (represented by the 50% and 80% exceedance flow respectively) were first plotted for each location. These are the same values that are shown in Figure 4-11 through Figure 4-15.

2. The portion of all water withdrawals that does not return to the stream (i.e., the consumptive uses) was added to water diverted for storage for each month and plotted on the same graph.

3. If an instream water right exists for the subwatershed this was also shown on the graph

4. Finally, the sum of instream water rights, consumptive uses, and storage was plotted on the graph.

Figure 4-25 shows the estimated net effect of water withdrawals on monthly stream flows at the mouth of Antelope Creek. These estimates indicate that consumptive water use plus storage exceeds the estimated volume of natural stream flow in the months of July through October in both average (50% exceedance flows) and dry (80% exceedance flows) years. In other words, if all of the water is withdrawn that is allowed under the existing water rights, there would be no flow remaining in the stream during these months. Instream water rights are limited to no more than the natural 50% exceedance stream flow (OWRD, 2001d). It appears, based on the data shown in Figure 4-25 that the instream water rights for Antelope Creek were set at the natural 50% exceedance stream flow. Consequently, the sum of instream water rights, consumptive uses, and storage exceeds the estimated volume of natural stream flow in all months in both average (50% exceedance flows) and dry (80% exceedance flows) years in Antelope Creek. In other words, there is no way, given these estimated volumes of natural flow and the water withdrawals allowed, for the instream water rights to be fulfilled in any month.

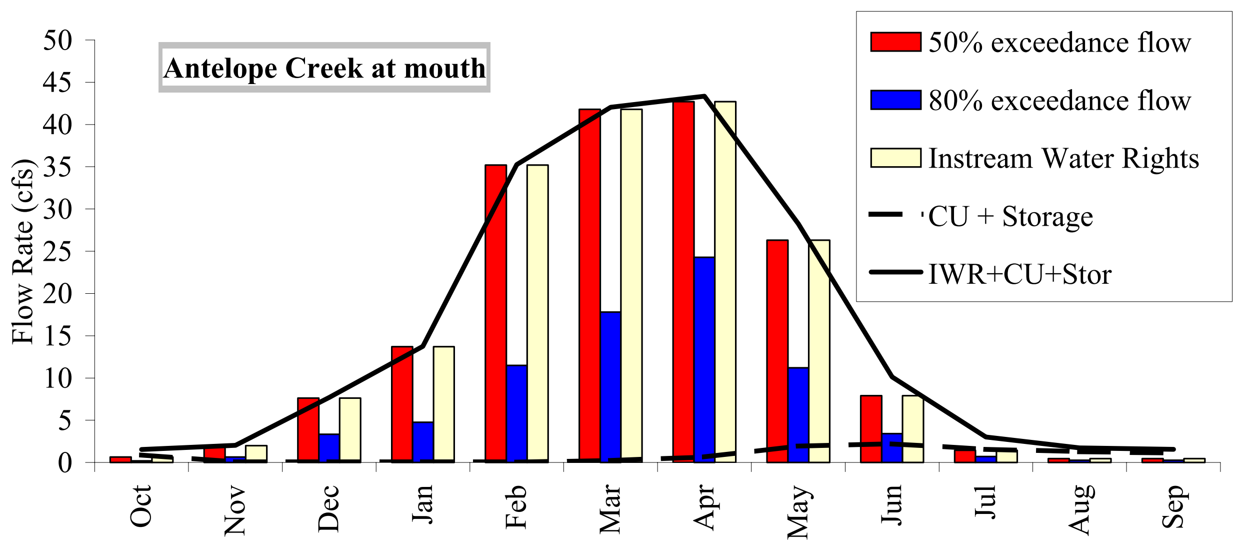

Figure 4-25. Estimated net effect of water withdrawals on monthly stream flows at the mouth of Antelope Creek. Shown are estimated natural stream flows for average and dry years (50% and 80% exceedance flows); the portion of water withdrawals that does not return to the stream (i.e., consumptive uses – CU) and water that is stored (STOR); instream water rights; and the sum of instream water rights (IWR), consumptive uses (CU) and storage (STOR). Data source: OWRD (2001d).

Figure 4-26 and Figure 4-27 show the estimated net effect of water withdrawals on monthly stream flows at the mouths of Mud Springs Creek and Hay Creek. Neither of these streams have instream water rights (OWRD, 2001d). These estimates indicate that consumptive water use plus storage exceeds the estimated volumes of natural stream flow in both subbasins during the months of June through October in average years (50% exceedance flows). In other words, if all of the water is withdrawn that is allowed under the existing water rights, there would be no flow remaining in the stream during these months during years of average stream flow. Furthermore, these estimates indicate that consumptive water use plus storage exceeds the estimated volumes of natural stream flow in both subbasins during the months of May through October in dry years (80% exceedance flows). In other words, if all of the water is withdrawn that is allowed under the existing water rights, there would be no flow remaining in the stream during these months during dry years.

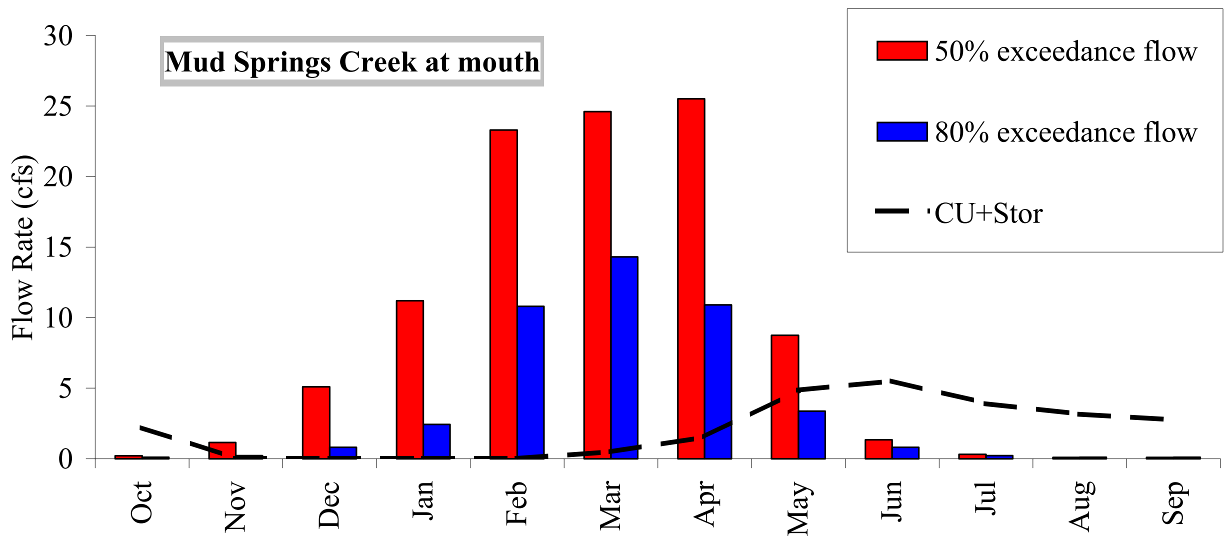

Figure 4-26. Estimated net effect of water withdrawals on monthly stream flows at the mouth of Mud Springs Creek. Shown are estimated natural stream flows for average and dry years (50% and 80% exceedance flows); and the portion of water withdrawals that does not return to the stream (i.e., consumptive uses – CU) and water that is stored (STOR). Data source: OWRD (2001d).

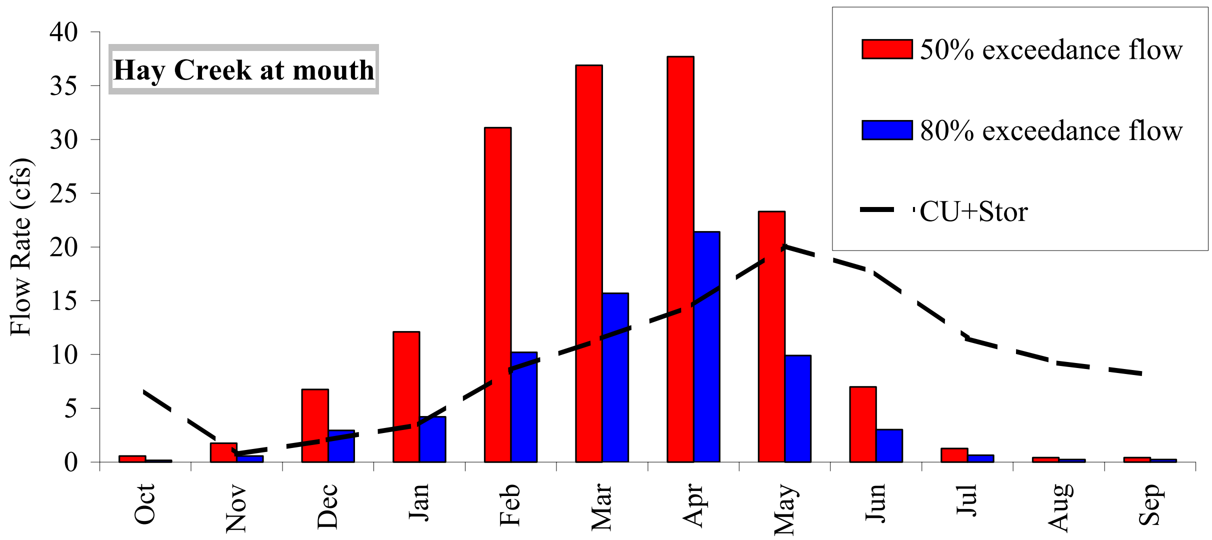

Figure 4-27. Estimated net effect of water withdrawals on monthly stream flows at the mouth of Hay Creek. Shown are estimated natural stream flows for average and dry years (50% and 80% exceedance flows); and the portion of water withdrawals that does not return to the stream (i.e., consumptive uses – CU) and water that is stored (STOR). Data source: OWRD (2001d).

Figure 4-28 shows the estimated net effect of water withdrawals on monthly stream flows for Trout Creek upstream of the confluence with Antelope Creek. These estimates indicate that consumptive water use plus storage exceeds the estimated volume of natural stream flow in the months of July through October in both average (50% exceedance flows) and dry (80% exceedance flows) years. In other words, if all of the water is withdrawn that is allowed under the existing water rights, there would be no flow remaining in the stream during these months. The sum of instream water rights, consumptive uses, and storage exceeds the estimated volume of natural stream flow in the months of May through November in years of average stream flow (50% exceedance flows), and in all months during dry years (80% exceedance flows).

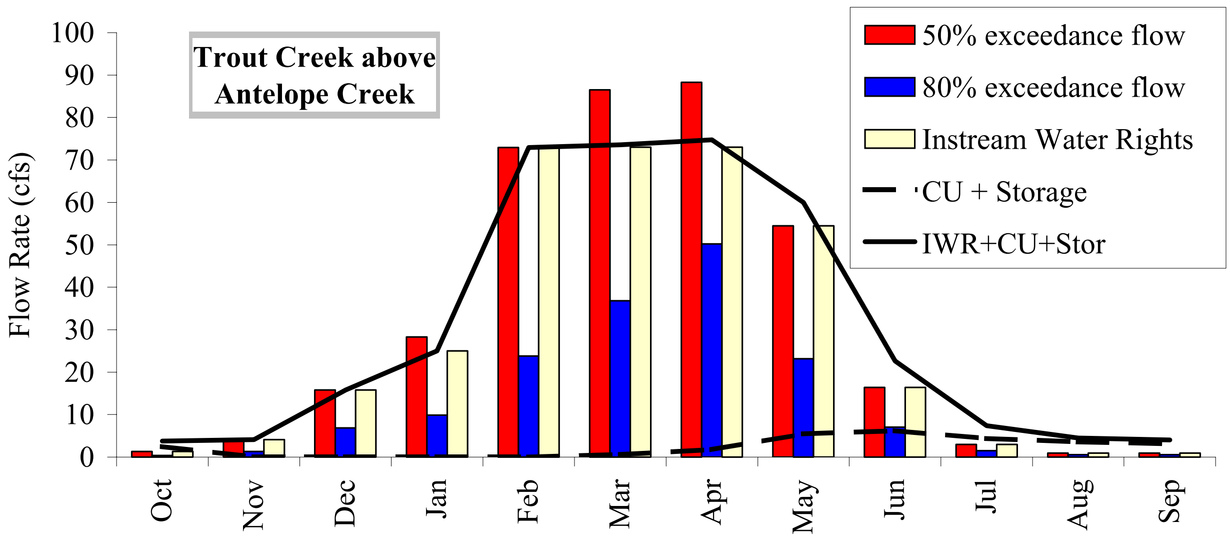

Figure 4-28. Estimated net effect of water withdrawals on monthly stream flows at Trout Creek above Antelope Creek. Shown are estimated natural stream flows for average and dry years (50% and 80% exceedance flows); the portion of water withdrawals that does not return to the stream (i.e., consumptive uses – CU) and water that is stored (STOR); instream water rights; and the sum of instream water rights (IWR), consumptive uses (CU) and storage (STOR). Data source: OWRD (2001d).

Figure 4-29 shows the estimated net effect of water withdrawals on monthly stream flows at the mouth of Trout Creek. These estimates indicate that consumptive water use plus storage exceeds the estimated volume of natural stream flow in the months of June through October in both average (50% exceedance flows) and dry (80% exceedance flows) years. In other words, if all of the water is withdrawn that is allowed under the existing water rights, there would be no flow remaining in the stream during these months. The sum of instream water rights, consumptive uses, and storage exceeds the estimated volume of natural stream flow in the months of June through November in years of average stream flow (50% exceedance flows), and in all months except March and April during dry years (80% exceedance flows).

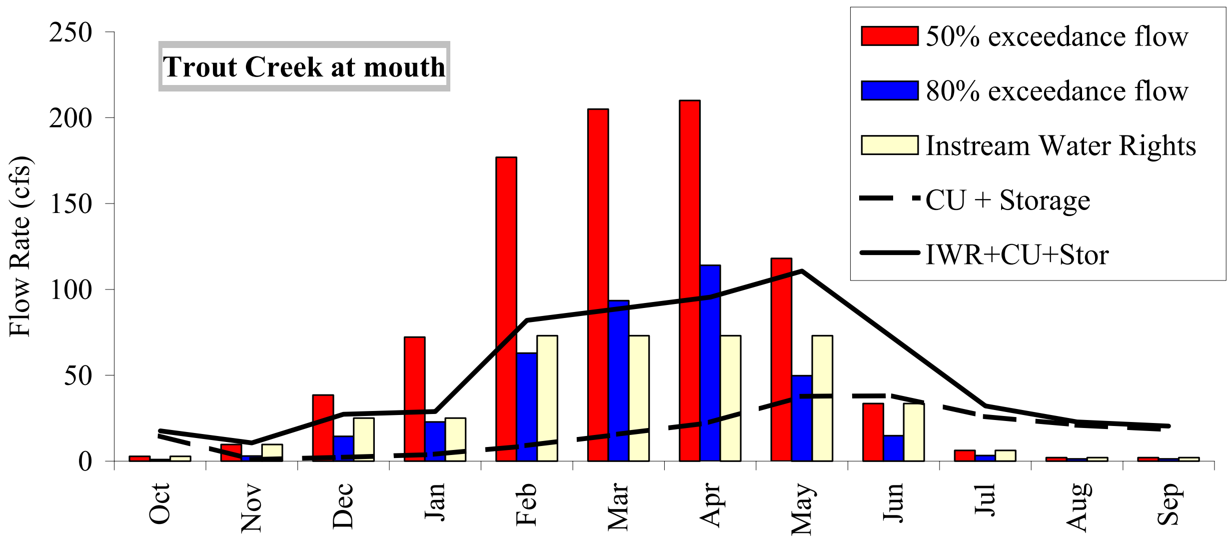

Figure 4-29. Estimated net effect of water withdrawals on monthly stream flows at the mouth of Trout Creek. Shown are estimated natural stream flows for average and dry years (50% and 80% exceedance flows); the portion of water withdrawals that does not return to the stream (i.e., consumptive uses – CU) and water that is stored (STOR); instream water rights; and the sum of instream water rights (IWR), consumptive uses (CU) and storage (STOR). Data source: OWRD (2001d).

4.4.2 Other Land Uses

Very little data or studies are available that addresses the effects of other land uses on peak and/or low stream flows within the Trout Creek watershed, and that which is available is mostly of a qualitative nature. The following narrative is broken into three parts. Section 4.4.2.1 provides background information on the primary ways that land use activities affect stream flows. Section 4.4.2.2 summarizes results from peak flow modeling study conducted by the NRCS (Edlund and Penhollow, 1996). Section 4.4.2.3 summarizes findings from the USFS watershed analysis conducted for the upper portion of the watershed in 1995 (USFS, 1995).

4.4.2.1 Background information on land use effects on stream flow

Figure 4-30 is a generalized diagram showing the primary interactions between land uses found in the Trout Creek watershed and changes in peak, annual, and low stream flows. Note that Figure 4-30 does not include "top-level" land uses (e.g., Urbanization, Agriculture, Forest Management, etc.). The reason for this is that there is considerable overlap between top level land uses and the underlying hydrologic processes that they affect. For example, both urbanization and agricultural practices have the ability to affect vegetation removal, soil erosion/mass wasting, wetland degradation, channel down cutting, dike/levee construction, soil compaction, and road development. This analyst believes that, rather than discussing impacts by top level land uses, it is more appropriate to discuss land use impacts in terms of the underlying processes.

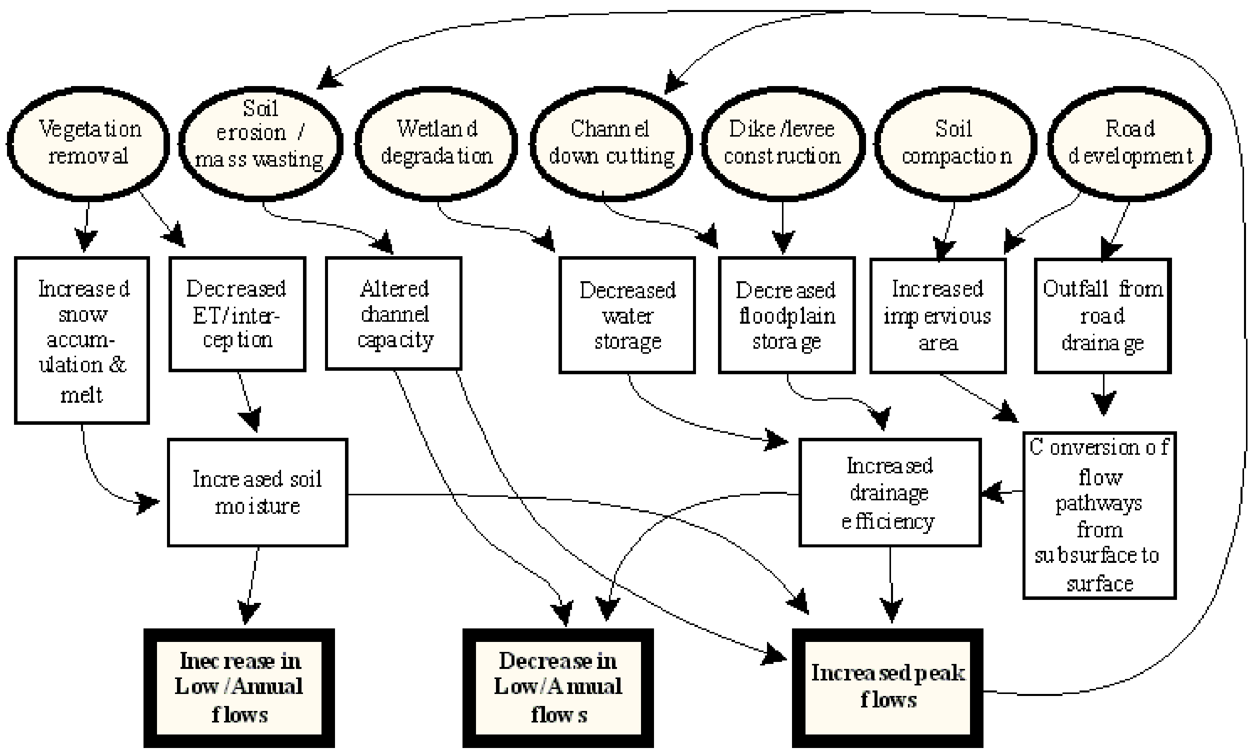

Figure 4-30. Generalized diagram of the primary interactions between land uses found in the Trout Creek watershed and changes in peak, annual, and low stream flows (adapted from Ziemer, 1998).

<u>Vegetation Removal:</u>

Rain-on-snow (ROS) is the common term used to describe wintertime conditions when relatively warm wind and rain combine to produce rapid snowmelt (Coffin and Harr, 1992). ROS flood events may occur in areas having significant wintertime snow packs, and are independent of land use. Removal of the forest canopy can augment ROS peak flows by increasing snow accumulation in openings (Troendle, 1983; Bosch and Hewlett, 1982) and increasing the rate of snowmelt by increasing the effective wind speeds at the snowpack surface (Harr, 1981; Harr, 1986; Coffin and Harr, 1992). The extent to which forest removal may augment ROS peak flows is a function of the amount of harvesting within the elevation range that defines the ROS zone. At low elevations (below the ROS zone) winter temperatures are generally too warm to allow for significant snow accumulation, and at higher elevations wintertime precipitation generally falls as snow. As discussed in section 4.1.2 above, ROS appears to be an important process in peak flow generation within the Trout Creek watershed. Consequently, the potential exists for peak flows to be augmented by forest harvesting.

Vegetation can intercept a portion of the precipitation falling on a watershed, a further portion of which is evaporated back to the atmosphere during or after a storm event, thereby reducing the net precipitation reaching the soil (Dunne and Leopold, 1978). Evapotranspiration by vegetation removes moisture from the soil profile and returns it to the atmosphere (Dunne and Leopold, 1978). Increases in peak flows have been observed in some situations following harvest of trees, which are presumed to be the result of loss of canopy interception and evapotranspiration (Ziemer, 1998). Several studies (Harr et al., 1979; Helvey, 1980; Harr and Krygier, 1972; Bosch and Hewlett, 1982; Harr, 1983; Hetherington, 1987; Kattelmann et al., 1983; Troendle, 1983; and Keppeler, 1998) have shown that water yield increases throughout the year, with the largest relative increases occurring during the summer and early fall months following logging. These studies have reported increases in summer flows ranging from 15 to 148 %.

Both increased snow accumulation and melt, and decreased evapotranspiration and canopy interception can increase levels of soil moisture, resulting in increased peak flows, low flows, and annual stream flow volumes. Conversely, the expansion of western juniper communities may have the effect of reducing water yields.

Western juniper is a native species to eastern Oregon. Juniper forests, defined as areas having at least 10 % juniper crown cover, occur on over 2.2 million acres in eastern Oregon today (Gedney et al., 1999). This is a five fold increase from an earlier inventory conducted in 1936 which estimated the area of juniper forest to be 420,000 acres (Cowlin et al., 1942). The majority of the present juniper forests were established between 1850 and 1900 during a period of reduced fire frequency and intensity, and drought-free climatic conditions (Gedney et al., 1999). Juniper expansion during this period may also be linked to the introduction of large numbers of livestock which led to a loss of fine fuels from grazing, further reducing the frequency of fire (Belsky, 1996). Future expansion of juniper forests is predicted to occur in areas now classified as juniper savanna, as crown cover of juniper trees increases from less than to more than 10 %, potentially increasing the area of juniper forest in the state to as much as 5 million acres (Gedney et al., 1999).

Juniper can have a significant effect on the amount of precipitation reaching the soil. Gedney et al. (1999) report that the crown of juniper trees intercept more than half of the annual precipitation, which is returned to the atmosphere through evaporation or sublimation (the process whereby snow passes directly to water vapor without melting). Juniper can out-compete other vegetation for available soil moisture by transpiring year-round and through their extensive root networks that can occupy an area several times larger than the trees crown diameter (Gedney et al., 1999).

Although the potential exists for juniper to reduce stream flows through canopy interception and removal of soil moisture, little quantitative research is available that proves this to be the case.

The majority of applicable water yield studies have been conducted in the southwestern United States on watersheds dominated by pinyon-juniper woodlands. Most of these studies found no increase in water yield following pinyon-juniper removal (Belsky, 1996). A study conducted by Clary et al. (1974) found no changes in water yield when trees were removed by cabling and then burned, or were felled by hand and left in place, but did find increases in streamflow when trees were killed by herbicide and left standing. The increases in water yield found by Clary et al. (1974) may have been due to the absence of soil disturbance and continued shade from the standing dead trees in the herbicide-treated watershed. Several reasons exist to explain why increases in water yield following removal of juniper may not be realized (the following is taken from Belsky, 1996):

- In arid and semi-arid climates, most snow- and rain-water simply recharges the soil column; little excess is available to move downslope to streams.

- Herbaceous plants and shrubs that replace trees also intercept rain and snow, reducing the amount of water reaching the ground.

- Replacement plants also transpire and deplete soil water.

- Tree removal exposes the soil and understory plants to direct sunlight, causing elevated temperatures and increased evapotranspiration.

- Tree removal exposes soils and understory plants to more wind, which increases evapotranspiration.

- In areas where water is in excess of that needed to recharge the soil, this water may go to shallow aquifers rather than to streams.

Soil erosion and mass wasting:

Soil erosion and mass wasting can increase quantities of sediments transported in stream systems. Deposition of both coarse and fine sediments in stream channels can result in a decrease in channel conveyance capacity, leading to an effective increase in frequency of flooding (Dunne and Leopold, 1978). In addition to the effects on peak flows, increases in aggradation of coarse sediments can increase the proportion of streamflow that travels subsurface, resulting in a reduction of effective summer low flows. Furthermore, as shown in Figure 4-30, increased peak flows can further exacerbate sedimentation problems through increased bank erosion and mass wasting.

Wetland degradation:

Wetlands have the ability to intercept and store storm runoff, thereby reducing peak flows (Mitsch and Gosselink, 1986). This water is released over time and may be important to augment summertime low flows. Information presented in Section 5.0 of this report show that wetlands currently make up a very small proportion of the watershed, and known situations of wetland degradation are few. It is not known if wetlands made up a larger proportion of the watershed in the past.

Channel down cutting and channelization:

Channel down cutting and channelization have the same effect on the stream system; decreasing the amount of water that can be stored in channel banks and the floodplain. The difference between the two processes are that channel down cutting occurs without direct human assistance in response to changes in water volume and sediment loads, whereas channelization occurs through conscious human design through the construction of dikes and levees. Dikes and levees have been constructed in several locations within the Trout Creek watershed for flood control purposes. Potential disadvantages to dikes and levees include loss of floodwater storage within the floodplain, which can result in higher downstream peak flows, reduced groundwater recharge, and subsequently lower summertime base flows.

Soil compaction:

Soil compaction can increase the amount of impervious area occurring in a watershed. Increases in the amount of impervious area result in increased peak flow magnitudes. By eliminating or reducing infiltration of precipitation, the travel time to stream channels is shortened (Dunne and Leopold, 1978). In addition to the effects on peak flows, increases in impervious area also reduce summer low flows by reduction of groundwater recharge (Dunne and Leopold, 1978). May and others (1997) suggest that impairment begins when percent total impervious area in a watershed reaches 10%.

Outfall from road drainage

In addition to increasing soil compaction, road networks have the potential to affect watershed hydrology by changing the pathways by which water moves through the watershed. Road networks affect flow routing by interception of subsurface flow at the road cutslope (Megahan, 1972; Burroughs et al., 1972; King and Tennyson, 1984; Best et al., 1995) and through a reduction in road-surface infiltration rates resulting in overland flow (Ziemer, 1998). The net result may be that surface runoff is routed more quickly to the stream system if the road drainage network is well-connected with the stream channel network.

4.4.2.2 NRCS peak flow modeling

Edlund and Penhollow (1996) provide a limited analysis of changes in peak flows in the portion of the Trout Creek watershed upstream of, and including, Pony Creek (Figure 4-31). The NRCS TR-20 watershed model (SCS, 1983) was used to estimate peak flow magnitudes under historic and current (as of 1993) watershed conditions. The variable that is used in the TR-20 model to characterize watershed conditions is the watershed curve number (CN). The CN integrates several watershed conditions (e.g., soil infiltration, vegetative resistance to overland flow, etc.) that effect peak flow magnitudes. Values for historic and current CNs were estimated by NRCS staff. Changes were modeled for the 2-, 5-, 10-, 25-, and 50-year peak flow events. Subwatershed characteristics used in the modeling are given in Table 4-2, and predicted increases in peak flows are given in Table 4-3.

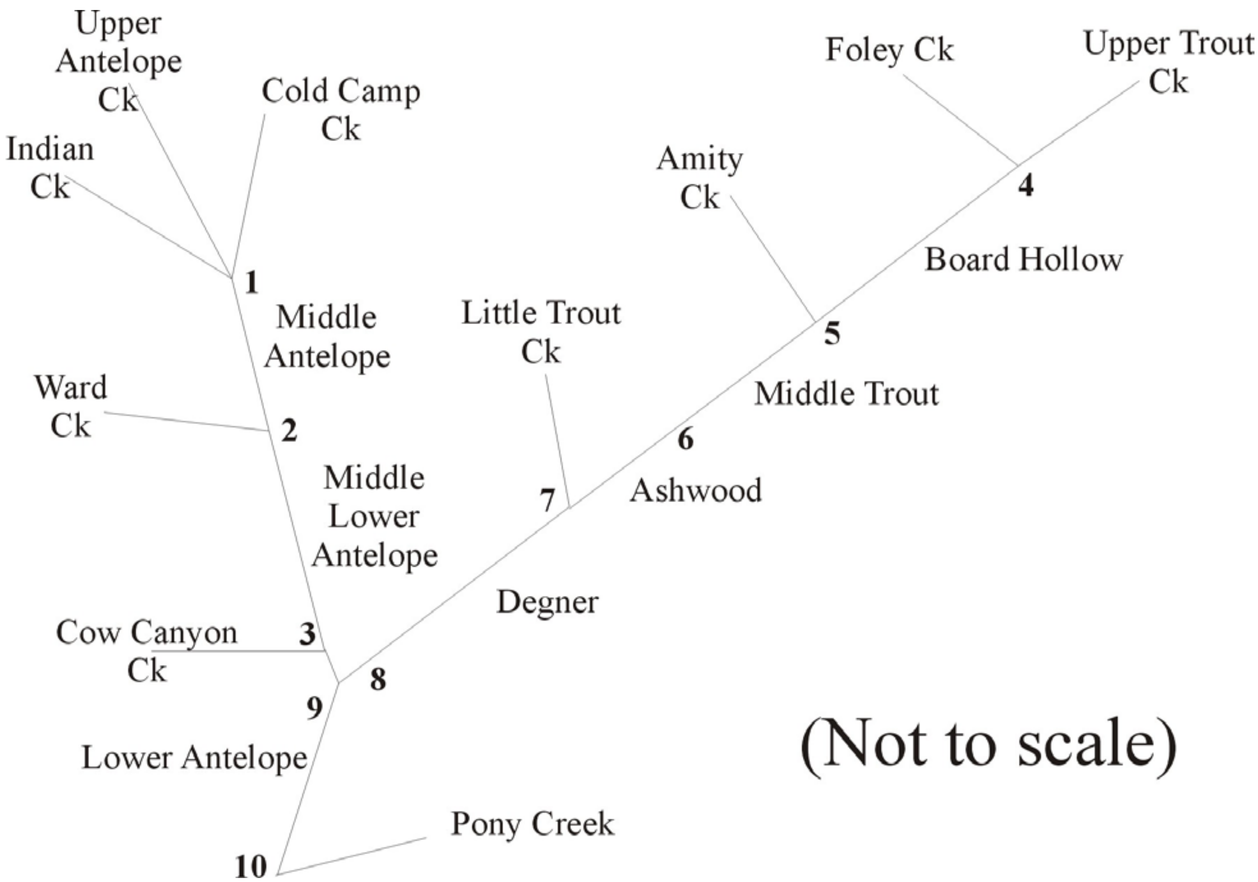

Figure 4-31. Trout Creek hydrology schematic (from Edlund and Penhollow, 1996).

Table 4-2. Sub-watershed characteristics (from Edlund and Penhollow, 1996).

Sub-watershed name	Area (mi2)	Runoff curve number *	
		Historic	Present
Upper Antelope	39.89	60	68
Cold Camp	28.88	57	63
Indian	13.16	74	78
Ward	55.94	64	68
Middle Antelope	16.27	66	69
Mid. Lower Antelope	1.89	74	79
Cow Canyon	4.77	70	73
Amity	23.39	58	64
Foley	35.15	58	70
Upper Trout Cr.	45.15	57	68
Board Hollow	18.75	58	63
Middle Trout Cr.	48.72	55	58
Ashwood	28.24	53	58
Little Trout Cr.	19.47	57	61
Degner	34.15	63	66
Lower Antelope	1.49	76	80
Pony	16.01	62	65
Total	**431.32**		

Note:
* Runoff curve numbers assigned by Gene Hickman, NRCS, 12/1993

Table 4-3. Predicted increase* in peak flow from historic to present (from Edlund and Penhollow, 1996).

Map #	Q_2	Q_{10}	Q_{25}	Q_{50}
1	2.2x	2.6x	2.2x	2.0x
2	2.5x	1.9x	1.6x	1.4x
3	2.1x	1.9x	1.6x	1.4x
4	**	7.9x	3.8x	3.Ox
5	**	7.1x	3.2x	2.6x
6	**	7.2x	2.8x	2.3x
7	**	7.7x	2.8x	2.2x
8	**	5.5x	2.5x	2.0x
9	2.5x	3.1x	2.0x	1.7x
10	2.4x	3.1x	2.1x	1.7x

Notes:
* Based on NRCS TR-20 computer program
** Locations 4-8 had no runoff for this event for historic period.

Edlund and Penhollow (1996) attribute the large predicted increases in peak flows to changes in watershed conditions that have occurred over time. Although the authors attribute some of the modeled changes to development, such as roads and buildings, the bulk of the changes were attributed to changes in vegetative cover, which included direct alteration from cropland development and timber harvest, as well as indirect alterations such as grazing and the exclusion of fire[12]. Although not directly accounted for in the modeling, the authors also attribute the loss

[12] According to Edlund and Penhollow (1996) fire suppression has allowed fir species to regenerate in many stands that were formerly ponderosa pine. Increase in the proportion of fir has led to increases in damaging insects, most notably spruce budworm. The authors claim that approximately half of the forested stands in the watershed have had some amount of defoliation in recent times

of beaver dams in the forested portions of the watershed to have adversely affected the ability of the system to capture, store, and safely release water.

There is insufficient detail included in Edlund and Penhollow (1996) to assess the likely validity of the results presented above. However, it is the opinion of this analyst, that the predicted increases in peak flows (increases approaching 800% for the 10-year peak flow at one location; Table 4-3) are extremely high. Further details on how the curve numbers were calculated for historic and current conditions would be needed to increase the confidence in these modeled results. In addition, the results presented here should be validated using a more robust modeling tool than the TR-20 model. One possible tool that could be used is the Distributed Hydrology-Soil-Vegetation Model (DHSVM) developed by the University of Washington and Battelle Pacific Northwest Research Labs. Rather than using a "lumped parameter" approach (i.e., choosing a single value to represent conditions within and entire modeling sub-watershed) as in TR-20, the DHSVM model uses an approach that explicitly solves the water and energy balance at the resolution of a digital elevation model (DEM) pixel. DHSVM has been applied to address specific land use issues in several studies (e.g., Bowling et al., 1997; Wetherbee and Lettenmaier, 1997; Storck et al., 1995). DHSVM requires spatial data that represents land characteristics of the modeled watershed (vegetation type and size, elevation, soil type) and meteorlogical data (precipitation, air temperature, wind speed, relative humidity, incoming short and long-wave radiation).

4.4.2.3 1995 USFS watershed analysis

The 1995 USFS Trout Creek Watershed Analysis report (USFS, 1995) examined land use effects on stream flows in the portions of the Upper Trout Creek watershed upstream of Foley Creek, and in the Foley Creek drainage. The following are the major hydrology-related findings from this report:

<u>Channel down cutting:</u>

The authors noted that certain stream reaches within the study area are no longer interacting with the floodplain due to channel down cutting, head cutting, and gullying. The authors point out possible negative effects from these processes including lowering of the water table, changes in riparian vegetation composition, and accelerated stream bank erosion, however, no assessment is given on the magnitude of these problems.

Large Woody Material (LWM):

Large woody material (LWM) in streams and floodplains provides bank stability, decreases flow velocities, increases water storage time (thereby decreasing the "spikiness" of peak flows), and stores sediment (USFS, 1995). The USFS surveyed approximately 60 miles of stream on Forest Service lands within the study area. Large woody material was defined as pieces of wood that were either embedded (so that they were unable to be transported) or $\geq$ 20 feet in length and 6 inches in diameter at the small end. Results from the survey showed that 40% of the reaches had less than one piece of LWM per 100 feet of channel and 80 % had less than two pieces. As a comparison the authors noted that forested reaches surveyed within the Bridge Creek Wilderness (located within the adjacent watershed to the east) all had more than two pieces of LWM per 100 feet, and half the reaches had more than three pieces of LWM per 100 feet. In the Bridge Creek survey sites logs that did not interact with high flows and snags leaning over the channel were not counted.

Annual water yield:

The authors note that any increases in water yield in the study area due to forest harvesting are likely to be offset to unknown extent by likely decreases in annual water yield resulting from the fire suppression which has resulted in higher stand densities than were present in the past. The authors concluded that there was little benefit to be gained in increasing water yield through juniper removal.

Peak flows:

The USFS (1995) evaluated the likelihood of significant peak flow increases in the study area from past forest harvest activities using the Forest Service's equivalent harvest area (EHA) approach. All public and private forest lands in the study area were included in the assessment. The Ochoco National Forest uses a threshold value of 25% of the forested land in a harvested condition as an indicator of possible peak flow impacts. The USFS uses the 25% threshold as an indicator of a hydrologic condition under which detrimental impacts may occur should a peak flow having a 10-year or greater recurrence interval occur. Equivalent harvest area values for the year of the study (1995) were given as approximately 33% for the Foley Creek subwatershed, and 20% for the Upper Trout Creek above Foley Creek subwatershed (USFS, 1995).

Low Flows:

With respect to the possibility of increasing summertime low flows in the study area through timber harvest, the authors conclude that measurable increases in low flows due to timber harvest have probably occurred in the Foley Creek subwatershed, although these flows have not been quantified. However, given the reduction in Forest Service harvest levels, it is unlikely that increased low flows could be maintained on a long-term basis. In the author's opinion, the primary cause for decreases in low flows (as compared to pre-settlement conditions) are the decrease in number and size of beaver dams, and the loss of wet meadows and other wetlands. The authors warn that, although beaver can be reintroduced and some wetlands restored, any increases in low flows resulting from actions may not be measurable for decades.

4.5 BANKFULL STREAM FLOWS

One of the critical questions outlined for this analysis was "what is the estimated unregulated and regulated bankfull flows at selected locations in the basin"? As discussed above there is no regulation of stream flow within the watershed, with the exception of irrigation withdrawals that occur outside of the winter months when peak flows typically occur. Consequently, estimates of bankfull stream flow were made using regional equations available for Eastern Oregon.

Eight locations were selected for estimating bankfull flows. These locations included the outlets of all subbasins, and three additional locations selected based on the inflow of major tributaries. The bankfull flow evaluation locations are shown in Figure 4-32 and summarized in Table 4-4.

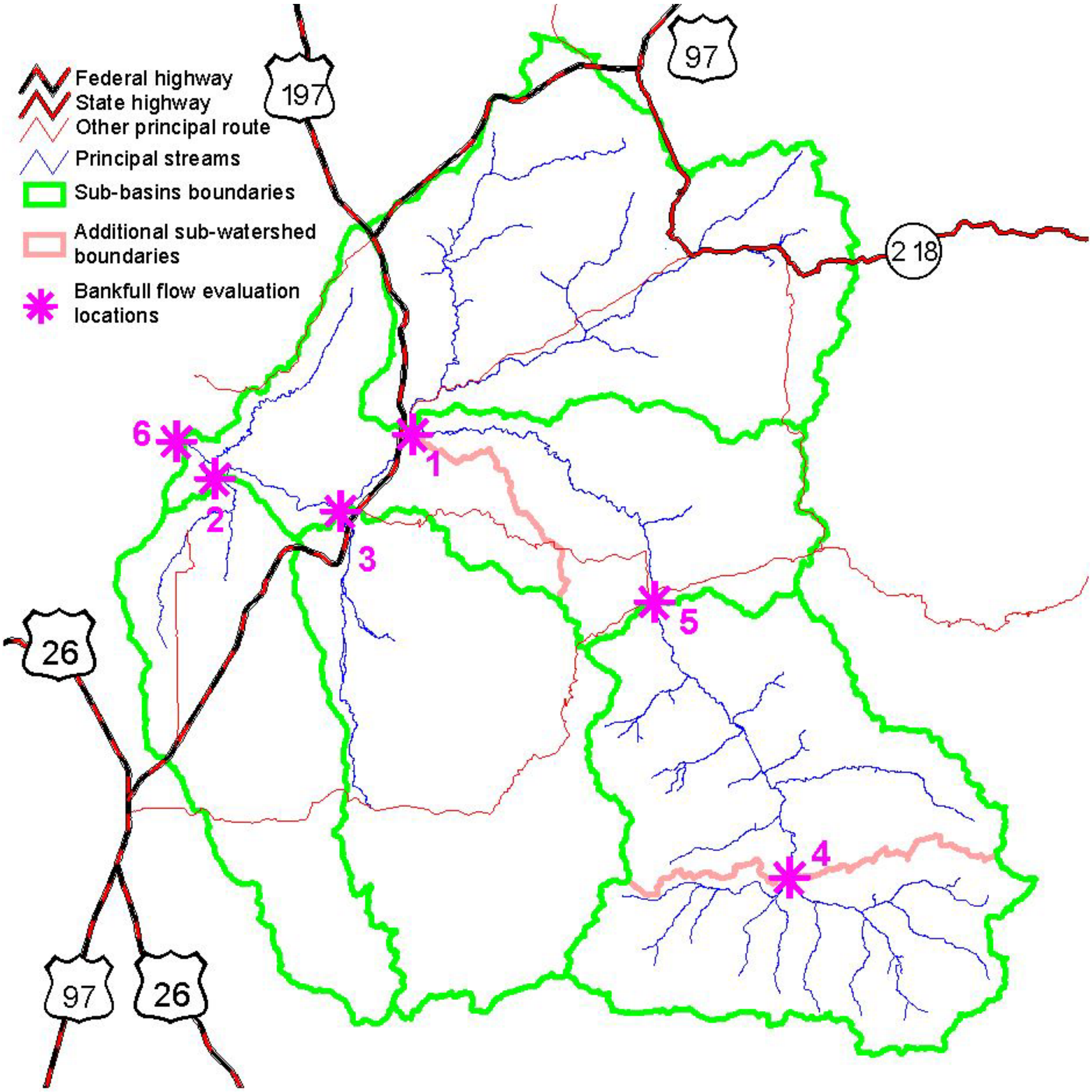

Figure 4-32. Bankfull flow evaluation locations. Refer to Table 4-4 for upstream watershed characteristics.

Table 4-4. Estimated peak flow magnitudes by recurrence interval for the evaluation locations shown in Figure 4-32.

Map #	Peak flow evaluation area	Drainage Area (mi^2)	Precip. Index (in)	Temp. Index (^0F)	Predicted peak flow magnitude (cfs) by recurrence interval:						
					$Q_{1.5}$	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
1	Antelope Creek subbasin	157.3	13.7	15.3	130	190	449	656	1,028	1,310	1,729
2	Mud Springs Ck subbasin	92.7	10.0	16.7	70	105	285	447	754	1,009	1,381
3	Hay Creek subbasin	137.9	14.1	15.0	115	168	396	575	899	1,144	1,507
4	Upper Trout subbasin below Foley Ck	78.2	26.0	16.5	210	291	574	767	1,091	1,318	1,658
5	Upper Trout subbasin	176.6	23.5	16.9	380	523	1,037	1,390	1,983	2,387	3,007
1	Lower Trout subbasin above Antelope Ck	246.7	20.8	17.1	460	605	1,236	1,681	2,437	2,955	3,752
1	Lower Trout subbasin below Antelope Ck	404.0	18.0	17.6	565	807	1,703	2,357	3,479	4,249	5,444
6	Entire watershed	692.4	15.4	16.9	640	923	2,002	2,805	4,203	5,157	6,656

Castro and Jackson (2001) investigated the recurrence intervals of peak flows associated with bankfull stage at 76 locations in the Pacific Northwest. They found that streams within the Blue Mountains Level III ecoregion (the ecoregion within which the majority of the Trout Creek watershed is located; Figure 1-9) bankfull flows have an average recurrence interval of from 1.4 to 1.5 years.

Peak flow magnitudes were first calculated for the 2-, 5-, 10-, 25-, 50, and 100-year recurrence interval events (denoted as Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, and Q_{100} respectively) at selected locations within the watershed using the following regional equations developed by Harris and Hubbard (1983) for the north-central region of Oregon:

$$Q_2 = 0.00013\ A^{0.80}\ P^{1.24}\ T^{2.53} \quad \textbf{Equation 1}$$

$$Q_5 = 0.00068\ A^{0.76}\ P^{0.90}\ T^{2.64} \quad \textbf{Equation 2}$$

$$Q_{10} = 0.00134\ A^{0.74}\ P^{0.73}\ T^{2.73} \quad \textbf{Equation 3}$$

$$Q_{25} = 0.00325\ A^{0.72}\ P^{0.55}\ T^{2.78} \quad \textbf{Equation 4}$$

$$Q_{50} = 0.00533\ A^{0.70}\ P^{0.44}\ T^{2.83} \quad \textbf{Equation 5}$$

$$Q_{100} = 0.00863\ A^{0.69}\ P^{0.35}\ T^{2.86} \quad \textbf{Equation 6}$$

Where **A** is drainage area (mi^2), **P** is an index of mean annual precipitation (inches) derived from maps provided in Harris and Hubbard (1983), and **T** is a temperature index (^0F) derived from maps in Harris and Hubbard (1983). Values of A, P, and T used in equations #1 - #5 are given in Table 4-4, along with estimated peak flow magnitudes for the Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, and Q_{100} peak flow events.

No regional equations are available for calculating values of the $Q_{1.5}$ peak flow (i.e., the bankfull flow event). Estimates of the magnitude of the $Q_{1.5}$ event were obtained by first plotting the probabilities (i.e., 1/recurrence interval) for the Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, and Q_{100} events against flood magnitude values computed using equations #1 - #5 for each peak flow evaluation area (Table 4-4). When plotted on log-probability paper, these values plot as a straight line (see example – Figure 4-33). The flood magnitude of the $Q_{1.5}$ event was then interpolated from the plot. Estimated values computed for each for each peak flow evaluation location are included in Table 4-4.

As a check on the validity of the approach presented above, predicted and observed values of peak flow magnitudes by recurrence interval were compared at OWRD gage #14093699 (Trout Creek below Amity Creek). The USFS (1995) calculated the magnitude of peak flows by recurrence interval at the gage using both the regional equations (Harris and Hubbard, 1983) and by using a Log Pearson Type III (LP3) approach with observed data from the gage. Results using both methods are shown in Figure 4-34. The data presented in Figure 4-34 suggest that the regional equations under-predict the actual flood magnitudes at the gage location. However, the predicted magnitudes of the bankfull flood (Q1.5) event are approximately the same (i.e., 180 cfs using the LP3 distribution, 230 cfs using the regional equation approach).

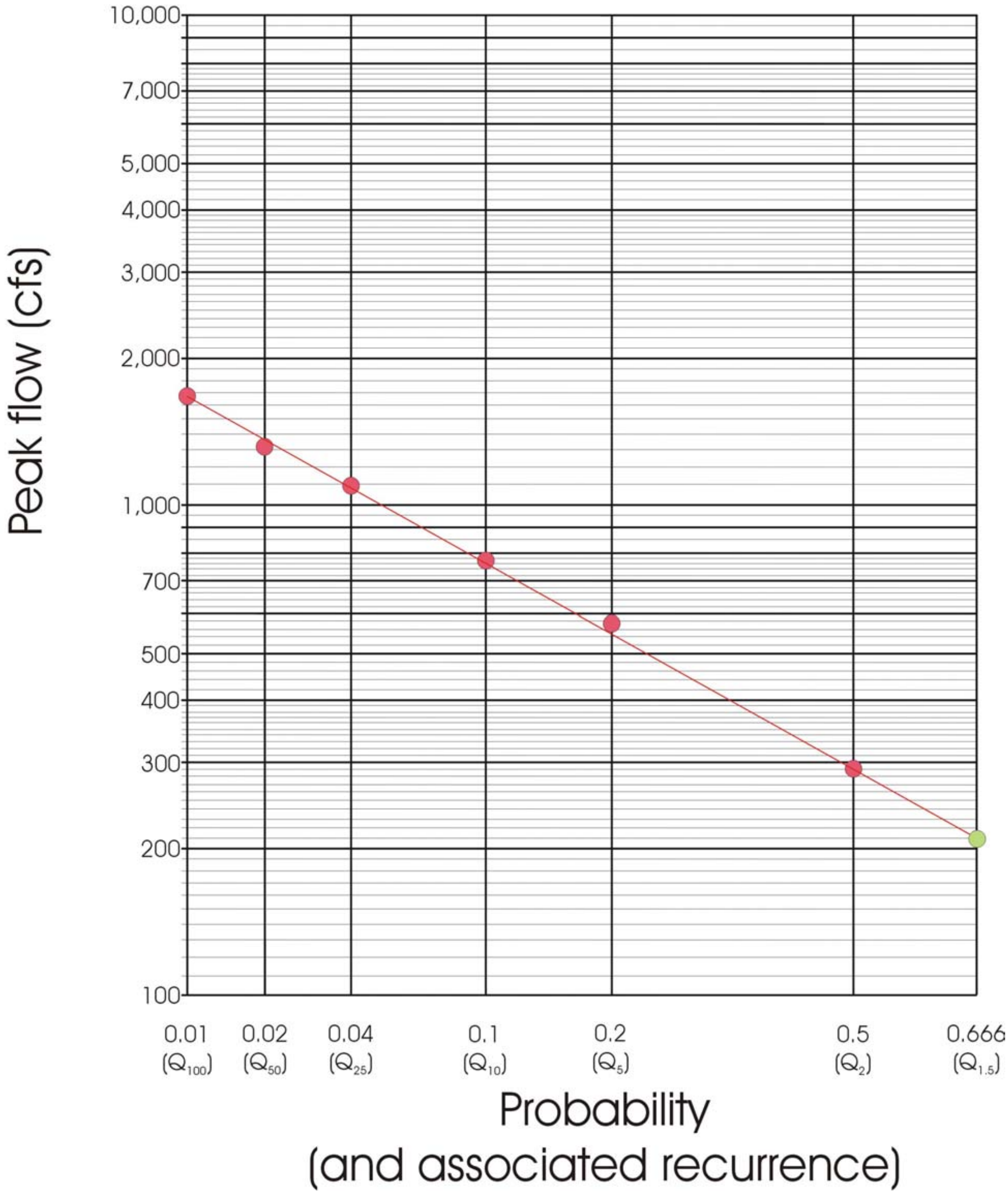

Figure 4-33. Example of log probability plot for Upper Trout Creek below Foley Creek.

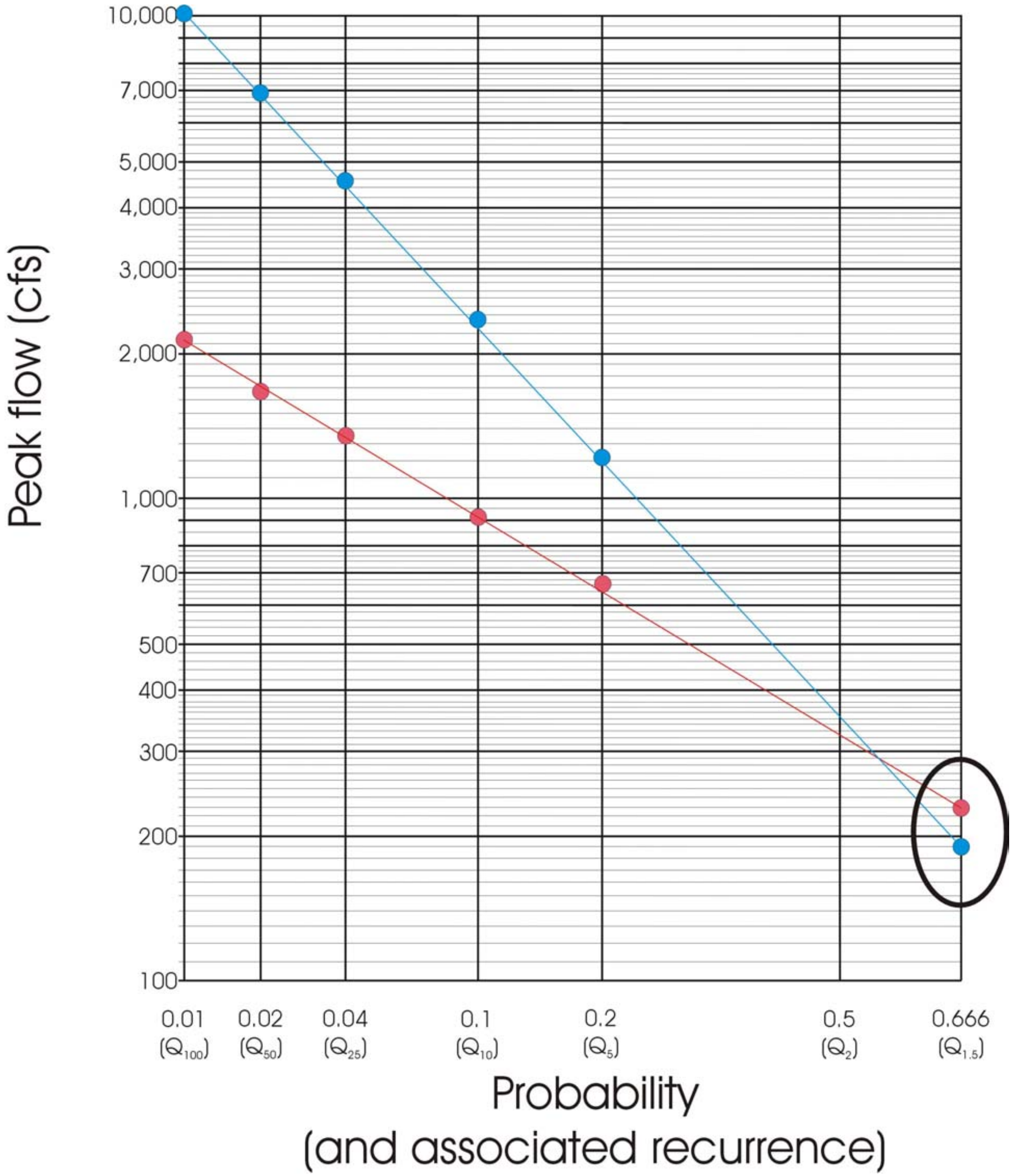

Figure 4-34. Log probability plot for Trout Creek at OWRD gage #14093699 (Trout Creek below Amity Creek). Points and lines shown in red were calculated using regional equations (Harris and Hubbard, 1983); points and lines shown in blue were calculated using USFS (1995) LP3 distribution.

4.6 OPPORTUNITIES FOR OFF-CHANNEL LIVESTOCK WATERING FACILITIES

The final critical question that was asked in this portion of the analysis was "what are the opportunities for development of off-channel live stock watering facilities?" The approach taken in this section was to outline the available options for off-channel watering and discuss the regulatory considerations involved. Most of the information presented in this section was taken from the Oregon Aquatic Habitat Restoration and Enhancement Guide published by the Oregon Watershed Enhancement Board (OWEB, 1999) and from MWSB (2002).

Livestock have traditionally had direct access to stream channels, however, the current trend in grazing management is to keep livestock away from stream channels and provide drinking water through some alternative means. The benefits to aquatic species from keeping livestock away from stream channels include protection of stream bank integrity, reduced levels of nutrient and sediment inputs, reduced damage to spawning area, and protection of riparian vegetation. Additional benefits to land managers include fewer livestock will drown or get stuck in the mud, improved water quality which can result in increased weight gain in cattle, less bank slumping may reduce the need for dredging, the possibility of poisoning due to blue-green algae is decreased, and the need for downstream water treatment is reduced. Methods for development of off-channel livestock watering facilities can be divided into two basic categories; mechanical systems that do not rely on gravity to distribute water, and gravity-dependent systems.

Mechanical Systems:

Mechanical systems include electrical (power grid) pumps, solar electric pumps, animal-activated pumps, windmills, gasoline-powered pumps, and hydraulic ram pumps. Perennial streams are the typical water source, but wells and springs can also be used

Electrical (power grid) pumps: Electric pumps powered from the power grid are the easiest way to power a mechanical pumping system. Water can be pumped into a storage tank then gravity-fed to the stock tank. Pumps can be automatically controlled by floats in the tank to pump water when levels drop below a certain point. Electric motors can be connected to a wide range of pump types, allowing flexibility in the amount of water pumped and the pumping pressure. Advantages of electric grid systems are their efficiency, relative low-cost, and ease to maintain. The primary limitation is that they can only be operated at sites where grid power already exists, as it can become uneconomical to extend a transmission line more than a few hundred feet.

Solar electric pumps: Solar panels collect electrical energy and either directly power DC pumps, or the power is stored in batteries to operate the pumps as required. Water can be pumped into a storage facility (e.g., tank) then gravity-fed to the stock tank. Pumps can be automatically controlled by floats in the tank to pump water when levels drop below a certain point. Water may be pumped from deep wells or across distances, but will require larger or additional solar panels and batteries. Systems will require installation in areas with a clear view of the sun all day; shadows drastically reduce solar power production. Cost of system will vary with size of the system, amount of water required and distance it must be pumped. One 43 watt solar panel will generally handle 40 cow/calf pairs under normal circumstances. Advantages include low maintenance, no external energy source required, and the ability to draw from deep wells or distant water sources. Limitations include a reliance on sunshine; at least two days water supply should be available to insure against poor sun conditions and battery run-down.

Animal-activated pumps: Livestock activate these pumps by pushing a pendulum with their noses. Nose pumps are the lowest-cost pump systems available for stock watering. Nose pumps work well when surface water sources are nearby, but are somewhat limited when used with wells. The capability of each pump is 25 to 30 head. Nose pumps have the advantage of being very portable, inexpensive, require no water storage structure, and require no power source. Limitations include a maximum vertical lift of about 20 feet; fencing is required to ensure cattle approach the pump from the front, livestock may require several days "coaching" to learn to use the pump.

Windmills: Large windmills (30 to 40 foot tower) operating a cylinder pump can extract water from wells and surface water sources. Large windmills are best suited to pumping into a storage tank which feeds a float-controlled stock tank. Smaller windmills (9 to 12 foot tower) are also available. Compressed air is used in small windmills for pumping by means of a diaphragm activated by the wind vane shaft. Small windmills should be placed as high as possible, and away from trees and other obstructions that might shelter the wind. The capability of large windmills is generally limited only by the size of the storage facility, and are capable of providing water for 75 to 100 head of cattle. Small windmills have a capability of 50 cow/calf pairs when used with a 2,250 gallon storage tank. The advantage of large windmills is the ability to pump a lot of water from a great depth or distance; limitations include the reliance on the wind (although a large storage facility will help overcome this problem), and expense. Advantages of small windmills are that they are inexpensive. Limitations include the need for an auxiliary system for periods of low wind, the need for at least three days storage of water, a limited vertical lift, and relatively low capacity.

Gasoline-powered pumps: Gas-powered pumps can be used to pump water into storage tanks and other facilities as required. Capability is high; capacity is dependent on the size of the pump. Gas-powered pumps have the advantage of being inexpensive, portable, and have a high capacity. Limitations are that someone must be present to run the pump.

Hydraulic ram pumps: Hydraulic ram pumps float and can be anchored in a stream where it is powered by the current. Hydraulic ram pumps run continuously, making them best-suited to filling off-channel storage facilities. Hydraulic ram pumps can pump from 800 to 4000 gallons per day depending on size. Hydraulic ram pumps have the advantages of requiring no external power source, are portable, and easy to install. Disadvantages are the requirement of having moving water and a minimum stream depth of 12 to 16 inches.

Gravity Systems:

Gravity systems require no mechanical pumps, relying solely on gravity to move water from a collection system located at a higher elevation than the watering location. Two main categories are included; troughs and ponds, and spring developments.

Troughs and ponds: Examples include systems that are gravity-fed through pipelines from streams, with or without a physical blocking of the stream channel. Perennial or intermittent streams are the typical water source. These developments may have an intermediate storage facility (above or below ground tank).

Spring developments: these systems are usually made up of a spring box, a pipeline that is usually above ground, and a stock tank for water collection. The water source is a spring or seep.

The advantages of gravity systems are low-cost of construction and low-maintenance requirements. Limitations are the difficulty in finding a water source that is conveniently located relative to the location where stock will be watered.

Regulatory Requirements:

The OWRD does not require a water right for development of off-channel livestock watering facilities providing that the following two criteria are met: 1) the water must be diverted through an enclosed delivery system equipped with either an automatic shut-off valve or an enclosed system for returning water to the stream, and 2) the operation is located on land where livestock would otherwise have access to the stream. The ODFW requires that water sources be screened if the water source is a fish-bearing stream.

4.7 DATA GAPS / RECOMMENDATIONS

The following list of key data gaps and recommendations for enhancement projects are organized by section of the report.

Flow regime

- Support the continued operation of all stream gages currently operating in the watershed.

Efforts to characterize stream flow in the watershed were hampered by the scarcity of flow data available. The continued collection of flow data from the five currently-active gages (i.e., gage #14095250, Sagebrush Creek near Gateway; #14095255, Trout Creek at Clemens Drive near Gateway; and the three USFS stream gages -Trout Creek above the USFS boundary, Dutchman Creek at 2720 road, and Cartwright Creek at 2720 road) would improve understanding of peak flow history, allow for better estimation of natural stream flows, provide calibration data for any future modeling activity, and allow for better regulation of water use

- Reinstall stream gage #14093600 (Trout Creek below Amity Creek near Ashwood).

Stream gage #14093600 provides the longest-term record of flow within the watershed. Reinstalling this gage would build upon the current data set, and would be useful for all of the reasons listed in the previous recommendation.

- Install new stream gages at or near the mouths of the Hay Creek and Antelope Creek subbasins.

No continuous stream flow data are available for several important areas within the watershed. Neither the Hay Creek nor Antelope Creek subbasins historically had or currently have stream gages installed. Installing gages at these locations would be useful for all of the reasons listed in the previous two recommendations.

- Investigate channel losses along the mainstem of Trout Creek and important tributaries.

Anecdotal information suggests that portions of the Trout Creek mainstem go dry during the summer months while other upstream reaches have surface flow. This condition was not observed during the channel loss study conducted by Wheeler (1969). A summertime channel loss assessment should be performed along the mainstem Trout Creek (and possibly along portions of important tributaries as well) to quantify the extent of channel loss, and to identify possible contributing reasons (e.g., increased sediment deposition).

- Investigate reasons for, and extent of, unique flow patterns in Mud Springs/Sagebrush Creek.

Short-term data available from the two OWRD stream gages on Sagebrush Creek near Gateway (#14095250) and Trout Creek at Clemens Drive near Gateway (#14095255) suggest that Sagebrush Creek has an unusually constant hydrograph, and that almost the entire summertime flow in the lower Trout Creek mainstem is from Sagebrush Creek. The extent of, and reasons for, this flow pattern should be investigated, as Sagebrush Creek may offer an opportunity for enhancement of fish production.

Distribution of springs and locations of groundwater inflow

- Gather spatially detailed information on water temperature patterns.

An attempt was made during the summer of 2001 to use Forward Looking Infrared (FLIR) thermal photography to measure thermal infrared energy emitted at the water surface along the mainstem of Trout Creek and high-priority tributaries. These data were to be used in identifying areas of groundwater inflow. Unfortunately, the quality of the imagery was not sufficient to provide any meaningful analysis. Future FLIR flights should be conducted this coming summer sometime between July 15 and August 31. Data collection should be timed to capture the maximum daily stream temperatures, which typically occur between 14:00 and 17:00 hours. Imagery should be geographically linked through a Global Positioning System (GPS) and geo-referenced to allow display and analysis within a Geographic Information System. FLIR data should be Correlated FLIR data with thermograph information

- Support development of better geologic information for the watershed.

Correlating the location of springs with geologic characteristics was hampered by the lack of high-resolution geologic maps for the watershed. The council should encourage and support future geologic mapping efforts by the USGS, Oregon Department of Geology & Mineral Industries, or other entities that may be interested in conducting this mapping

Water withdrawals

- Support efforts of the OWRD to improve the Water Rights Information System (WRIS).

The OWRD is considering changes to their Water Rights Information System (WRIS) that will allow estimation of instantaneous withdrawals associated with water rights. This information would allow a better understanding of the impacts of withdrawals on stream flows. It is recommended that the Trout Creek Council support these proposed improvements to the system.

Current land use effects on flow regime

- Implement improvements in summertime stream flows through increased water use efficiency, transfer of water rights to instream uses, and other voluntary actions.

Despite some uncertainty in the exact magnitude of the problem, it is clear that consumptive use of water for irrigation exceeds the estimated volumes of natural stream flow during the summer months in all subbasins within the watershed. These withdrawals contribute to an inability to meet instream water rights in the areas where they have been established. This problem must be addressed if a serious desire exists to enhance fisheries production. Voluntary measures such as an increase in the efficiency of water distribution and application to irrigated areas will help improve summertime flow conditions. However, further reductions in withdrawals through voluntary transfer of water rights (either temporarily or permanently) to organizations such as the Oregon Water Trust is recommended.

- Support efforts to better understand the true nature of the effect of juniper expansion on low flows.

Although the potential exists for juniper to reduce summertime stream flows through canopy interception and removal of soil moisture, the current state of knowledge does not support wide-scale juniper removal. It is recommended that the Council support ongoing efforts to better-understand the effects of juniper expansion. An additional possibility would be to identify possible subwatersheds within the Trout Creek watershed where a pilot juniper removal program could be implemented to further investigate the effects of removal on low flows. Any such pilot study should be conducted under the guidance of a research entity such as OSU, and observe proper monitoring protocols.

- Implement watershed-wide evaluation of land use effects on peak flows.

The NRCS study on peak flow augmentation due to land use in the watershed (Edlund and Penhollow, 1996) provides insufficient detail to assess the validity of the large predicted increases in peak flows. Further details on how the curve numbers were calculated for historic and current conditions should be evaluated to increase the confidence in these modeled results. Additionally, the results presented in Edlund and Penhollow (1996) should be validated using a more robust modeling tool such as the Distributed Hydrology-Soil-Vegetation Model (DHSVM) developed by the University of Washington and Battelle Pacific Northwest Research Labs. Such a modeling effort should include an evaluation of all items included in Figure 4-30 of this report.

- Support efforts to increase levels of large woody material in streams within the forested portions of the watershed.

The USFS (1995) study reports that quantities of instream large woody material (LWM) are about half the levels found in adjacent, unharvested watersheds. Large woody material in streams and floodplains provides bank stability, decreases flow velocities, increases water storage time (thereby decreasing the "spikiness" of peak flows), and stores sediment (USFS, 1995). The Council should support efforts by the USFS to increase LWM levels in streams on USFS lands, and consider options for increasing LWM levels in streams on private lands.

- Initiate pilot efforts to restore wet meadow areas to augment base flows.

The authors of USFS (1995) conclude that the primary cause for decreases in low flows (as compared to pre-settlement conditions) are the decrease in number and size of beaver dams, and the loss of wet meadows and other wetlands. The Council should support the initiation of a pilot wet meadow development project as detailed in USBR (1999). Any such project should be properly monitored to assess the benefits and possible impacts.

Bankfull stream flows

- Support flow data gathering and peak flow modeling efforts as described above.

The ability to calculate bankfull stream flows at un-gauged sites for purposes of designing instream enhancement projects is limited by the lack of local stream flow data. Implementation of the recommendations given in the "Flow Regime" section above will also enhance future ability to calculate accurate design flows. Additionally, development of a continuous stream flow model for the watershed (as discussed in the "Current land use effects" section above) would aid in the calculation of design flows at un-gauged sites.

Opportunities for development of off channel live stock watering facilities

- Implement further off-channel livestock watering projects.

Additional off-channel livestock watering projects should be developed to protect and enhance water quality and fisheries habitat in the watershed.

5.0 RIPARIAN/WETLAND HABITAT CONDITIONS

The Riparian/Wetland Conditions assessment generally followed the methodology as outlined in the Oregon Watershed Assessment Manual (WPN, 1999). The assessment methodology outlined in the manual is designed around a series of critical questions that form the basis of the assessment. For the Trout Creek assessment some of the critical questions given in the manual were replaced or modified through communication with the client. The critical questions that were addressed in this assessment were:

1. What is the current condition of riparian vegetation in the watershed?

2. How does current riparian conditions compare to potential riparian conditions?

3. What is the estimated rate of riparian vegetation recovery?

4. Where are the wetlands in the watershed?

5. What are the general characteristics of wetlands in the watershed?

6. What are the limitations to restoration of riparian communities and wetlands in the watershed?

Section 5.1 describes some of the overall limitations to the riparian/wetland assessment. The assessment itself was divided into two primary parts. Section 5.2 describes the riparian assessment and section 5.3 the wetlands assessment.

5.1 LIMITATIONS TO THIS ASSESSMENT

Over the course of this assessment, and through review and comment of draft products by members of the Trout Creek Watershed Council, it has become apparent that an explicit statement is needed about some of the major limitations of the assessment presented below. Four primary areas of concern have been voiced by members of the Council. These concerns are 1) natural limitations to riparian development, 2) the influence of legacy conditions, 3) acknowledgement of landowner stewardship, and 4) concerns over limited field-verification of remotely-sensed data.

Members of the Council have correctly pointed out that within the Trout Creek watershed there undoubtedly are some sparsely vegetated areas incapable of producing what is considered to be adequate riparian vegetation due to naturally-occurring site limitations. <u>Some</u> of the areas where current riparian conditions have been labeled inadequate due to land use activities most likely are areas of naturally poor site productivity. However, the reader must appreciate the scale at which this assessment was produced (i.e., a watershed almost 700 square miles in size). The conditions reported below do, in this analyst's opinion, correctly represent the impacts found within the watershed and the five subbasins taken as a whole. Any party planning site-specific enhancement activities will need to take this limitation into consideration and gather the appropriate information about the specific site.

Members of the Trout Creek Watershed Council have also correctly pointed out that both natural and human-caused legacy conditions exist in the watershed, and influence our perception of current condition. For example, Council members have pointed out that the 1964 flood event destroyed much riparian vegetation throughout the watershed, and that this "resetting of the clock" influences what we see on the ground today. Similarly, past forestry and range practices caused degradation to many areas that are still in a recovery phase. Although these legacy conditions are likely responsible for some of the degraded conditions seen today they do not explain all. For example, riparian vegetation may have been completely removed by the 1964 flood in some areas; however, this does not adequately explain the absence of any trees or shrubs in these areas almost 40 years later.

Over the course of the assessment this analyst has been impressed with both the level of knowledge that Council members have on technical watershed issues within "their" watershed, as well as a sense of real commitment by the landowners to being stewards of the resource. Landowners within the watershed are working hard to improve their land management practices, not only to benefit their own operations, but also to improve the quality of the streams which play a large part in the success of their operations and the culture of their community. Reductions in grazing, development of off-channel watering facilities, elimination of push-up dams, installation of riparian fencing, and placement of juniper rip-rap are examples of projects that have been completed by landowner themselves or in cooperation with agencies working in the watershed. Our task in developing this assessment has been to focus on what appear to be the problem areas that exist in the watershed, and to help the Council identify and prioritize enhancement opportunities. Consequently, the tone of this report may sound excessively negative with respect to the current landowners. This analyst wishes to acknowledge both the good work that landowners have done in managing the resources within the watershed, as well as the importance of the landowners in developing and implementing future enhancements. The Trout Creek ecosystem will survive and improve only through the continued stewardship of the people who make it their home.

Finally, members of the Council have correctly pointed out that the assessment presented below, which is based almost exclusively on evaluation of aerial photos, suffers from a limited amount of field-verification. The limited amount of field-verification increases the uncertainty in the conclusions that are reached. We completely agree that additional field-verification would have enhanced the overall quality of the report. Due to these limitations, additional field-verification of riparian conditions will be necessary for site-specific project planning.

5.2 RIPARIAN ASSESSMENT

The purpose of this portion of the assessment was to evaluate current riparian vegetation[13] conditions for their ability to provide recruitment[14] of large woody material[15] (LWM) and stream shading. Section 5.2.1 describes the assessment methods that were used, section 5.2.2 gives the results of the assessment, and section 5.2.3 provides a discussion on estimated rates of riparian recovery.

5.2.1 Assessment Methods

This assessment was conducted using 1: 30,000 scale color stereo aerial photo pairs[16] that were taken during June, 2000, and provided for this assessment by the Jefferson County SWCD. A limited amount of field-verification was performed during November, 2001. Field-verification was limited to the publicly-accessible portions of the watershed, and consisted of observations of vegetation type and size. Locations included in the field visits were Trout Creek along Coleman Road to the confluence with the Deschutes River, Trout Creek in the vicinity of Ashwood, Antelope Creek along Antelope Highway, and portions of Pony Creek.

Only a subset of the streams shown in Figure 1- (from Section 1.0) was included in this assessment. Streams were chosen in consultation with staff of the Jefferson County SWCD, and Tom Nelson of the ODFW. A total of 254 miles of stream were included in the assessment. In general, all streams identified as having perennial stream flow (as identified on 7.5" USGS topographic maps) were included in the assessment.

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[13] Riparian vegetation refers to the vegetation found on stream banks and adjoining floodplain

[14] Recruitment, in the context of riparian function, refers to the natural addition over time of new large wood pieces to a stream channel from riparian forests. It is the physical movement of large wood from stream-side forest into the stream channel

[15] Large woody material, as it is used in this context, refers to pieces of wood (either tree trunks, stumps, or large branches) important in the formation of channel shape, and consequently, in creating and enhancing fish habitat.

[16] stereo aerial photo pairs refers to high-resolution aerial photographs that are taken from an airplane along a straight flight line. When sequential pairs are viewed with a device called a stereoscope the land features appear three-dimensionally.

5.2.1.1 Riparian condition units (RCUs)

The fundamental mapping unit, for which all information in this portion of the assessment was collected, is the Riparian Condition Unit or RCU. An RCU is a portion of the riparian area for which riparian vegetation type, size, and density remain approximately the same. When riparian characteristics change a new RCU is defined. Each RCU occurs on only one side of the stream (i.e., riparian areas on the opposite side of the stream are separate RCUs).

Riparian characteristics typically change with distance from the stream as soil moisture and stream-related disturbance changes. Typically, the immediate streamside area will contain hardwoods or shrub species, while areas farther away from the stream will be dominated by upland vegetation. Within the Trout Creek watershed riparian characteristics also vary considerably between the forested headwater areas and the non-forested areas that make up the majority of the watershed. In recognition of these differences in vegetation, three data collection zones were defined moving laterally away from the edge of the stream:

Riparian area #1 (RA1) was defined from the edge of the stream channel out to the approximate limit of the streams immediate influence. The lateral distance of RA1 varied from a 25 feet to 75 feet depending on the characteristics of the stream (see examples, Figure 5-1). The widths of RA1 were defined based on the channel habitat type (CHT) defined for the stream segment by the channel analyst (see section 3.0 for further discussions on CHTs). The width of RA1 was 25 feet along channels that were classified within the “constrained” group of CHTs. These included channels classified as Bedrock canyon (BC), channelized streams (D), Low gradient confined (LC), Moderate gradient confined (MC), Moderate gradient headwater (MH), Moderately steep narrow valley (MV), Steep narrow valley (SV), and Very steep headwater (VH). The width of RA1 was 50 feet along channels that were classified within the “semi-constrained” group of CHTs. These included channels classified as Low gradient moderately confined (LM). The width of RA1 was 75 feet along channels that were classified within the “unconstrained” group of CHTs. These included channels classified as Low gradient small floodplain (FP3). Riparian data was collected within RA1 along all stream segments included in the assessment.

Along streams within the forested portions of the watershed, a second mapping unit was defined. For these segments riparian area #2 (RA2) was defined from the outer edge of RA1 to a distance of 100 feet from the edge of the stream channel (see examples, Figure 5-2). The purpose of including this additional riparian area was to account for additional recruitment that may come from as far away as 100 feet from the stream edge[17]. Consequently, the width of RA2 also varied depending on the CHT defined for the stream segment. The width of RA2 was 75 feet along channels that were classified within the "constrained" group of CHTs, 50 feet along channels that were classified within the "semi-constrained" group of CHTs, and 75 feet along channels that were classified within the "unconstrained" group of CHTs.

Finally, along streams where the 100-year floodplain extends beyond RA2 (or beyond RA1 in the case of stream segments within the non-forested portion of the watershed) a third mapping unit was defined that covered this additional floodplain area (see examples, Figure 5-1). The 100-year floodplain was defined using Federal Emergency Management Agency (FEMA) Q3 digital flood data coverage for Wasco and Jefferson Counties (FEMA, 1996). No digital data were available for the Crook County portion of the watershed, however, as these stream segments are located in very high-gradient headwater areas (see Figure 1-7) it is unlikely that the 100-year floodplain extended beyond RA1 and RA2. The extent of the 100-year floodplain as defined by FEMA was modified during the analysis in some areas where it appeared to be mapped incorrectly.

[17] Although recruitment has the potential to come from as far away from the stream as the site potential tree height, the majority of functional wood is recruited within 100 feet (horizontal distance) or less of the stream's edge (McDade et al. 1990).

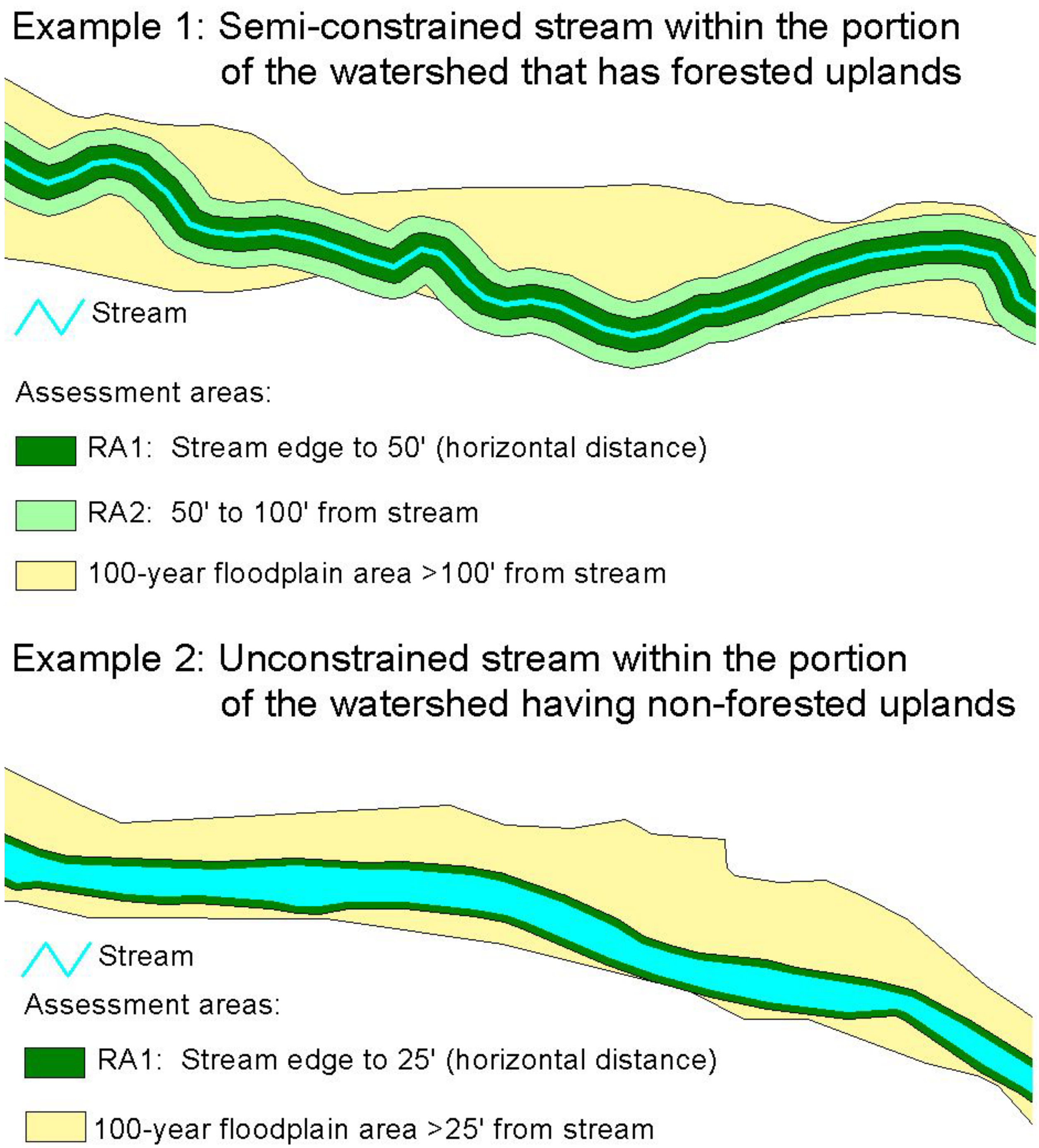


Figure 5-1. Examples illustrating riparian condition units (RCUs).

Information for each RCU was mapped directly in ArcView GIS, using USGS orthophotos as a backdrop to properly place the RCU location. RCUs were mapped within ArcView as polygon units. The following information was collected for each RCU and is included in the attribute table of the GIS coverage:

- **ID number**: Unique number assigned to each RCU.
- **Stream Bank**: The stream bank that each RCU lies on: "R" for right bank looking downstream or "L" for left bank looking downstream
- **Width**: Width (horizontal distance) of the RCU as measured perpendicular to the stream.
- **Zone**: Either "RA1" (for riparian area #1 as described above), "RA2" (for riparian area #2), or "FP" (for the 100-year floodplain).
- **CHT**: Channel habitat type of the stream segment, as defined by the channel analyst.
- **Subbasin**: Sub-basin that the channel segment falls within.
- **Ecoregion**: EPA level IV ecoregion (see section 1.2.5) that the stream segment falls within.
- **Water-body**: Name of the stream segment (e.g., "Hay Creek")
- **Code**: For RA1, RA2, and FP, the vegetation characteristics were noted using a three-letter code that describes vegetation type (first letter), vegetation size (second letter), and vegetation density (third letter). The choices are given in the following table. For example, "CSD" would mean a riparian stand that is predominantly conifer, small in size (i.e., 4-12 inch average stand diameter at breast height), and dense. Note that size and density only apply to forested stands.

Table 5-1. Codes used to describe vegetation (from WPN, 1999).

Vegetation type code	
C	Mostly conifer trees (>70% of area)
H	Mostly hardwood trees (>70% of area)
M	Mixed conifer/hardwoods
B	Brush species
G	Grass/meadow
N	No riparian vegetation
Size class code	
R	Regeneration (<4-inch average diameter at breast height (DBH)
S	Small (4- to 12-inch average DBH)
M	Medium (>12- to 24-inch average DBH)
L	Large (>24-inch average DBH)
N	Non-forest (applies to vegetation Types B, G, and N)
Stand density code	
D	Dense (<1/3 ground exposed)
S	Sparse (>1/3 ground exposed)
N	Non-forest (applies to vegetation Types B, G, and N)

- **Permanent discontinuities**: In some situations the vegetation characteristics of an RCU were broken up, and recruitment limited, by permanent discontinuities. When any permanent discontinuity was found within an RCU, and it covered more than 30% of the total area of the RCU, the source of the discontinuity was noted. Permanent discontinuities found in the Trout Creek watershed were due to agriculture, development, grazing (by domestic stock and/or wildlife), power lines, roads, and railroads.

- **Vegetation notes**: Additional notes were taken describing, to the extent possible from aerial photographs, the dominant vegetation types that occur within each RCU (e.g., “alder with scattered shrubs”, “cultivated fields”, “juniper with shrub under story”, “riparian grass with scattered conifers”, “upland grass with scattered juniper”, etc.).

5.2.1.2 Shade mapping

Shade was mapped separately from the RCUs as a GIS line theme. Riparian shading was estimated from the aerial photographs using the criteria given in Table 5-2. Streams were broken into segments having similar riparian shading (H, M, or L) using the indicators of riparian shading given in Table 5-2. Stream orientation (i.e., the compass direction that the stream runs) and topographic shading (i.e., the shade provided by hills and other landscape features) were not assessed due to the difficulty in evaluating their importance from aerial photographs.

Table 5-2. Shade estimation criteria

Indicator	Shade	Code
Stream surface not visible, slightly visible, or visible in patches	>70%	H
Stream surface visible but banks are not visible	40-70%	M
Stream surface visible; banks visible or visible at times	<40%	L

5.2.1.3 Determination of current riparian large wood recruitment potential

The approach to assessing current riparian large wood recruitment potential involves defining what historic recruitment potential was likely to have been, and comparing current recruitment potential against this benchmark to decide if current potential is “satisfactory” (i.e., defining areas that should be protected and where no enhancement is needed), and what factors are limiting current recruitment potential in the areas that are not “satisfactory”.

The Oregon Watershed Assessment Manual (WPN, 1999) uses EPA Level IV ecoregions to describe potential streamside recruitment conditions. The Trout Creek watershed falls within five Level IV ecoregions (Figure 1-9). Potential streamside vegetation descriptions for the five ecoregions found in the Trout Creek watershed are given in Table 5-3. Potential conditions would vary within an ecoregion depending on the geomorphic conditions of a given reach, as well as varying over time in response to disturbance. The potential conditions listed in Table 5-3 can perhaps be considered a “most probable condition” of the riparian vegetation, recognizing that there would be some variability over time.

Table 5-3. Potential streamside vegetation within the Trout Creek watershed (WPN, 2001).

Level IV ecoregion	RA1 description	RA2 description
10c: Umatilla Plateau	Type: Shrubs such as Douglas spirea, red osier dogwood, willows, water birch, and mountain alder. Size: N/A Density: N/A	Non-forested
11a:John Day/Clarno Uplands	Type: Hardwoods (cottonwood, alder and aspen) and/or shrubs (willows, mountain alder, Douglas spiraea and common snowberry). Infrequent juniper and ponderosa pine. Size: Small Density: Sparse	Non-forested
11b:John Day/ Clarno Highlands	Type: Hardwoods (alder & cotton-wood) and/or shrubs (willows, Sitka alder, mountain alder and common snowberry) Size: Small Density: Dense	Type: Conifers (infrequent true fir and ponderosa pine) Size: Medium Density: Sparse
11l:Mesic Forest Zone	Type: Hardwoods and/or shrubs (willows, bog blueberry, dogwood, mountain alder, Pacific ninebark, common snowberry). Size: Small Density: Dense	Type: Conifers (Engelmann spruce, Douglas-fir, true fir, larch, lodgepole pine) Size: Large Density: Dense
11n:Deschutes River Valley	Type: Hardwoods (Black and narrow leaf cottonwoods, aspen) and/or shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose and silver sage). Size: Small Density: Dense	Non-forested

The Oregon Watershed Assessment Manual (WPN, 1999) provides a methodology for placing similar RCUs into groupings that can help summarize the major riparian impacts in the watershed. These groupings, called *riparian recruitment situations*, also provide a way to categorize riparian areas in ways that will respond similarly to restoration treatments.

The first step in developing riparian recruitment situations for the Trout Creek watershed was to determine which RCUs currently have "satisfactory" riparian recruitment. Determination of current satisfactory recruit potential followed the approach given in the Manual (WPN, 1999); current conditions in both RA1 and RA2 (for the RCUs within the forested portions of the watershed) were compared to potential conditions given in Table 5-3.

The remaining RCUs in the watershed currently have unsatisfactory riparian conditions as compared to potential conditions shown in Table 5-3. These remaining RCUs were further divided into a set of riparian recruitment situations that are appropriate for the watershed. Riparian Recruitment Situations were defined using the information that was collected in section 5.2.1.1 above. Questions considered when developing these riparian recruitment situations included what are the land uses that limit recruitment potential, what is the stand structure (e.g., stands are too small or sparse to provide riparian function), and what are the areas where infrastructure and development limit riparian development? Descriptions of the riparian recruitment situations defined for the Trout Creek watershed are as follows:

- **Satisfactory**: Current riparian recruitment potential is satisfactory. No enhancement needed to achieve the potential conditions for the portion of the watershed where the RCU occurs. A classification of satisfactory does not mean that these areas are as productive (in terms of riparian function) as they can be. However, these stands generally fall within the range of potential conditions and, if protected, will provide more desirable conditions over time.

- **Small/sparse/hardwood stands**: This grouping of RCUs represents stands that are below, but close to, potential conditions. Riparian tree sizes within these stands are either smaller than potential conditions, canopy closure is less than potential conditions, or stands are dominated by hardwoods where the potential vegetation is conifer-dominated. In general, stands within this grouping should be protected, and will provide more desirable conditions over time. Appropriate enhancement techniques may include releasing the conifer component (if present) in hardwood-dominated stands, converting hardwood-dominated stands to conifer, or under-planting sparse stands.

- **Bermed/diked areas**: This grouping of RCUs represents stands where current riparian conditions are unsatisfactory (as compared to potential conditions) due to the construction and maintenance of flood control dikes. Appropriate enhancement techniques for these areas may include removing the dikes completely and restoring soil conditions conducive to riparian vegetation, moving dikes laterally away from the channel to maintain flood protection but allow an area for riparian vegetation to be established, or improving soil conditions on the existing dikes.

- **Agriculture related**: This grouping of RCUs represents stands where current riparian conditions are unsatisfactory (as compared to potential conditions) due to agricultural practices. These are the areas that have no, or very narrow, riparian buffers between agricultural land and the streams. Appropriate restoration/enhancement techniques would include riparian plantings.

- **Grazing-related**: This grouping of RCUs represents stands where current riparian conditions are unsatisfactory (as compared to potential conditions) due to grazing (by domestic stock and/or wildlife). It must be noted that it is difficult to determine from aerial photos if grazing is actually occurring in these areas. In addition, many of the current grazing-related impacts are due to legacy conditions from past practices when considerably larger herd sizes existed within the watershed then at present (see Chapter 2.0 for a discussion of historic conditions in the watershed). Appropriate restoration/enhancement techniques would include livestock exclusion and riparian plantings.

- **Forestry-grazing related**: This grouping of RCUs represents stands where current riparian conditions are unsatisfactory (as compared to potential conditions) due to either past forest harvest or grazing (by domestic stock and/or wildlife). This grouping differs from the "grazing-related" grouping discussed above in that it is confined to the forested portions of the watershed. It is important to note that the current conditions for most of the riparian stands in this category are due to legacy conditions from past forest harvest; current state forest practice regulations and USFS policy would prohibit much of the degradation that occurred under past practices. Appropriate restoration/enhancement techniques would include grazing exclusion and riparian plantings. Current restrictions on allowable riparian harvest are probably adequate to provide for passive restoration of riparian conditions in these areas.

5.2.2 Results

5.2.2.1 Riparian / floodplain vegetation

Riparian and floodplain vegetation was mapped for approximately 2,500 individual riparian condition units (RCUs) covering a total of 6,650 acres (10.4 mi^2) within the Trout Creek watershed. An example RCU map for a small portion of the watershed is shown in Figure 5-2. Because of the detailed nature of these maps it is not possible to include hard copies with this report. The digital GIS files needed to reproduce these maps will be made available to the Jefferson County SWCD for use in enhancement project planning. The material presented in this section of the report summarizes current riparian and floodplain vegetation conditions as estimated through aerial photo interpretation.

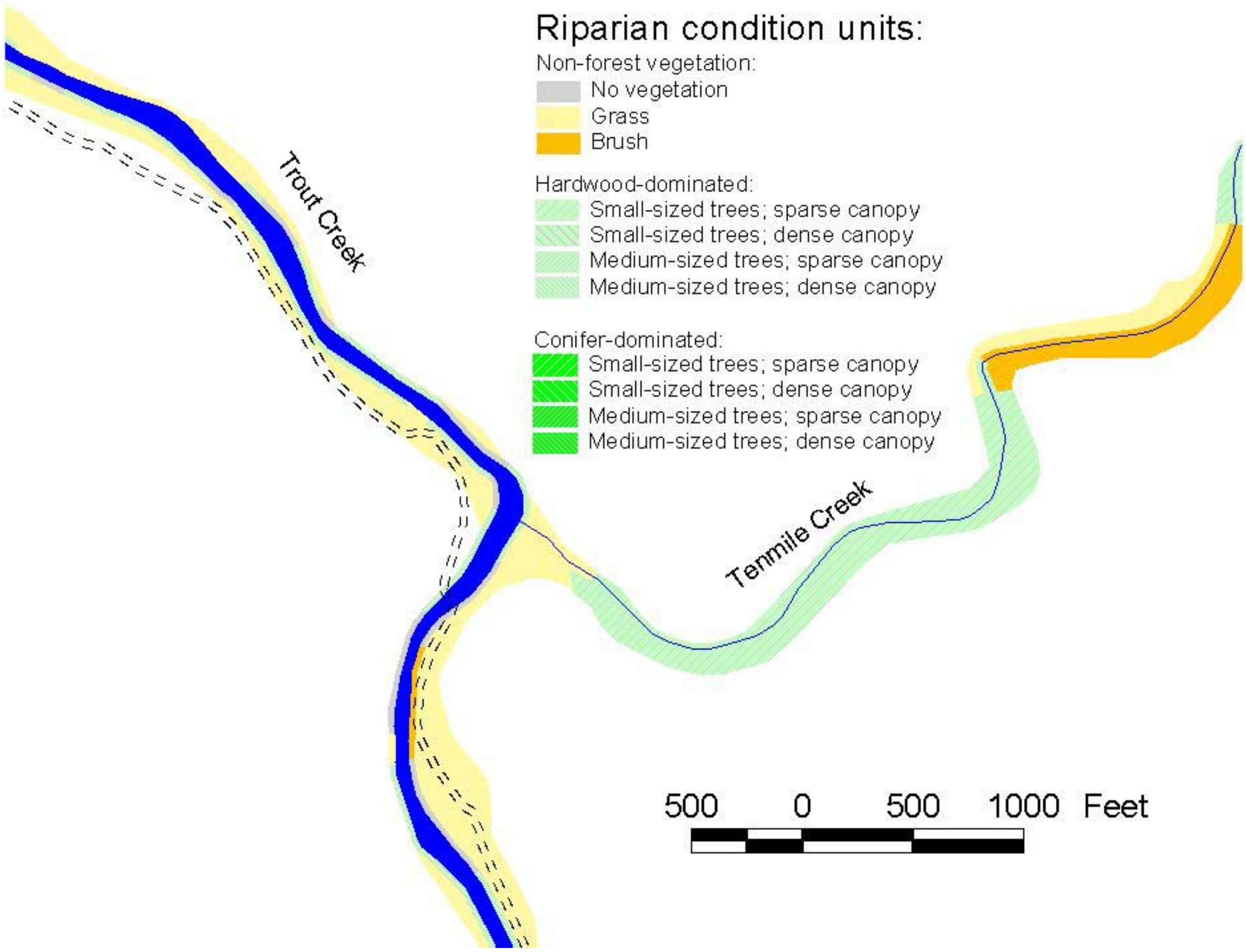


Figure 5-2. Example of riparian condition unit (RCU) mapping near the mouth of Tenmile Creek

The distribution of riparian vegetation by type, size, and density classes within the entire Trout Creek watershed is summarized in Figure 5-3. Additionally, the distribution of floodplain vegetation within the watershed is shown in Figure 5-4. In these figures, *riparian vegetation* refers to the vegetation found in RA1 and RA2 as defined in section 5.2.1.1, and illustrated in the examples given in Figure 5-1. Riparian vegetation in this context means the near-stream vegetation that occurs adjacent to the stream, and has the most direct influence on the stream in its current location. The *floodplain vegetation* refers to the vegetation found in the "floodplain" RCUs as defined in section 5.2.1.1, and illustrated in Figure 5-1. Floodplain vegetation in this context refers to the vegetation that is within the approximate 100-year floodplain, but not immediately adjacent to a stream in its current location. However, should the current location of a channel shift, the floodplain vegetation may come in direct contact with the stream.

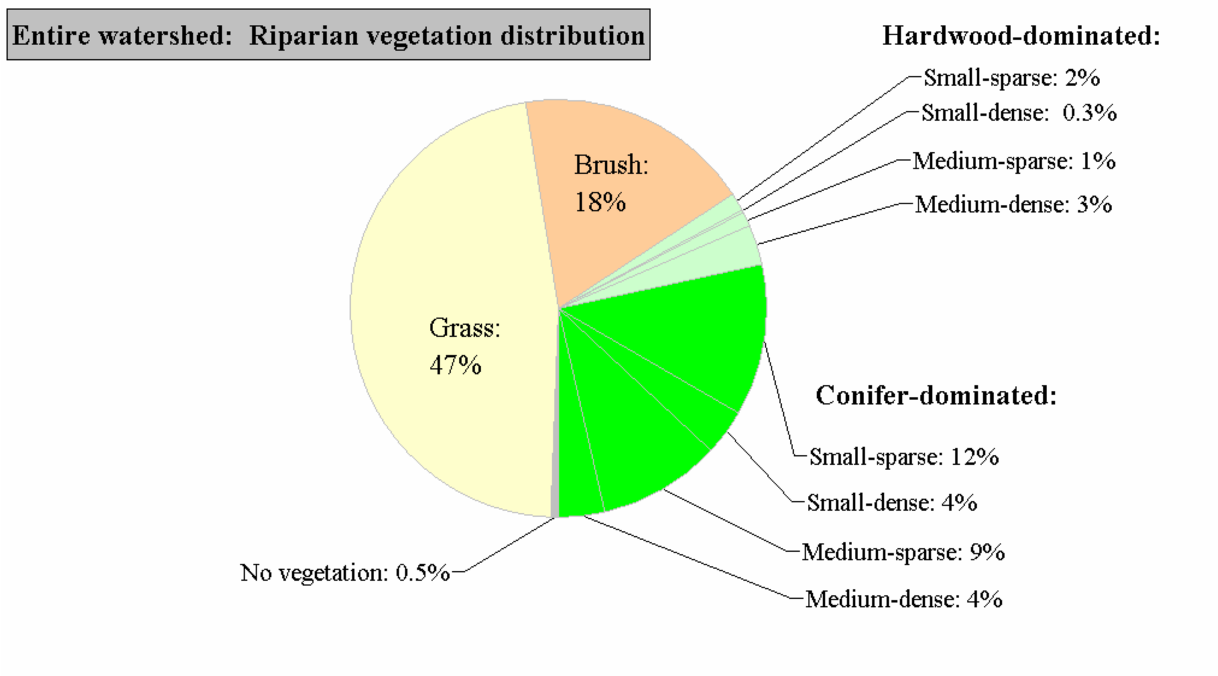


Figure 5-3. Distribution of riparian vegetation by type, size, and density classes within the entire Trout Creek watershed. See Table 5-1 for definitions of terms (e.g., "small", "dense") used in this figure.

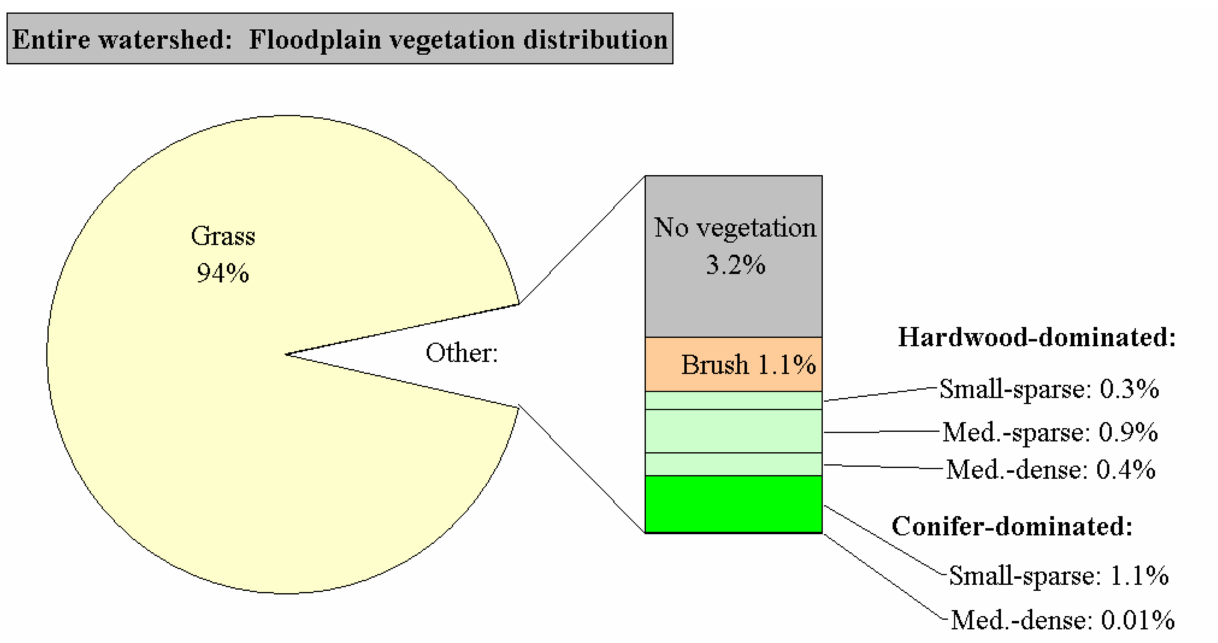


Figure 5-4. Distribution of floodplain vegetation by type, size, and density classes within the entire Trout Creek watershed. See Table 5-1 for definitions of terms (e.g., "small", "dense") used in this figure.

The majority of both the riparian and floodplain vegetation within the watershed is classified as "Grass" (Figure 5-3 amd Figure 5-4). This classification includes areas that are completely comprised of riparian and upland grasses (or grass-like plants), as well as areas that contain some scattered trees and shrubs, but the dominant vegetation are grasses. The large representation of grasses in floodplain areas reflects the use of these areas for tillage and pasture. Riparian grasses within the watershed include reed canarygrass (*Phalaris arundinaceae*), rushes (*Juncus effusus* and other *Juncus* species) sedges (*Carex* sp.), some bulrush (*Scirpus* sp.), Puccinellia (*Puccinellia*), basin wildrye (*Elymus cinereus*), meadow foxtail (*Alopecuris pratensis*), foxtail barley (*Sitanion hystrix*), timothy (*Phleum pratensis*), and Kentucky bluegrass (*Poa pratensis*). The riparian zone on Trout Creek also included a type of watercress. Also included in this category were areas dominated by larger wetland plants such as cattails (*Typha latifolia*), and bulrushes (*Scirpus* sp.). Also included are irrigated meadows, which are more likely to be planted in non-native grass species or alfalfa. In some areas introduced grasses have also been planted for forage, erosion control, and wildlife.

Vegetation classified as "Brush", or shrubs, currently make up 18% of riparian areas (Figure 5-3) and only about 1% of floodplain vegetation (Figure 5-4). The biggest change in vegetation from historical to current conditions most likely is represented by the shift from shrub- to grass-species in both the riparian and floodplain areas of the watershed. It is nearly impossible to distinguish shrub species on aerial photographs. Common shrub species that most likely comprise this grouping include several species of willow (*Salix* sp.), sitka alder (*Alnus sitchensis*), hawthorn (*Crateagus sp.*), chokecherry (*Prunus virginiana*), wood's rose (*Rosa woodsii*), sage (*Artemesia sp.*), spirea (*Spirea douglasii*), snowberry (*Symphoriocarpos* sp.), and shrubby cinquefoil (*Potentilla fruticosa*).

Vegetation classified as "Hardwoods" currently makes up approximately 6% of riparian areas (Figure 5-3) and only about 2% of floodplain vegetation (Figure 5-4). The most prevalent species of hardwood found in the watershed was alder (*Alnus sp.*). Water birch (*Betula occidentalis*) is probably found in the drier canyons, and aspens (*Populus* sp.) were noted in some areas. Cottonwoods (*Populus sp.*) were generally absent from the watershed, being observed only in scattered groupings. The extent to which cottonwoods were historically present within the watershed is unknown.

Vegetation classified as "Conifers" currently makes up approximately 29% of riparian areas (Figure 5-3) and only about 1% of floodplain vegetation (Figure 5-4). Conifer species are primarily western juniper (*Juniperus occidentalis*) in the lower-elevation portions of the watershed; with Ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), and true firs (*Abies* sp.) being the most common species found in higher elevation areas.

Vegetation classified as "No vegetation" currently makes up less than 1% of riparian areas (Figure 5-3) and only about 3% of floodplain vegetation (Figure 5-4). These areas include primarily cultivated fields, but also include developed areas and un-vegetated (or sparsely vegetated) steep slopes.

The distribution of primary riparian vegetation types by subbasin is summarized in Figure 5-5. Additionally, the distribution of primary floodplain vegetation types by subbasin is shown in Figure 5-6. The majority of the riparian conifer vegetation is found in the Upper Trout Creek subbasin (Figure 5-5). All subbasins with the exception of the Upper Trout Creek subbasin show 70% or greater of the riparian vegetation in the "Grass" type (Figure 5-5). The Mud Springs subbasin has almost 40% of its floodplain area in the "No vegetation" category (Figure 5-6), reflecting the large presence of cultivated fields within the 100-year floodplain.

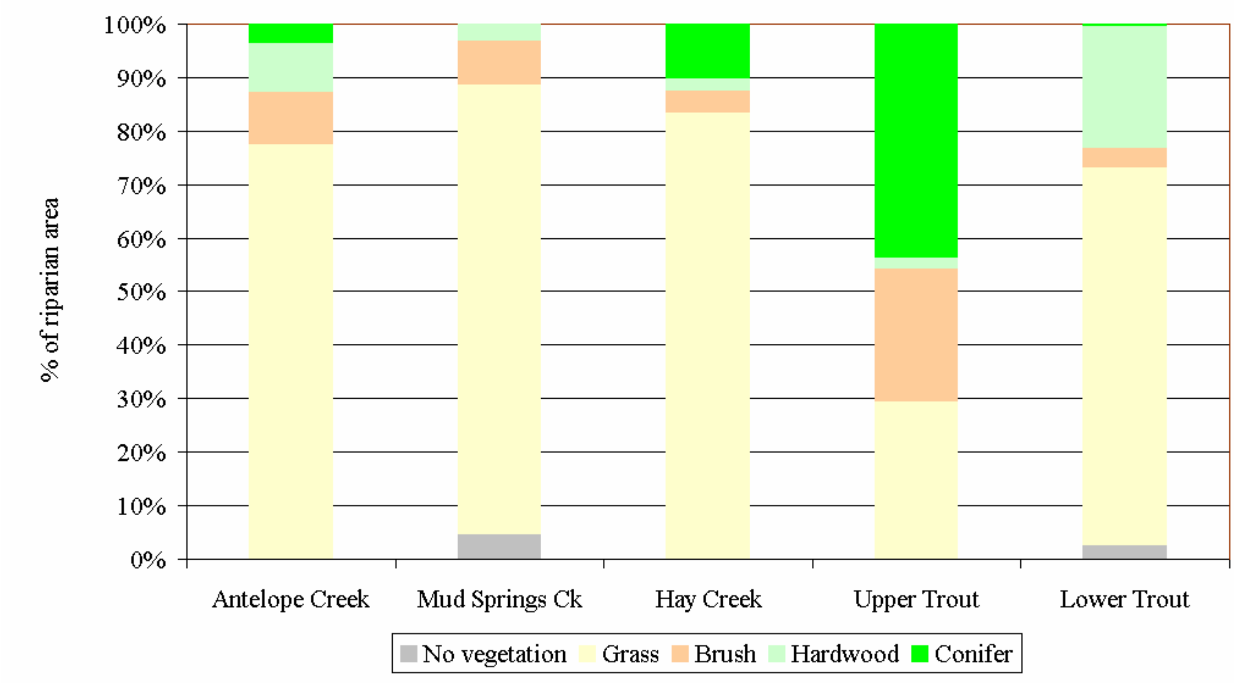


Figure 5-5. Distribution of riparian vegetation by primary type within the subbasins of the Trout Creek watershed.

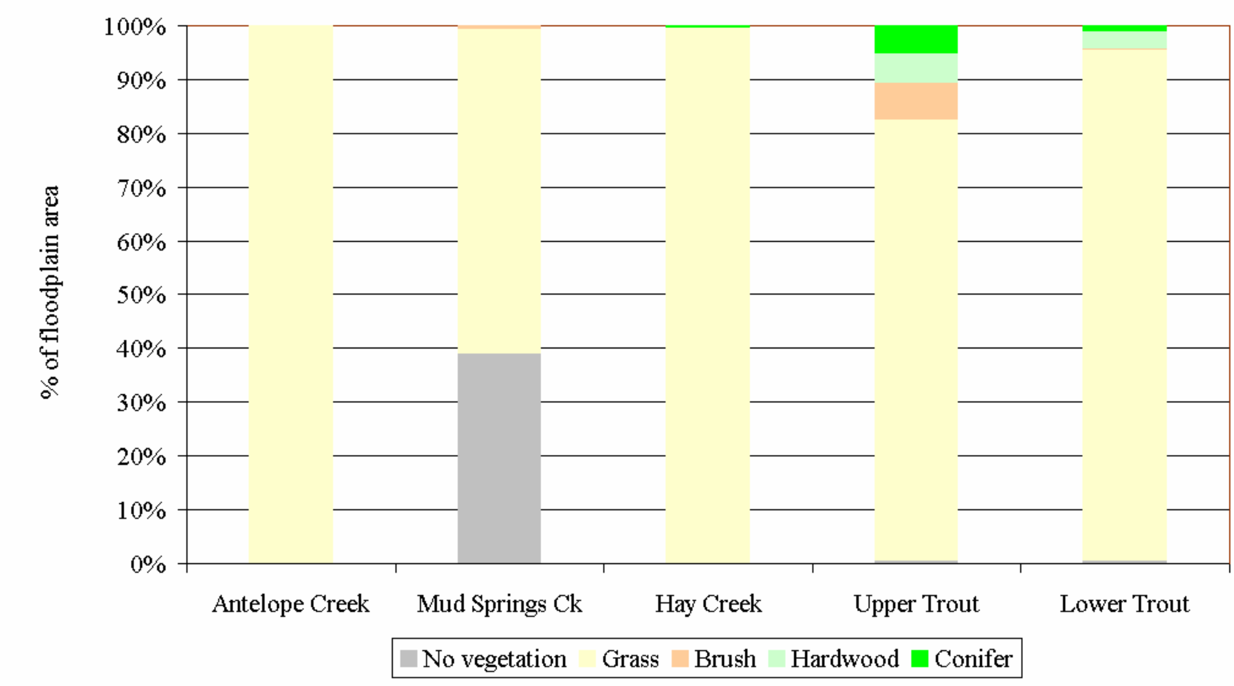


Figure 5-6. Distribution of floodplain vegetation by primary type within the subbasins of the Trout Creek watershed.

5.2.2.2 Riparian recruitment potential

Current riparian recruitment potential was assessed for 508 miles of riparian area located along 254 miles of stream in the Trout Creek watershed[18]. Current riparian recruitment potential was organized by the six riparian recruitment situations described in section 5.2.1.3 above. Riparian recruitment situations within the Trout Creek watershed are shown in Figure 5-7 and summarized in Figure 5-8. Figure 5-9 provides a summary of current riparian situations by subbasin.

Approximately 31% of the length of riparian areas in the entire watershed currently has "satisfactory" recruitment potential for the ecoregion in which they are located (Figure 5-8). Bear in mind that does not mean that all of these stands contain trees large enough to provide significant channel function if recruited to the stream. For example, some of the areas shown as having "satisfactory" conditions along the lower portion of Antelope Creek have only "brush" type vegetation. Brush-type vegetation is the likely historic/potential vegetation type for some streams that fall within this ecoregion (i.e., Level IV ecoregion 11a; Table 5-3). The rating of "satisfactory" indicates that recruitment potential is satisfactory *relative* to potential conditions. However, these stands generally provide some amount of recruitable wood and, if protected, will provide more desirable conditions over time. The Upper Trout Creek subbasin has the largest proportion of riparian stands in the "satisfactory" category (41% of total riparian length; Figure 5-9), and the Mud Springs and Hay Creek subbasins have the lowest (10% and 17% respectively; Figure 5-9).

Approximately 8% of the length of riparian areas in the entire watershed is currently classified within the "small-sparse-hardwood" recruitment situation (Figure 5-8). This grouping represents stands that are below, but close to, potential conditions. Riparian tree sizes within these stands are either smaller than potential conditions, canopy closure is less than potential conditions, or stands are dominated by hardwoods where the potential vegetation is conifer-dominated. In general, stands within this grouping will provide more desirable conditions over time if protected. The Upper Trout Creek subbasin has the largest proportion of riparian stands in the "small-sparse-hardwood" category (20% of total riparian length; Figure 5-9). This category is not found in the Antelope Creek or Hay Creek subbasins, and occurs over less than 2% of the total riparian length within the Mud Springs and Lower Trout subbasins (Figure 5-9).

[18] Length of riparian areas = 2 x stream length because each side of the stream is assessed independently

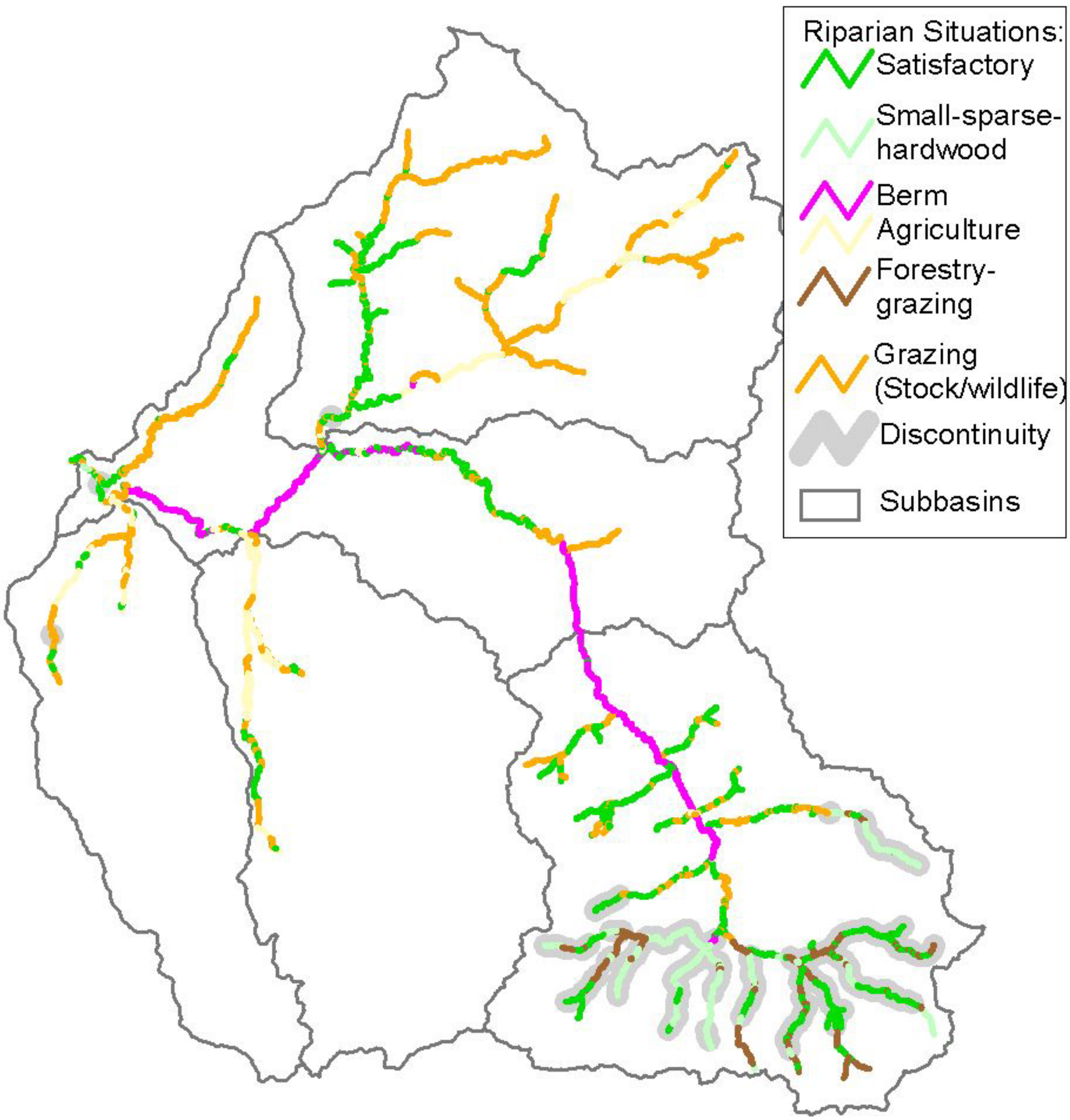


Figure 5-7. Areas where current riparian recruitment is satisfactory; and areas where current riparian recruitment is unsatisfactory grouped by most likely source of degradation. See narrative for descriptions of the various riparian recruitment situations.

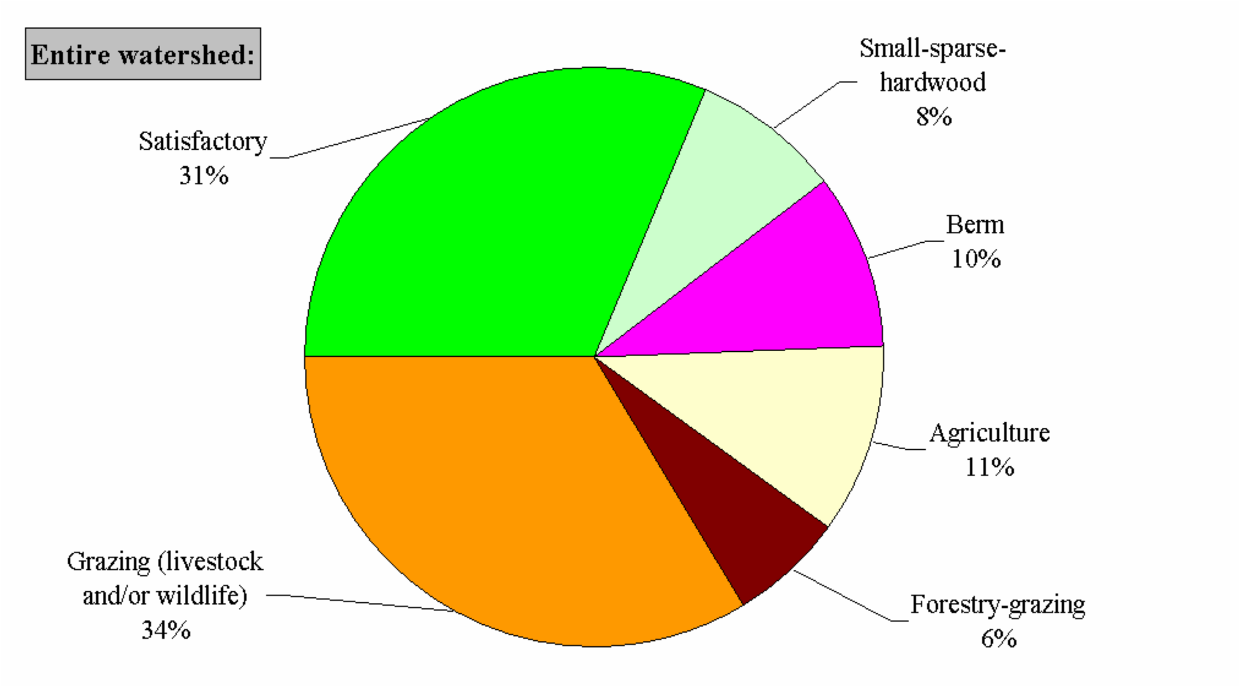


Figure 5-8. Summary of current riparian situations within the entire Trout Creek watershed. Categories are percent of total riparian length.

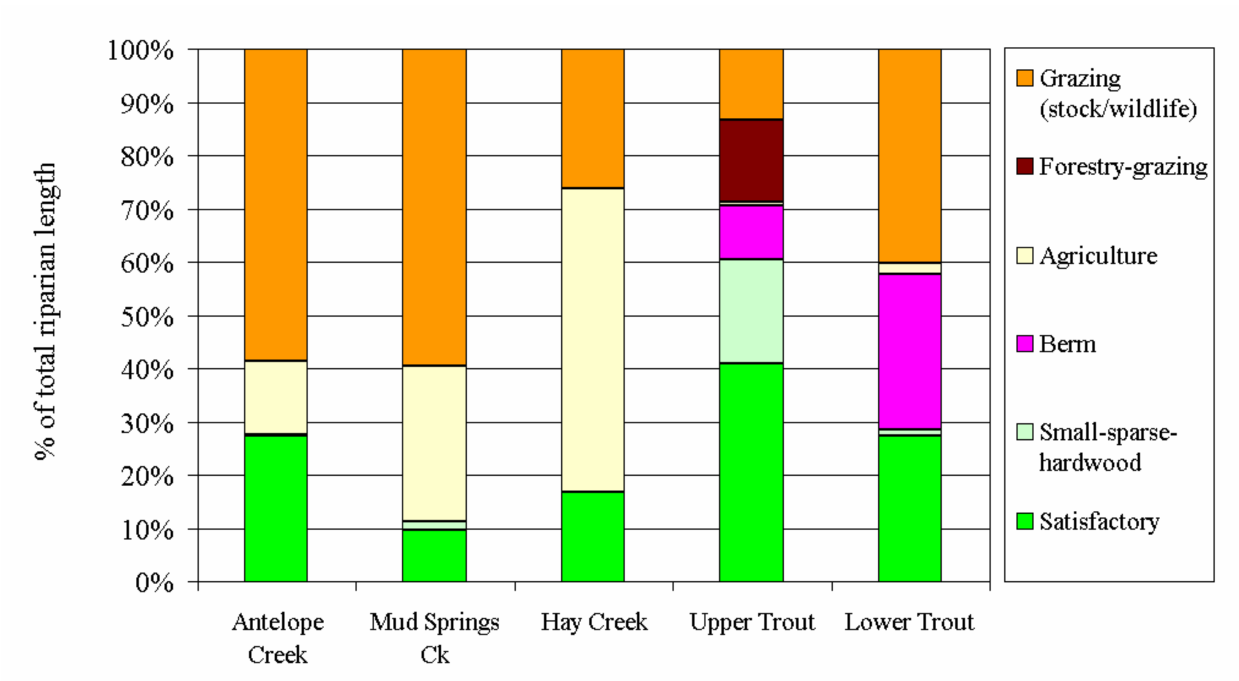


Figure 5-9. Summary of current riparian situations by subbasin within the Trout Creek watershed. Categories are percent of total riparian length for each subbasin.

Approximately 10% of the length of riparian areas in the entire watershed is currently classified within the “Bermed/diked” recruitment situation (Figure 5-8). This grouping represents stands where current riparian conditions are unsatisfactory (as compared to potential conditions) due to the construction and maintenance of flood control dikes. The Lower Trout Creek subbasin has the largest proportion of riparian length in the “Bermed/diked” category (29% of total riparian length; Figure 5-9), and the Upper Trout Creek subbasin has approximately 10% of total riparian length in this category (Figure 5-9). Antelope Creek subbasin has less than 1% of the total riparian length in this category, and the remainder of the subbasins has none (Figure 5-9).

The “Agriculture-related” recruitment situation makes up approximately 11% of the total length of riparian areas within the watershed (Figure 5-8). This grouping represents stands where current riparian conditions are unsatisfactory (as compared to potential conditions) due to agricultural practices. These are the areas that have no, or very narrow, riparian buffers between agricultural land and the streams. The Hay Creek subbasin has the largest proportion of riparian length in this category (57% of total riparian length; Figure 5-9), and the Upper Trout Creek subbasin has the least (1%; Figure 5-9).

The largest grouping of riparian areas within the watershed is the “Grazing-related” recruitment situation, which makes up approximately 34% of the total length of riparian areas (Figure 5-8). This grouping represents stands where current riparian conditions are unsatisfactory (as compared to potential conditions) due to grazing by domestic stock and/or wildlife. The Antelope Creek and Mud Springs Creek subbasins both have approximately 60% of their total riparian length within this category (Figure 5-9). The Upper Trout Creek subbasin has the lowest proportion of riparian length in this category (13%; Figure 5-9).

The “Forestry-grazing related” recruitment situation makes up approximately 6% of the total length of riparian areas within the watershed (Figure 5-8). This grouping represents stands where current riparian conditions are unsatisfactory (as compared to potential conditions) due to either past forest harvest or grazing (by domestic stock and/or wildlife). This grouping differs from the “grazing-related” grouping discussed above in that it is confined to the forested portions of the watershed. This grouping only occurs within the Upper Trout Creek subbasin where approximately 15% of the total riparian length falls within this category (Figure 5-9).

Also shown in Figure 5-7 are riparian areas that have a significant discontinuity[19] in riparian conditions due to the presence of roads within the riparian area. These areas occurred primarily within the Upper Trout Creek subbasin and were due to roads that were located immediately

[19] A “significant discontinuity” was defined in section 5.2.1.1 as a permanent discontinuity in riparian vegetation that limits recruitment potential over more than 30% of the total area of a RCU.

adjacent to stream channels. These areas impacted approximately 18% of the total length of riparian areas in the Upper Trout Creek subbasin.

The summary of riparian recruitment situations given above is for all streams in the watershed, irrespective of which streams are most "important" to fish use. One possible way to look closer at those streams that are important to fish is to look at the distribution of riparian recruitment situations by channels that are most responsive to inputs of large woody material (LWM). The channels that are most responsive to LWM are the most likely to develop favorable fish habitat characteristics if recruitment is adequate, and conversely, are the most likely to be degraded if LWM recruitment is impaired. Within the Trout Creek watershed, the channels that are most likely to respond to LWM are the "low gradient moderately confined" (LM) and "low gradient small floodplain" (FP3) channel habitat types (CHTs). Together, streams within these two CHT types make up only 19% of the total length of streams included in the assessment; however, these are probably the most responsive to LWM recruitment. A breakdown of the percent length of riparian areas by Riparian Recruitment Situation among these most responsive CHTs is given in Figure 5-10.

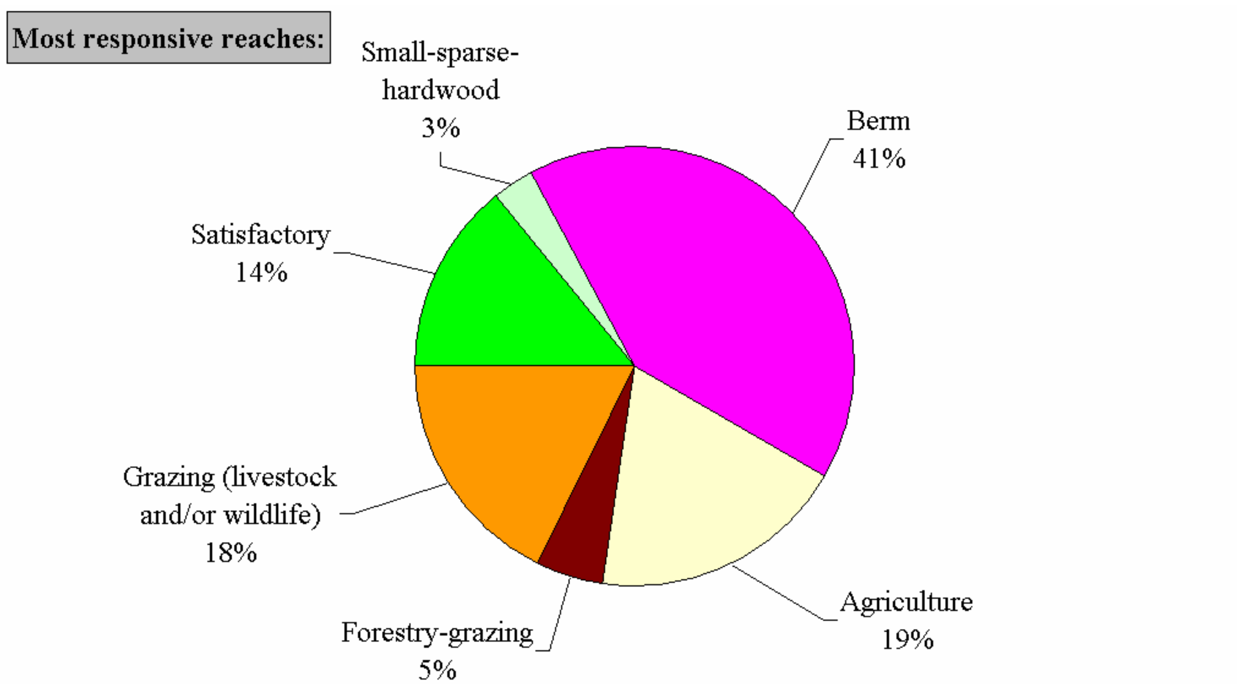


Figure 5-10. Summary of current riparian situations along channels that are the most responsive to inputs of large woody material (i.e., CHT types FP3 and LM). Categories are percent of total riparian length along these CHT types.

Current riparian conditions are rated as "satisfactory" along only 14% of the most responsive channel reaches (Figure 5-10), as compared to 31% for all channels (Figure 5-8). The largest single source of impairment along these most responsive reaches is from berms/dikes that currently impact 41% of the total length (Figure 5-10), as compared to 10% along all streams (Figure 5-8). Agricultural impacts are also greater along the most responsive reaches (19% of total length; Figure 5-10), as compared to 11% for all channels (Figure 5-8).

5.2.2.3 Riparian shade

Current riparian shade levels within the Trout Creek watershed are shown in Figure 5-11 and summarized in Figure 5-12. Seventy-five percent of the total stream length in the watershed was classified as having a "Low" level of riparian shade. Ninety-four percent of the stream length within the Hay Creek subbasin was classified as having low-levels of riparian shade, as compared to 59% of the stream length within the Upper Trout subbasin. Fourteen percent of the total stream length in the watershed was classified as having "Moderate" riparian shading; ranging from 2% of the total stream length within the Hay Creek subbasin to 17% within the Upper Trout Creek subbasin. Eleven percent of the total stream length in the watershed was classified as having "High" riparian shade levels; ranging from 3% of the total stream length in the Mud Springs Creek subbasin to 24% within the Upper Trout Creek subbasin.

Based on the summary data illustrated in Figure 5-11 and Figure 5-12 it is clear that shade levels within the watershed are very low. However, it is difficult to assess if current shade levels are below potential levels, and if so, to what extent. The Oregon Watershed Assessment Manual (WPN, 1999) does not include a methodology for estimating potential shade levels. Nevertheless, given the degree to which riparian areas within the watershed are deficient in terms of recruitment potential, we can qualitatively assume that riparian shade levels are similarly impacted. Many of the riparian areas that are currently in a "grass" type vegetation probably consisted of shrub communities historically. In addition, it is probable that cottonwood stands occupied a larger proportion of riparian areas historically. Any enhancement actions that are designed to increase riparian recruitment are likely to also improve riparian shading over current levels.

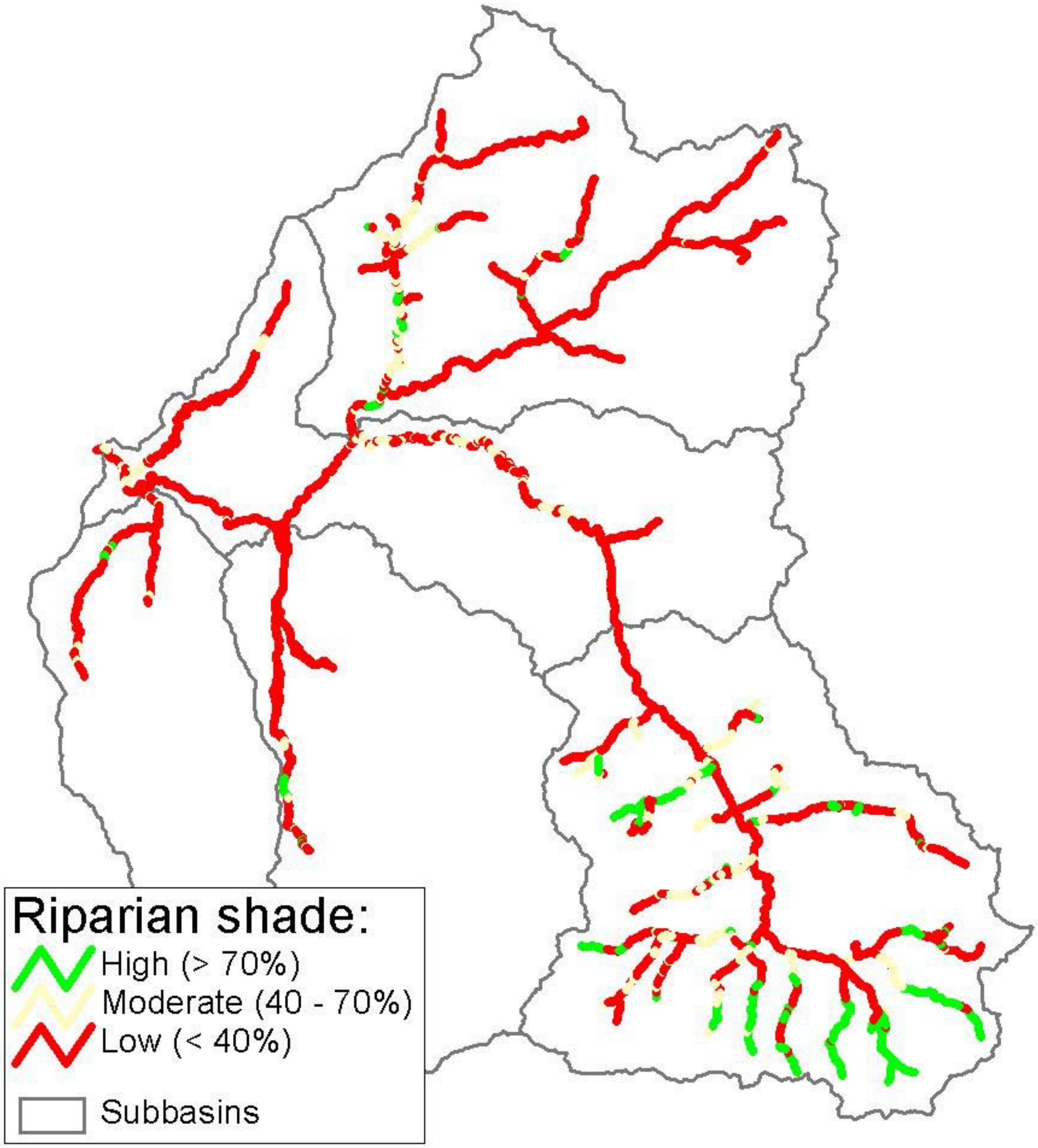


Figure 5-11. Current riparian shade levels within the Trout Creek watershed.

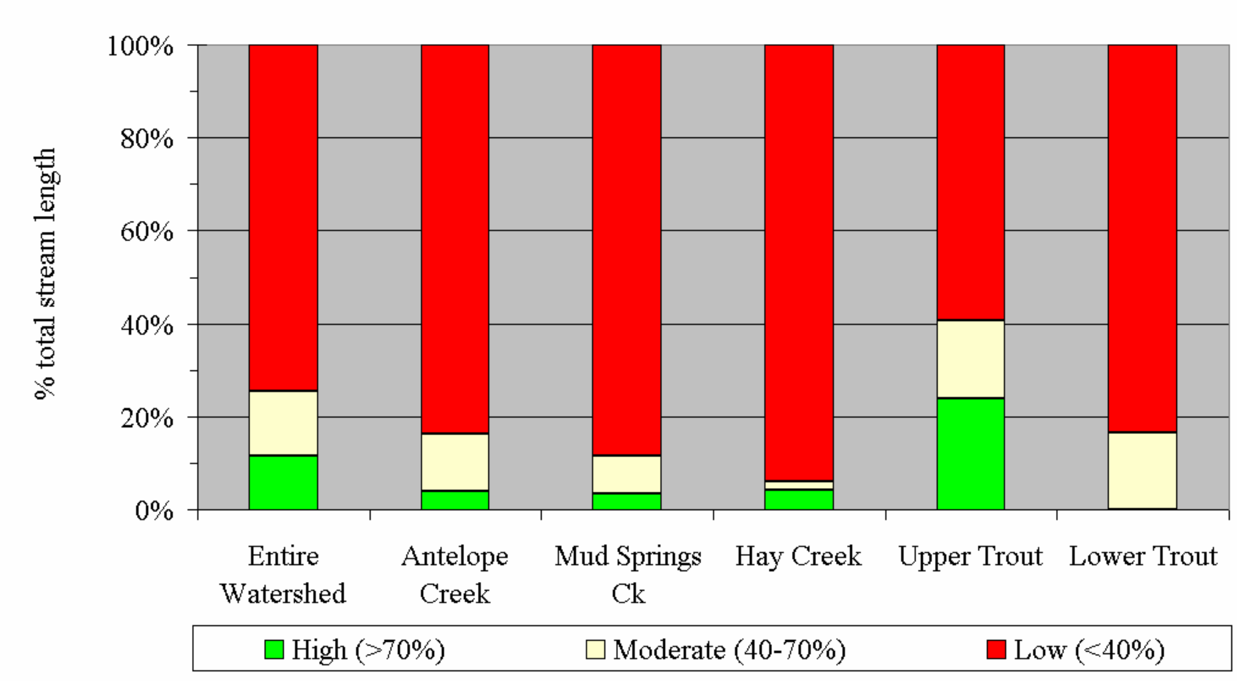


Figure 5-12. Summary of current riparian shade levels within the entire Trout Creek watershed (first column), and by subbasin (remaining columns). Categories are percent of total stream length.

5.2.3 Estimated Rate of Riparian Recovery

Rates of riparian vegetation recovery vary depending on many factors. For example, a minimum of eight years of exclosure of riparian vegetation to livestock on Big Creek, Rich County, Utah, was necessary to restore the habitat for productive fish and wildlife uses, as well as water quality maintenance (Duff, 1979). Where a channel is currently beginning a cycle of erosion, seed sources for native riparian species are absent, channels have steep gradients, or silt loads are low, recovery may require decades or more (Elmore and Beschta, 1987). Simply excluding livestock may not greatly improve the riparian habitat, in which case active restoration efforts may be required to restore the habitat to a functional condition (Manci, 1989). Where the potential vegetation type is grass or grass-like plants, restoration will probably proceed faster than in areas where the potential vegetation is shrubs or trees. Restoration goals should include not only vegetation cover but functional condition as well.

Livestock exclosures have been constructed since the mid 1980s along approximately 50 miles of stream within the Trout Creek watershed. No quantitative assessment of the benefit of these projects on riparian vegetation was possible through this assessment. However, it appears that riparian vegetation is recovering within the current exclosures that could be identified on the aerial photographs. The USFS (1995) noted in the watershed assessment that was conducted for the upper portion of the Trout Creek subbasin that riparian conditions appear to be improving on Forest Service lands where riparian areas have been fenced. Members of the Trout Creek Watershed Council have noted that feral pig populations within some parts of the watershed have had adverse effects on riparian conditions within and outside of exclosures.

An appendix in section 11.1 of this report includes additional information on riparian plant associations, site conditions, wildlife use, fire effects, and restoration pathways for the riparian areas of the Trout Creek watershed.

5.3 WETLAND ASSESSMENT

5.3.1 Assessment Methods

The methods used in this assessment are described in the Oregon Watershed Assessment Manual (WPN, 1999), with exceptions noted below. The purpose of this assessment was to identify locations of wetlands within the Trout Creek watershed and to summarize available data on current wetland conditions. The critical questions addressed in this assessment were "where are the wetlands in the watershed?" and "what are the general characteristics of wetlands in the watershed?" Additional critical questions included in the Oregon Watershed Assessment Manual but not considered in this assessment were "where are the priority wetlands within the watershed?" and "What opportunities exist to restore wetlands in the watershed?" Answering these questions would require 1) a functional assessments of wetlands, which was beyond the scope of this assessment; and 2) more information on wetland location and characteristics than currently exists.

All information about wetland locations and current conditions used in this assessment was derived from digital and hardcopy National Wetland Inventory (NWI) data produced by the U.S. Fish and Wildlife Service (USFWS); no local wetland inventory information being available for the watershed. Digital NWI information was available for the Buck Butte, Eagle Butte, Gateway, Madras East, and Madras West 7.5" quad maps (USFWS, 2001). The dates of the source imagery used to produce the digital maps is not known, but is probably sometime in the 1980's. Hardcopy NWI maps of all remaining quads within the watershed were scanned and digitized into ArcView GIS. The source photography used to produce the NWI map for the Shaniko quad (USFWS, 1990) was dated 1981. The source photography for all remaining quads

(USFWS, 1995) was dated 1982. No aerial photo interpretation was performed for this assessment.

The Oregon Watershed Assessment Manual suggests assessing only the wetlands that are greater than 200 feet from the channel to avoid having to examine the very complex NWI mapping that can occur near stream channels. In this assessment all wetland polygons were included regardless of distance from stream channels, however, wetlands that appear in the NWI as line features (i.e., riparian wetlands) were not included. The following information was collected for each wetland and is included in the attribute table of the GIS coverage:

- **Wetland polygon #**: Each wetland polygon was assigned a unique identifying number

- **Subbasin**: The subbasin that each wetland polygon was located within.

- **Acres**: The size of the wetland polygon, in acres.

- **Ownership**: Wetland polygons were overlain with land ownership information (BLM, 2001) to determine ownership of each wetland. Wetland polygons were split at ownership lines.

- **Source**: Source of the wetland information; either digital or hardcopy maps

- **Wetland complex**: In some cases groups of one or more contiguous wetland polygons existed. These wetland complexes were identified using a unique number.

- **Cowardin Classification Code**: The Cowardin classification code (Cowardin et al., 1979) was noted for each wetland in the GIS attribute table. The System-Subsystem, Class, Water Regime Modifiers, and Special Modifiers for wetlands found within the Trout Creek watershed are shown in Table 5-4.

Information identified in the Oregon Watershed Assessment Manual that was not collected as part of this assessment included surface water connections between wetlands and streams, buffer condition, and wetland position in the watershed.

Table 5-4. Classification for NWI wetlands found in the Trout Creek watershed (Cowardin and others, 1979).

System - subsystem	Class
R3 (Riverine-Upper Perennial)	**UB** (Unconsolidated Bottom) **US** (Unconsolidated Shore)
L1 (Lacustrine-Limnetic)	**UB** (Unconsolidated Bottom)
P (Palustrine)	**UB** = Unconsolidated Bottom **AB** = Aquatic Bed **US** = Unconsolidated Shore **EM** = Emergent **SS** = Scrub-Shrub **FO** = Forested

Water regime modifiers:
A=Temporarily Flooded
B=Saturated
C=Seasonally Flooded
F=Semi-permanently Flooded
H=Permanently Flooded

Special modifiers:
b=Beaver
h=Diked/Impounded
x=Excavated

5.3.2 Results

5.3.2.1 Wetland Distribution

A total of 871 wetlands covering 1,441 acres were identified by the NWI in the Trout Creek watershed (Figure 5-13; Table 5-5). Wetland density (area occupied by wetlands/area of sub-basin) ranged from 0.1% of the Upper Trout Creek subbasin to 0.5% of the Antelope Creek subbasin, and was 0.3% of the watershed overall (Table 5-5).

The majority (63%) of the total wetland acreage in the watershed falls within the "palustrine emergent" category (Figure 5-14). Palustrine emergent wetlands are wetlands dominated by rooted herbaceous plants, such as cattails and grass. Palustrine emergent wetlands make up the largest proportion of wetland area within each of the subbasins, with the exception of the Lower Trout Creek subbasin (Figure 5-15).

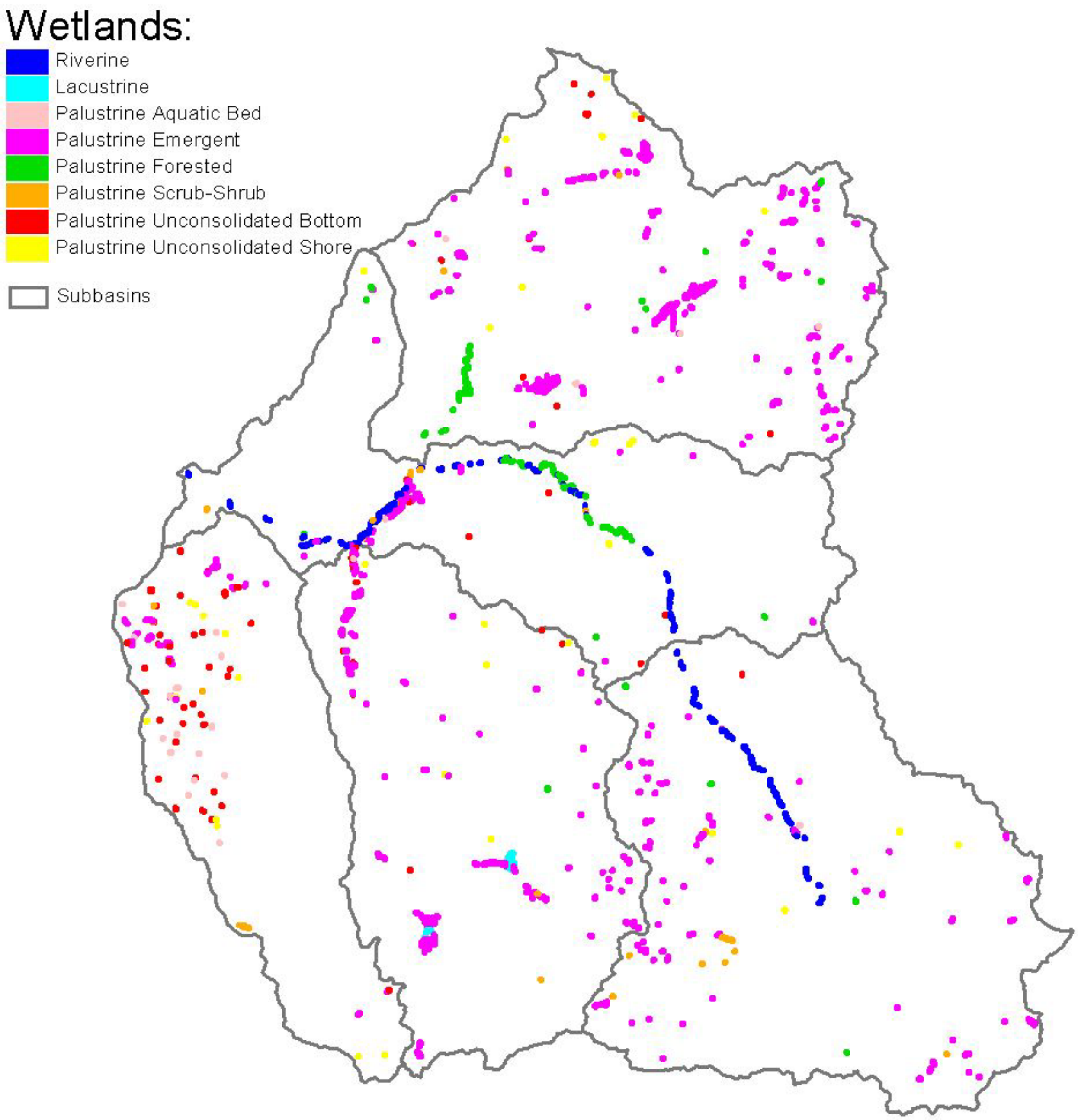


Figure 5-13. Wetlands in the Trout Creek watershed. Data source: USFWS (1990, 1995, 2001).

Table 5-5. Summary of wetlands distribution within the Trout Creek watershed. Data source: USFWS (1990, 1995, 2001).

Subbasin	# of wetlands	Wetland acres	% subbasin area in wetlands
Antelope Creek	239	543	0.5%
Mud Springs Ck	156	114	0.2%
Hay Creek	135	356	0.4%
Upper Trout	177	160	0.1%
Lower Trout	164	266	0.3%
Entire watershed	871	1,441	0.3%

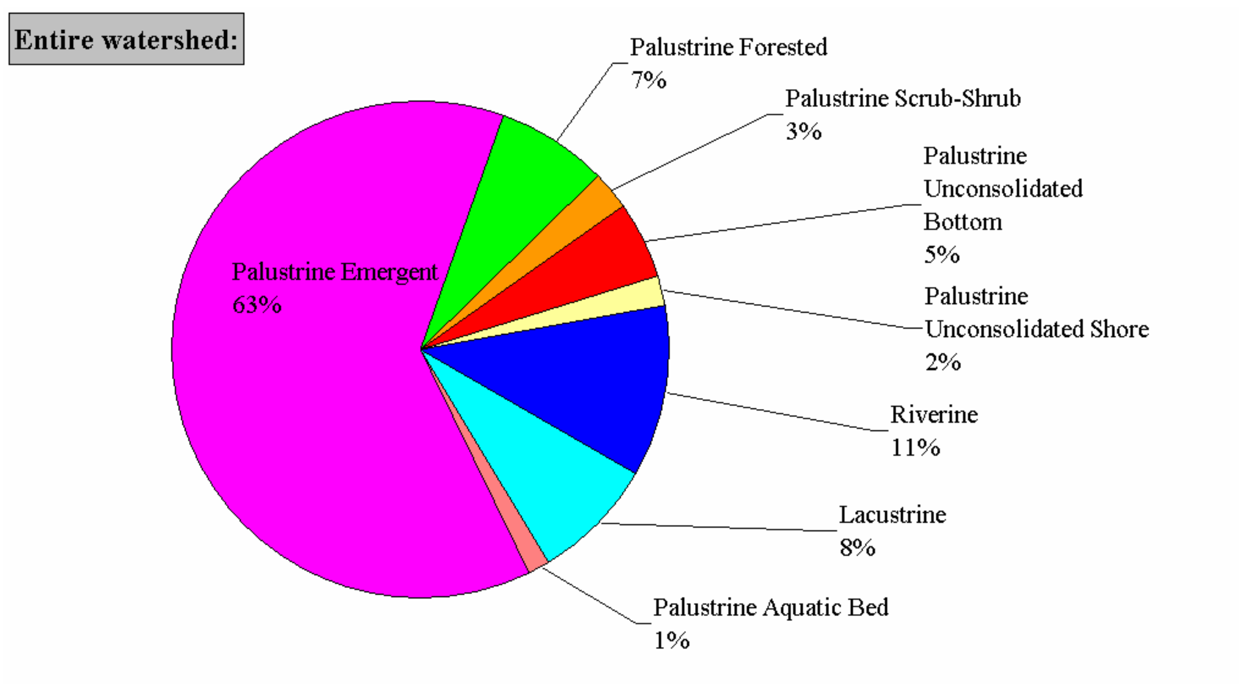


Figure 5-14. Distribution of wetland area in the Trout Creek watershed by System and Class.

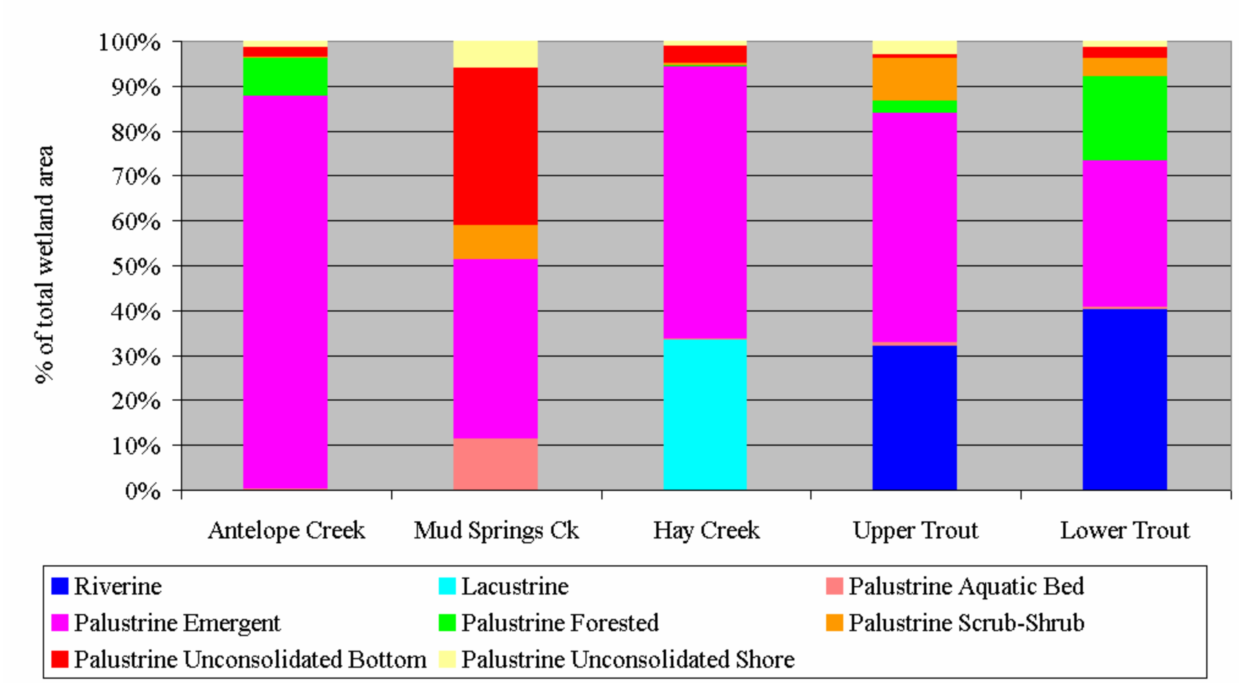


Figure 5-15. Distribution of total wetland area within subbasins.

Palustrine forested wetlands, which are defined as wetlands dominated by trees taller than 20 feet, make up 7% of the total wetland area in the watershed (Figure 5-14), and range from 0% of the total wetland area in the Mud Springs Creek subbasin to 19% of the total wetland area in the Lower Trout Creek subbasin (Figure 5-15).

Palustrine scrub-shrub wetlands are defined as wetlands that are dominated by shrubs and saplings less than 20 feet tall. Overall palustrine scrub-shrub wetlands make up 3% of the total wetland area in the watershed (Figure 5-14). Palustrine scrub-shrub wetlands range from less than 1% of the total wetland area in the Antelope Creek and Hay Creek subbasins, to 10% of the total wetland area in the Upper Trout Creek subbasin (Figure 5-15).

Palustrine unconsolidated bottom wetlands are those wetlands whose substrate is primarily mud or exposed soils, and have less than 30% vegetative cover. Overall palustrine unconsolidated bottom wetlands make up 5% of the total wetland area in the watershed (Figure 5-14), and range from less than 1% of the total wetland area in the Upper Trout Creek subbasin to 35% of the total wetland area in the Mud Springs Creek subbasin (Figure 5-15).

Palustrine unconsolidated shore wetlands are those wetlands that have less then 30% cover of vegetation other than pioneering plants; and are periodically flooded. Overall palustrine unconsolidated shore wetlands make up 2% of the total wetland area in the watershed (Figure 5-14), and range from 1% of the total wetland area in the Hay Creek subbasin to 6% of the total wetland area in the Mud Springs Creek subbasin (Figure 5-15).

Palustrine aquatic bed wetlands are those that are dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Palustrine aquatic bed wetlands make up 1% of the total wetland area in the watershed (Figure 5-14). This grouping makes up 1% or less of the total wetland area in all subbasins except the Mud Springs Creek subbasin where 11% of the total wetland area consists of palustrine aquatic bed wetlands (Figure 5-15).

Riverine wetlands include all wetlands contained within a channel, except wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. Riverine wetlands make up 11% of the total wetland area in the watershed (Figure 5-14). Riverine wetlands are only found in the Upper Trout Creek and Lower Trout Creek subbasins, along the mainstem of Trout Creek (Figure 5-13). Riverine wetlands make up 32% of the total wetland are in the Upper Trout Creek subbasin and 40% of the total wetland area in the Lower Trout Creek subbasin (Figure 5-15)

Lacustrine wetlands are wetlands situated in a topographic depression or a dammed river channel, have less than 30% vegetative cover, and the total area of an individual wetland exceeds 20 acres. Lacustrine wetlands make up 8% of the total wetland area in the watershed (Figure 5-14). Lacustrine wetlands are only found in the Hay Creek subbasin where they make up 34% of the total wetland area of the subbasin (Figure 5-15). The lacustrine wetlands in the watershed consist of Brewer Reservoir and Little Willow Creek Reservoir (Figure 5-13).

5.3.2.2 Wetland ownership

Wetland ownership within the Trout Creek watershed is summarized in Figure 5-16. Wetland ownership in the watershed is primarily private (95.6% of total wetland area), with limited public ownership on lands managed by the BLM (2.6%), Forest Service (1.4%), and other Department of Agriculture (0.4%) lands. The subbasin having the largest proportion of public wetland ownership is the Upper Trout Creek subbasin, where 13% of the total wetland area is on lands managed by the USFS, and an additional 3% is on BLM-managed lands.

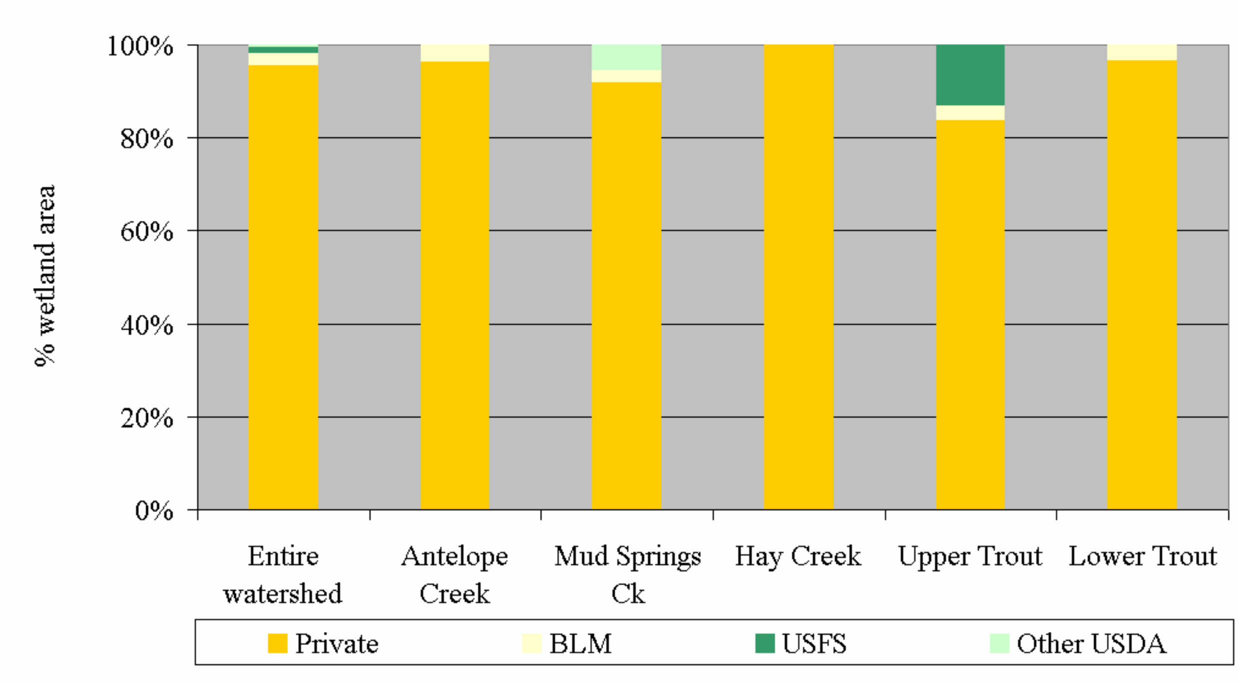


Figure 5-16. Distribution of wetland area by ownership category within the entire Trout Creek watershed (first column), and by subbasin (remaining columns).

5.3.2.3 Wetland modifications

Many wetlands have been created, modified or destroyed through the intentional or unintentional actions of humans and beavers. The NWI attempted to identify these modifications where possible. Three of these "special modifiers" (Table 5-4) were noted for wetlands within the Trout Creek watershed:

- **Excavated wetlands**: Wetlands that lie within a basin or channel excavated by humans.
- **Diked/Impounded wetlands**: Diked wetlands are created or modified by a human-made barrier or dike designed to obstruct the inflow of water. Impounded wetlands are created or modified by a barrier or dam which purposefully or unintentionally obstructs the outflow of water.
- **Beavers**: Wetlands that have been created or modified by beavers.

Beaver-related wetland modifications were only noted in two small wetlands, both located in the Lower Trout Creek subbasin. Due to the limitations of the NWI data, it is probable that many beaver-created wetlands were not included in this assessment. In particular, members of the Trout Creek Watershed Council have noted that the NWI does not include a large beaver-created wetland in the Foley Creek area. Modifications due to excavation and dikes/impoundments are summarized in Figure 5-17.

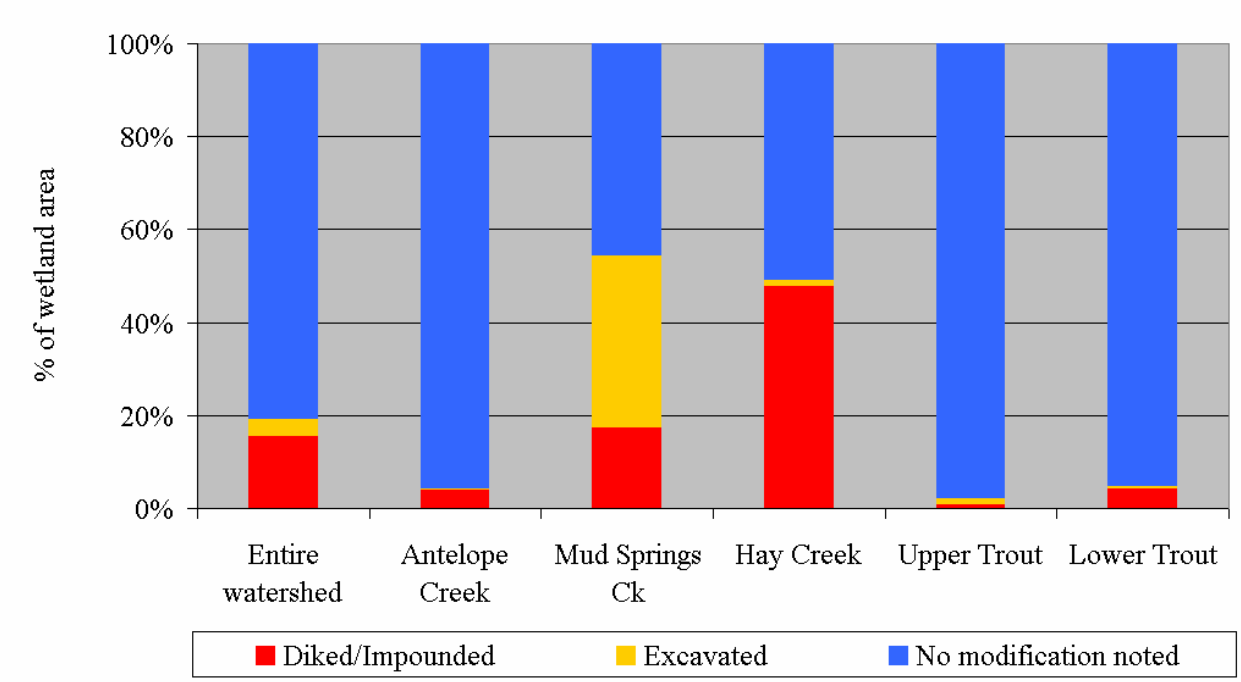


Figure 5-17. Proportion of wetland area identified by the NWI to have been modified due to dikes/impoundments and excavation within the entire Trout Creek watershed (left column) and by subbasin (remaining columns).

Modifications due to dikes and impoundments were identified in 16% of the total wetland area within the watershed, and excavated wetlands made up an additional 4% of the total (Figure 5-17). Among the subbasins, modifications due to dikes and impoundments ranged from 1% of wetland area in Upper Trout Creek to 48% of the wetland area in the Hay Creek subbasin (Figure 5-17). Proportion of wetland area affected by excavation was 1% or less in all subbasins with the exception of Mud Springs Creek, where 37% of the wetland area were affected (Figure 5-17).

5.3.2.4 Wetland loss

The National Wetland Inventory provides a "snapshot" of current wetland conditions within the watershed, and provides some limited information on wetland disturbance (discussed in the previous section), but does not give us any insight on the amount of wetlands that may have been lost due to draining, conversion to cropland, or through natural processes (e.g., changes in climatic conditions). One approach to estimating the area historically occupied by wetlands is by comparing present-day wetlands to the area within the watershed that is classified as having hydric soils. Hydric soils are soils that are, or have been, saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part. If soils classified as hydric do not currently support wetlands they may be areas where wetlands formerly were located.

Two NRCS soil surveys cover the majority of the Trout Creek watershed; the Soil Survey of the Trout Creek-Shaniko Area (NRCS, 1975), and the Soil Survey of Upper Deschutes River Area (NRCS, 1999). Figure 1-11 shows the locations covered by these two soil surveys. The Natural Resource Conservation Service (NRCS) maintains lists of hydric soils associated with each soil survey area within the state (NRCS, 1999b; NRCS, 2000). Four of the mapping units within these two survey areas have been identified as containing hydric soils:

- Fluvents, 0 to 1 percent slopes
- Mixed alluvial land
- Riverwash, and
- Willowdale Loam

Not all of the area within these mapping units contains hydric soils, and not all of the hydric soils necessarily supported wetlands historically. However, this information provides us with an approximation of the extent that may have been occupied by wetlands historically. The area of hydric soils within the Trout Creek watershed is shown in Figure 5-18. Figure 5-19 provides a summary of the potential area of hydric soils compared to the area currently occupied by wetlands.

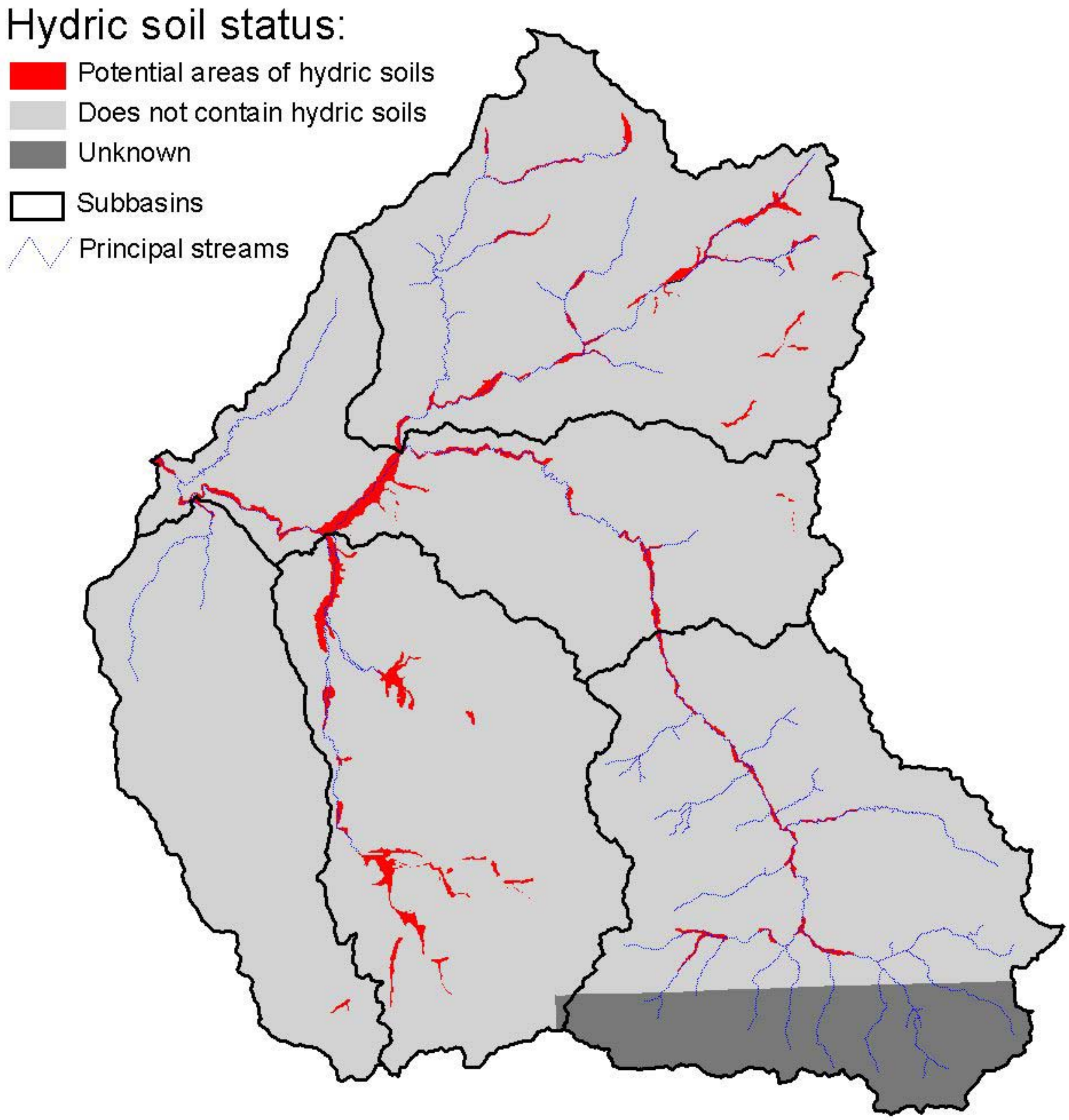


Figure 5-18. Soil mapping units that contain hydric soils within the Trout Creek watershed. Data source: NRCS (2000), NRCS (1999), NRCS (1999b), NRCS (1975).

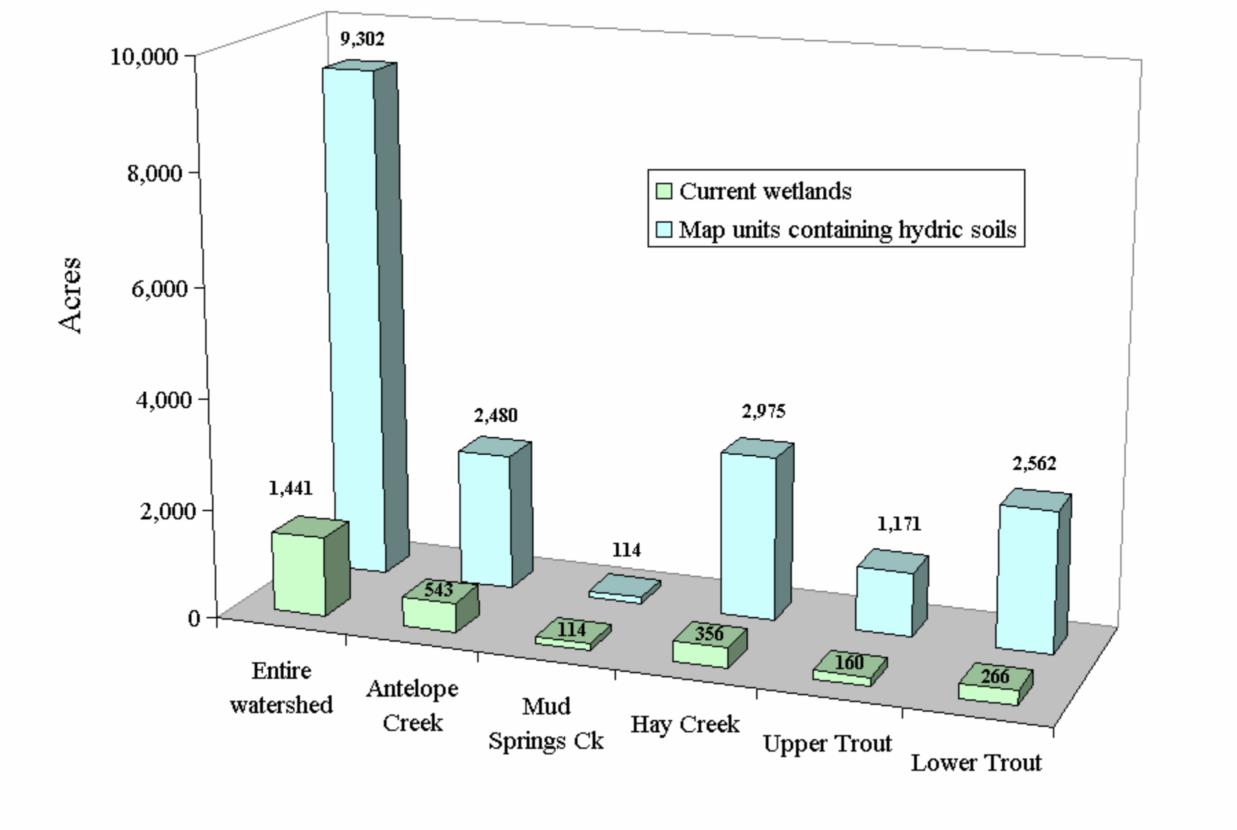


Figure 5-19. Comparison of area occupied by soil mapping units that contain hydric soils and area currently occupied by wetlands for the entire Trout Creek watershed (left hand columns) and by subbasin (remaining columns).

Overall the Trout Creek watershed has approximately 9,300 acres within soil mapping units that contain hydric soils and 1,441 acres currently occupied by wetlands (Figure 5-19). If all of these mapping units historically contained wetlands this would indicate that wetlands currently occupy only 15% of the area that they occupied historically. A comparison of current wetland locations (Figure 5-13) and soil mapping units that contain hydric soils (Figure 5-18) shows that not all current wetland locations are within areas mapped as hydric soils. This is most likely due to the fact that most wetlands are very small in size, and would not be captured at the resolution at which soils are mapped.

Current wetland area as a percentage of hydric soil area ranges from 10% (Lower Trout Creek subbasin) to 22% (Antelope Creek subbasin) for all subbasins with the exception of Mud Springs Creek (Figure 5-19). Data for Mud Springs Creek indicates that current wetland area exactly equals the area of hydric soils (114 acres, Figure 5-19). This result appears to be coincidental, as the area currently occupied by wetlands (Figure 5-13) does not match up with the soil mapping units that contain hydric soils (Figure 5-18). Mud Springs Creek subbasin appears to have an anomalously low area of hydric soils which should be further investigated.

5.4 LIMITATIONS TO RIPARIAN AND WETLAND RESTORATION

Factors limiting the restoration of riparian and wetland areas generally occur on a site-specific basis. Limitations can be divided into those of a technical nature (e.g., will a certain site support the potential vegetation given current soil and hydrological conditions) and those that are related to the personal desires and financial constraints of the landowner and the public. Section 11.1 includes some of the technical limitations that may apply to various potential restoration sites. The discussion here relates to the more significant socioeconomic limitations likely to occur in the Trout Creek watershed.

In some areas it may not be practical to restore sites to their original potential. Examples are areas where large capital expenditures have been made to develop highway and railroad-related structures within riparian, floodplain, and/or wetland areas. However, it may be possible to partially restore conditions to provide some degree of riparian/wetland function. An example might include enhancement of a narrow riparian buffer along a stream segment where a road exists within the riparian area. It may not be practical to relocate the road due to topographic constraints (e.g., narrow valley bottom and steep valley walls), however, the existing riparian buffer may allow enhancement so that some LWM recruitment and stream shading can be restored.

Another significant limitation may be an unwillingness or inability to remove the source(s) of impact(s). Many of the riparian and wetland impacts within the watershed would respond favorably to both active restoration (for example riparian plantings) and passive restoration (allowing areas to return to potential conditions on their own over time), however, this is dependent on removing the sources of impacts that have resulted in degraded conditions in the first place. Landowners may be unable or unwilling to remove these sources of impacts, in most case because of the loss of income that may result. For example, many of the areas in the watershed that may historically have supported wetlands are currently being used as cropland. The landowner may not be able to forgo the use of these lands for agricultural uses because of financial needs. Similarly, it may not be possible to remove the grazing (by domestic stock and/or wildlife) that limits riparian potential in much of the watershed, although compromise efforts such as establishing and maintaining grazing exclosures may provide a workable compromise. In the case of berms and dikes that limit riparian and wetland potential the problem is further complicated by the multiple, and potentially conflicting, desires of multiple landowners. For example, although one landowner may be willing to forgo the perceived flood control benefits of a dike on their property, the adjacent landowner may not.

Certain riparian and wetland impacts are due to multiple causes, and as such will require a comprehensive restoration design and implementation. For example, wetland conditions may be degraded due to a combination of effects such as stream incision and the consequent lowering of the water table that may be due to off-site, upstream, impacts. Along with this there may be limitations on the development of wetland vegetation due to agricultural practices and grazing (by domestic stock and/or wildlife). Restoration efforts focused on restoring the vegetation component may fail without also including efforts to restore the hydrology of the system, both on site (e.g., in-stream structures to raise water tables) and off-site (e.g., elimination of upstream sediment sources). Not only must the overall costs of implementing a comprehensive restoration plan be considered, but also the cooperation of multiple landowners.

5.5 DATA GAPS / RECOMMENDATIONS

The following list of key data gaps and recommendations for enhancement projects are organized separately by riparian and wetland recommendations.

Riparian data gaps / project recommendations:

- Protect riparian areas that are currently in satisfactory conditions from degradation.

Protection of riparian areas that are currently in satisfactory condition should be the highest priority enhancement effort. Although some of these areas are not currently as productive (in terms of riparian function) as expected, these areas generally fall within the range of potential conditions and, if protected, will provide more desirable conditions over time.

- Maintain existing livestock exclosures, monitor their effectiveness in enhancing riparian conditions, and consider expanding the size of certain exclosures.

Existing livestock exclosures that have been constructed within the watershed over the past 15 years appear to be effective in enhancing riparian conditions. These areas should continue to be maintained. In addition, a yearly monitoring program should be implemented to evaluate the effectiveness of these structures in order to justify their continued operation. Monitoring should include an evaluation of the rate of vegetation re-growth within the structures as compared with vegetation conditions outside of the structures (i.e., establishment of control plots). Existing exclosures appear (from the aerial photos) to be narrow in some locations, with only a limited lateral distance for the establishment of vegetation. These areas should be considered for expansion.

- Construct additional livestock exclosures and monitor their effectiveness in enhancing riparian conditions.

The existing program of constructing livestock exclosures to allow for riparian vegetation re-growth should be expanded to cover additional streams within the watershed. In considering areas for future exclosures priority should be given based on four factors: 1) channel sensitivity to inputs of large woody material (LWM), 2) current or potential fish usage of the stream reach, 3) current stream shade, and 4) stream size. Within the Trout Creek watershed, the channels that are most likely to respond to LWM are the "low gradient moderately confined" (LM) and "low gradient small floodplain" (FP3) channel habitat types (CHTs). Together, streams within these two CHT types make up only 19% of the total length of streams included in the assessment; however, these are probably the most responsive to LWM recruitment. Results from the riparian analysis indicate that few of these sensitive reaches currently have satisfactory riparian vegetation. Areas that are more heavily used (or have the potential to be more heavily used) by fish should be prioritized higher than areas that are used less. Areas that currently have low riparian shade should be higher priority areas for enhancement than reaches currently having higher levels of shade. Although all streams are important to aquatic resources it is reasonable to consider that larger sized streams are relatively more important to fish (particularly large-bodied anadromous salmonids), and should be a higher priority for enhancement.

- Investigate and implement removal or setback of bermed/diked areas.

Results from this assessment indicate that the construction and maintenance of flood control dikes has resulted in extensive degradation of riparian conditions, primarily along the mainstem of Trout Creek. All or a portion of these structures should be considered for removal or setback to allow for the development of riparian vegetation. Complete removal would be preferable to allow for natural river function, however, a partial setback from existing locations would allow for some development of riparian conditions while maintaining some level of flood control. Any dike removal or setback will require modification of the soil so as to support riparian vegetation, riparian plantings, and livestock exclosures.

- Investigate and implement, where practical, removal of roads and other infrastructure from riparian areas.

In some areas of the watershed, development of riparian vegetation is limited by the presence of roads and other types of infrastructure (buildings, power lines, and railroads) within the riparian area. In many cases it may not be practical to remove these structures. Most of the roads that are located within riparian areas are in the steeper, headwater portions of the Upper Trout Creek subbasin. Many of these roads are low-standard, low-density, logging roads, some of which may be available for abandonment and removal.

- Enhance riparian conditions in buffers where removal of infrastructure is not practical.

Existing riparian conditions should be enhanced in those riparian areas where it is not practical to remove existing infrastructure. Opportunities for enhancing the narrow buffer areas that exist between the stream and the structure may include livestock exclosure and riparian plantings.

- Enhance riparian conditions in areas where current vegetation is rated as small/sparse/hardwood stands.

Some riparian areas within the watershed currently have vegetation conditions that are below, but close to, potential conditions. Riparian tree sizes within these stands are either smaller than potential conditions, canopy closure is less than potential conditions, or stands are dominated by hardwoods where the potential vegetation is conifer-dominated. In general, stands within this grouping should be protected, and will provide more desirable conditions over time. The most appropriate enhancement technique for these areas is probably to simply let the stands grow (passive restoration).

- Establish riparian buffers along areas of agricultural land use.

Riparian vegetation development is limited in some portions of the watershed where streams are bordered by agricultural lands. These areas have no, or very narrow, riparian buffers between agricultural land and the streams. Opportunities for enhancing these areas would include setback of crop production, riparian plantings, and livestock exclosure.

Wetland data gaps / recommendations:

- Investigate historical extent of wetlands within the watershed.

The current wetland density within the watershed is very low (approximately 0.3% of the watershed area is in wetlands). A comparison of current wetland area to watershed area containing hydric soils indicates that wetlands may have historically occupied up to six times more area within the watershed than they currently do. Further analysis is needed to define the historic extent of wetland area within the watershed.

- Perform functional assessment of wetlands within the watershed.

More information on wetland condition and function is needed in order to identify and prioritize wetland enhancement efforts. It is recommended that a comprehensive wetland inventory and functional assessment be conducted for the watershed. Over 45 wetland inventories have been completed by communities in Oregon. Examples of these inventories, and assistance in developing an inventory for the watershed, can be obtained from the Oregon Division of State Lands. Among the items to be considered in developing an inventory/functional assessment are:

  - What functional assessment technique will be used? Among the methods that should be considered are the Hydrogeomorphic Approach for Oregon (Adamus, 2001), the Oregon Freshwater Assessment Methodology (Roth and others, 1996), the Indicator Value Approach (Hruby et al., 1995), and the Wetland Evaluation Technique (Adamus and others, 1991).

  - What materials are available (e.g., aerial photographs, soil surveys, vegetation surveys, etc.), what additional materials will be needed?

  - What expertise is available in-house? Are there opportunities to use volunteers or college interns? What expertise will need to be contracted?

6.0 SEDIMENT SOURCES

6.1 INTRODUCTION

This section of the watershed analysis presents the results of an inventory and classification of known sediment sources within the Trout Creek Watershed. Sediment production, delivery, transport, and deposition are natural processes that occur in all watersheds. The timing, magnitude, and significance of these processes vary over time and across the watershed. In addition to the natural processes that control sediment production and movement, human activities can alter sediment-related processes in a number of ways.

Erosion processes are quite dynamic and display a wide range of cause and effect relationships. It is not always possible to assign changes in sediment related conditions within the channel to specific events or activities within the watershed. More often, changes to a particular parameter such as the amount of fine sediment within the channel bed are related to natural conditions and changes within the contributing basin. The goal of this portion of the watershed analysis is to determine the primary sources of sediment in the various subbasins, and where sediment production levels are significantly beyond what appears to be background or natural levels, suggest actions which could reduce sediment levels. Excessive stream sediment has been identified as a potential problem by nearly all previous studies of the Watershed. In addition, the mainstem of Trout Creek from the mouth to the headwaters has been 303d listed under the Clean Water Act as water quality limited with respect to sedimentation.

6.2 METHODS

The methods employed to complete this portion of the watershed analysis are found in the Oregon Watershed Assessment Manual (OWEB, 1999). Due to the large size of the basin, some changes to the methodology presented in the manual are necessary. Specific deviations from the methods presented in the Manual are discussed under each of the identified sediment sources. In many cases, changes to the presented methodology are undertaken due to lack of information. For example, the level of detail concerning road related sediment presented in the Manual requires a road inventory or detailed field surveys. Field survey constraints as outlined in the analysis contract and the lack of existing road survey information limit the ability to fully assess the role of roads in the overall sediment picture. As a surrogate for these data, information concerning road miles and crossings associated with water courses are summarized.

Primary sources of information to aid in sediment source identification include 1:24000 USGS topographic maps, aerial photographs, data and reports from the US Forest Service (USFS) and

Oregon Department of Fish and Wildlife (ODFW), Soil Surveys from the Natural Resources Conservation Service (NRCS), miscellaneous reports on Watershed condition and history, and discussions with agency personnel and landowners familiar with current and past basin conditions. Due to budget constraints and private land access, only limited checking of field conditions was undertaken.

6.3 BACKGROUND/GEOLOGY AND SOILS

Before presenting the results of the sediment source investigation, it is worthwhile to review some information concerning the underlying landform features that control sediment production and delivery. This is particularly important in the Trout Creek Watershed, as the geologic and soil conditions in the basin provide an abundant supply of rather fine-grained material that is readily transported to and within the channel network. Part of the challenge in investigating sediment sources in the basin is the recognition that instream sediment levels have likely always been fairly high, and that aquatic species have to some degree adapted to these levels.

Approximately 75% of the Trout Creek basin is underlain by three formations of volcanic rock. The least extensive of these three lies north of Antelope Creek and consists of basalts of the Grande Ronde and Columbia River flows. These formations are capped with shallow soils that are conducive to rapid surface runoff and erosion where slopes are moderate or steep. The other two dominant formations in the basin are the John Day and Clarno formations. The Clarno formation is older and occupies the southern and eastern portion of the Watershed while the John Day occupies the central portion of the basin.

In terms of sediment production, there is not a significant difference between the John Day and Clarno formations (Gordon, pers. comm.). Both are highly weathered and yield large quantities of fine-grained silts and clays. Significant quantities of volcanic ash are also found within these formations, adding to the amount of fine sediment available. Interspersed in these erodible formations are harder lava flows that form the more resistant bedrock outcroppings such as those found in Degner Canyon. The Grande Ronde and Columbia River basalts are less productive from a sediment standpoint. The remainder of the basin is underlain by a mixture of sedimentary deposits, alluvium, and old landslide deposits of varying erosivity.

From the soil perspective, geologic mapping can be used as a rough guide to describe general soil associations. Although many soil series are present in the Watershed, the following discusses the dominant soil series in the region. In the area north of Antelope Creek underlain by the Grande Ronde and Columbia basalts, Bakeoven loams dominate the plateau areas. These are shallow soils with a high erosion hazard where adequate vegetative cover is absent. On steeper slopes, soils have a high gravel component and are mapped as the Lickskillet series. Soils in the Mud Springs subbasin are dominated by deep loams and sands of the Madras and Era series. These soils possess a high infiltration rate and low runoff rate compared to other soils in the Trout Creek Watershed.

In the Upper Trout Creek subbasin, soils are generally moderately deep with high clay content. A one to three foot layer of volcanic ash at the surface is common. On steep areas, soils are much shallower and contain significant quantities of gravel and cobble. The central portion of the Watershed is underlain by soils of the Tub and Simas series. These soils are moderately deep and contain high percentages of clay. In addition, a layer of volcanic ash is widely distributed on the surface, particularly on north and east facing slopes.

6.4 CRITICAL QUESTIONS

In order to guide the assessment, two critical questions were developed during project scoping:

- Where are the significant sediment sources within the watershed?

- Prioritize to the extent possible sediment reduction actions which would have the greatest water quality improvement effect within a 10-year completion deadline?

6.5 RESULTS

The results of the sediment source investigation are organized to address the critical questions.

6.5.1 What are the significant sediment sources within the watershed?

The Trout Creek basin contains a wide variety of sediment sources ranging from unimproved roads to eroding streambanks. The first task in assessing the significance of these sources is to identify possible sediment sources, followed by locating known information concerning the magnitude and extent of the sources, and finally assessing the relative importance of the various sediment sources. In the Trout Creek Watershed, the following sources of sediment are identified.

- Surface erosion from crop and pastureland

- Surface erosion from rangeland

- Surface erosion from forestland

- Mass failures (landslides)
- Roads
- Channel erosion

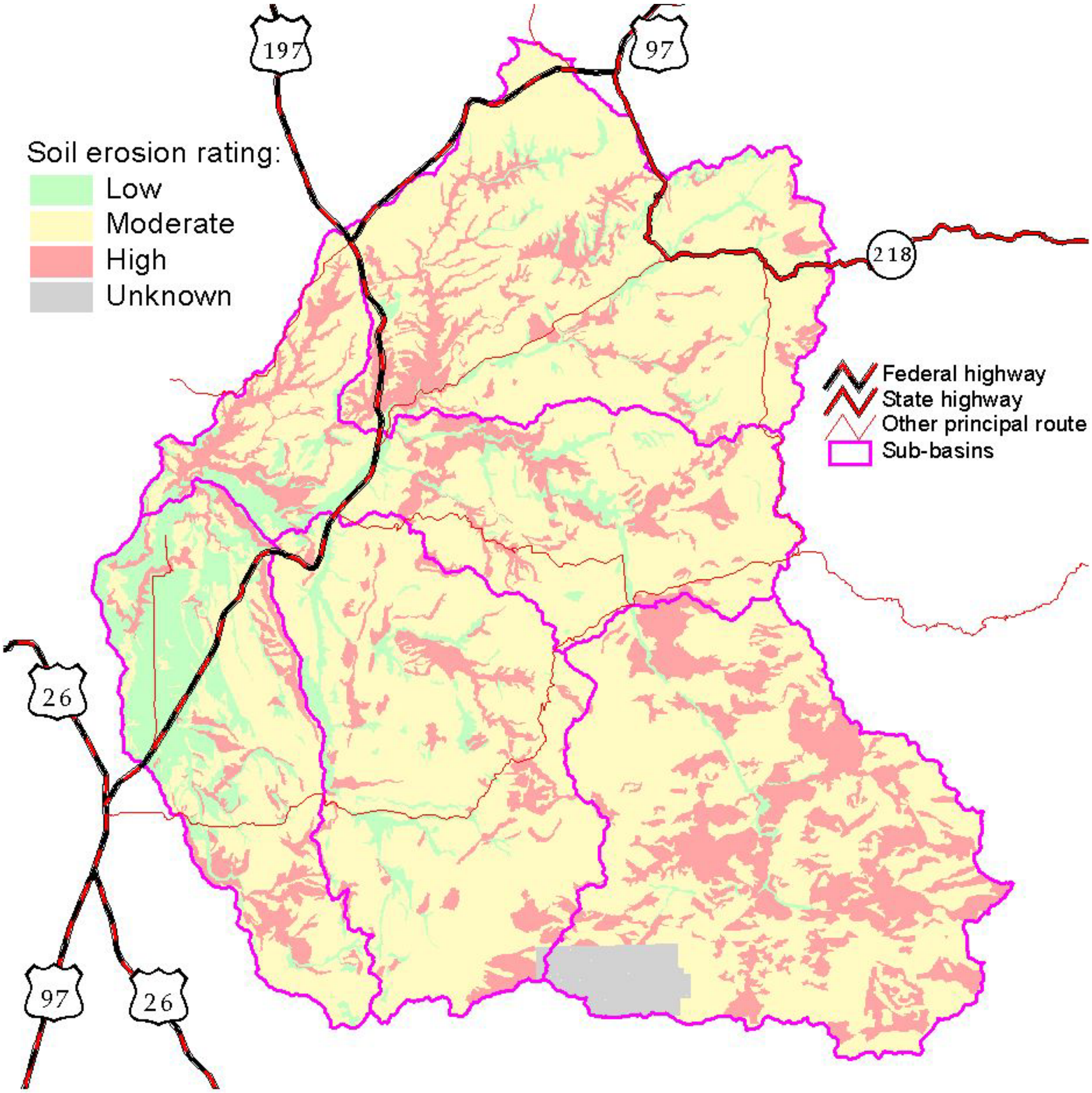
6.5.1.1 Surface erosion

Surface erosion includes soil lost from the land surface from wind and overland flow and sheet and rill erosion. The following discussion breaks surface erosion down by the different land use categories, as the process of identifying erosion hazard areas is slightly different for each land group. As of 2002, areas burned in the 1996 fire are not considered a significant sediment source (Nelson, pers. comm.). As noted below, information regarding surface erosion is scarce or unavailable for much of the Watershed. The lack of information for rangeland in particular is considered one of the key data gaps in the assessment. In lieu of data concerning actual surface erosion rates, erosion potential is used as a surrogate for actual erosion. The Watershed is broken down into areas of low, moderate, or high erosion potential based primarily on soil type and land slope. Within each land use description that follows, more detail is presented concerning what information is used to assign erosion potential. Table 6-1 presents the square miles of each erosion hazard class for the subbasins. Figure 6-1 displays the erosion hazard classes for the Watershed.

Table 6-1. Soil erosion hazard in square miles.

Erosion Hazard	Antelope Creek	Mud Springs Creek	Hay Creek	Upper Trout Creek	Lower Trout Creek	Entire Watershed
Low	8.9	31.6	10.6	3.5	12.9	67.4
Moderate	123.3	46.1	108.9	114.5	88.4	481.2
High	25.2	15.0	18.5	58.7	26.5	143.8

Figure 6-1. Surface soil erosion hazard.



6.5.1.2 Surface erosion from crop and pastureland

Crop and pastureland make up a relatively small portion (approximately 5 percent of the basin) of the Trout Creek Watershed (NRCS, 2000). Unlike other portions of the basin, however, there is some information available as to the relative soil loss from these lands. The NRCS has undertaken a program though their National Resources Inventory to estimate sheet and rill erosion from these types of lands using the Universal Soil Loss Equation. This equation was developed for cropland and utilizes factors such as precipitation, soil erosivity, slope angle and length, and vegetative cover to estimate erosion.

The most current information for the subbasins within the Deschutes Watershed is from 1997. These data indicate that soil loss from managed lands in the Trout Creek Watershed is within the moderate range when compared to other Deschutes subbasins (NRCS, 2000). When scrutinized further by land use, however, it appears that the soil loss from pastureland in the Trout Creek Watershed is significantly higher than other Deschutes subbasins. Given that the error estimate assigned to these data is approximately 50 percent of the value of soil loss, it appears that sample size or other factors may be influencing the reported high soil loss rate for pastureland. If this is the case, then overall soil loss/acre from crop and pastureland in the Trout Creek Watershed may be low to moderate when compared to elsewhere in the Deschutes basin.

The actual data generated by this NRCS program are tentative and not presented here. At this point, data can be used for comparative purposes, but using them in a strictly quantitative fashion is not recommended (Tilton, pers. comm). It should be noted that the equation employed to estimate soil loss was originally developed solely for soil loss from managed lands and does not reflect soil delivery to the stream channel. It can however, give us some qualitative estimate as to how managed lands in the Trout Creek Watershed compare to other local basins with respect to soil loss.

Similar to that described for rangeland below, soil series and phase (NRCS, 1970) are utilized to assign a soil erosion hazard rating to crop and pastureland. This information is mapped on Figure 6-1.

There are two programs administered by the NRCS in the Watershed that involve landowners and can affect sediment production. The first is the Conservation Reserve Program that covers about 5600 acres in the Watershed, primarily in the Antelope Creek and Lower Trout Creek subbasins. This program assists landowners in establishing vegetation on highly erodible lands and has been shown to dramatically reduce soil loss in the Deschutes basin (NRCS, 2000). The second program is the development of Resource Management Plans (Farm Plans) for specific landowners. This program addresses primarily upland and rangeland areas and is therefor discussed in the following section covering rangeland.

6.5.1.3 Surface erosion from rangeland

Rangeland is the dominant land use within the Trout Creek Watershed. Unfortunately, there are no data available that quantify soil loss or delivery from rangeland in the Trout Creek Watershed. While studies of rangeland soil loss have taken place in other areas of the West, application of these data to specific basins is unwise. Variability in basin specific factors such as soil type, landform, climate, vegetation, and range condition preclude universal or regional estimates of soil loss from rangeland. Given this, estimates of soil loss and delivery from rangeland in the Trout Creek Watershed remains one of the larger data gaps in the analysis process.

The basin has been utilized for over 100 years to support livestock operations of varying size and grazing practice. While certain soils such as those with high ash content in the upper horizons have always been subject to surface erosion; there can be little doubt that grazing by livestock and wildlife has affected erosion processes within the basin. Improper grazing practices have been shown to increase soil compaction, reduce streambank stabilization, and increase sediment delivery to streams (Platts, 1981). In addition to grazing impacts, encroachment of juniper has led to a decrease in grass and forb cover (Peplin, pers. comm.). Without sufficient vegetation, the fine-grained soils of the basin are extremely susceptible to surface erosion.

As stated in the crop and pastureland discussion, many landowners are working with the NRCS to develop and implement Farm Plans to improve range condition. Approximately 75% of the landowners along the mainstem from the mouth to the USFS boundary are working with the NRCS to develop and implement these Plans (Peplin, pers. comm.).

After the floods of 1996 and early 1997, there has been a marked increase in interest by landowners in developing Plans and improving land management activities with respect to surface erosion. While the information in the Plans is not available to the public, Plans do address sediment reduction efforts and range condition. One of the most common activities associated with the Plans is the installation of water/sediment control basins in upland areas. These basins, estimated to be over 50 in number, are placed in draws in order to capture sediment, promote infiltration, and reduce surface runoff (Peplin, pers. comm.). Additionally, livestock and grazing management practices are changing with a resultant improvement in overall range condition. While there is considerable variability, overall range condition in the basin is described as fair (Peplin, pers. comm.). Many riparian areas, however, are in poor condition (Middle Deschutes Local Advisory Commission, 2001).

Resource professionals familiar with general range condition and soil properties in the Trout Creek and adjoining watersheds were contacted in an effort to determine, at least a relative sense, the location of highly erosive areas (Repp, Peterson, Clark, Weinheimer, pers. comm.). The initial effort at mapping highly erosive lands using the NRCS Highly Erodible Lands listing is deemed too general as nearly all soil types mapped in the Watershed are listed as highly erodible. After consultation with the resource experts, the analyst charged with determining sediment sources utilized the erosion hazard listing by soil type and phase from the NRCS soil surveys for the region to assign a low, moderate, or high erosion hazard listing to each soil type polygon. The results are combined with the forest erosion hazard information to produce Figure 6-1. While this map presents erosion hazard and not actual erosion activity, it does give a picture of where the most susceptible lands are located.

6.5.1.4 Surface erosion from forestland

Surface erosion from forestland is primarily in the form of sheet and rill erosion and is controlled by many factors, including precipitation intensity, soil compaction, slope, vegetative cover, and the inherent erodibility of soil particles exposed to erosive forces. While high intensity storms have always had the capability to produce surface runoff and attendant erosion, land management activities within the forested regions of the upper Trout Creek basin have affected soil conditions and vegetative cover to the degree where surface erosion characteristics have been altered. The following few paragraphs describe mapping of inherent soil erosion potential for the forestland within the Watershed. This is followed by a discussion of potential impacts to surface soil erosion processes associated with forestland management activities.

The best available information concerning soil erosion potential from forestland within the Ochoco National Forest is found in their Soil Resource Inventory (USFS, 1977). This inventory utilizes primarily slope and soil type to assign a rating of low, moderate, or high soil erosion hazard to lands within the Forest. This information has been captured in a GIS file and combined with soil erosion information for the remainder of the Trout Creek Watershed to produce Figure 6-1. As depicted on this map, the majority of forestland within the National Forest is rated moderate with respect to erosion hazard. High erosion hazard areas are concentrated in upper and central Dutchman Creek and in Upper Trout Creek. Smaller areas of high erosion hazard are found in Upper Potlid and Auger Creeks.

Erosion hazard information for the forested portions of the Upper Trout Creek subbasin located west of the Ochoco National Forest lands is available from the NRCS State Soil Geographic (STATSGO) Data Base (NRCS, 2001a). This information is compiled at a 1:250,000 scale as compared to soil information for the remainder of the basin which is compiled at the 1:24,000 scale. As such, information for this area is likely to be less accurate than that for elsewhere in the basin. In addition, erosion hazard is not defined in the database. Based on information in the Trout Creek-Shaniko Area Soil Survey (NRCS, 1970) which covers the majority of the remainder of the Trout Creek Watershed and conversations with local NRCS staff, it was determined to assign low, moderate, and high erosion hazard ratings to this region based on land slope. While this may result in some inaccuracies, it provides a general rating consistent with that applied elsewhere in the basin. For areas within the STATSGO mapping whose slope is 0-10 percent, a low erosion hazard is assigned, a moderate rating is assigned to slopes between 11 and 30 percent, and a high rating is assigned to those areas whose slope is over 30 percent.

For the forestland outside of the National Forest and STATSGO mapping, soil erosion hazard is assigned and mapped based on information provided by the Trout Creek-Shaniko Area Soil Survey (NRCS, 1970). This assignment of low, moderate, or high hazard is similar to that described for pasture and rangeland. While Figure 6-1 provides useful information regarding the location of potentially erosive soils, it does not provide information as to the current state of surface erosion on forestland. Timber harvest, grazing, and other activities can alter soil properties and erosion rates. While it is beyond the scope of this Watershed Assessment to quantify changes that may have occurred, there is enough anecdotal information from previous studies to gain some insight as to the type and general degree of changes which may have occurred.

From 1950 to the mid 1970's logging activity increased dramatically on forested regions of the basin and the much of the existing road system was developed. Nearly all of the logging was done with tractors or other ground based equipment. This type of equipment generally results in soil compaction of between 25 to 33% of the area logged and likely produced a soil surface compacted beyond the natural range of variability (USFS, 1995). Beginning in the late 1970's, timber harvest on USFS land employed more cable yarding systems, with 60 to 70% of the area logged between 1978 and 1995 utilizing cable systems (USFS, 1995). These systems tend to result in significantly less soil compaction and resulting overland flow. Current timber harvest practices on private lands have improved over time with respect to sediment production. This has resulted from better siting of skid trails, lower pressure vehicles, and establishment of Riparian Management Areas (Perkins, pers. comm.).

In addition to timber harvest activities, grazing can alter erosion process through compaction of upland and riparian areas as well as increase stream bank erosion through trampling and removal of riparian vegetation. Although no quantitative data are available for Trout Creek, much of the riparian damage associated with livestock in a stream in the Crooked River basin likely occurred prior to 1900 (Buckley, 1994). Due to historic grazing pressure, this statement may apply to much of the Trout Creek Watershed as well.

The USFS Watershed Analysis for their lands in the Upper Trout Creek subbasin estimated in 1995 that 90 to 95% of riparian areas received "heavy impacts" from livestock (USFS, 1995). This document states that many areas are currently recovering, but the rate of recovery is variable. Another factor related to improvement in erosion rates and riparian recovery could be the switch from cattle to sheep grazing on USFS lands which occurred in 1990. In addition, riparian fencing of many of the creeks on both private and Federal land has allowed for establishment of more robust vegetative cover. A complete discussion of fencing can be found in the channel modification section. Finally, localized impacts from recreational activities such as off-road vehicle use can increase the erosion potential.

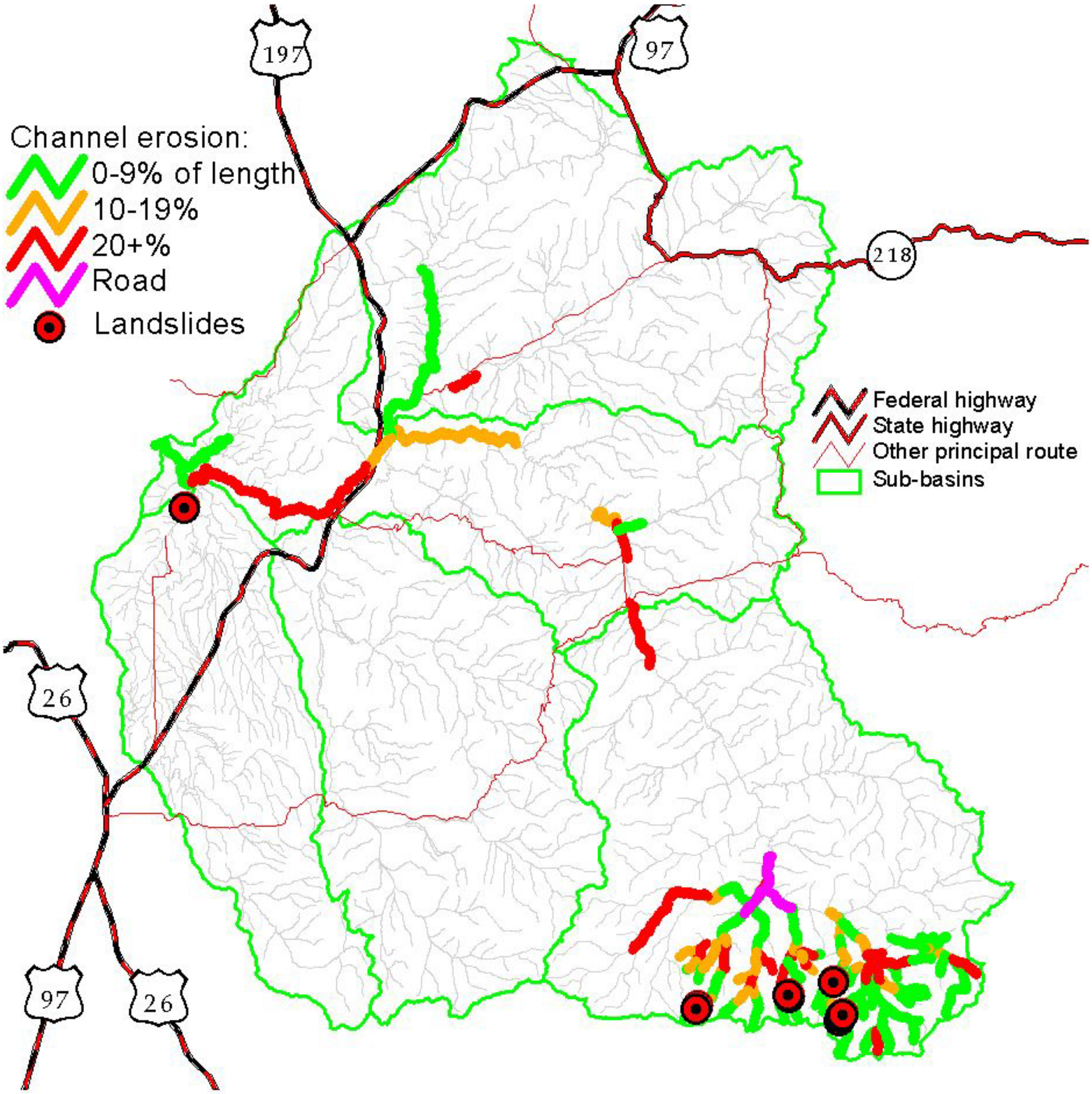
6.5.1.5 Mass failures

Mass failures, either naturally occurring or associated with land management activities can deliver significant amounts of sediment to stream channels. A basin-wide inventory of mass failures is not available. Considering the general propensity for failures to occur on steep slopes (Turner and Schuster, 1996) and/or areas where loss of root strength associated with vegetation removal, mass failures are most likely to occur in the Upper Trout Creek subbasin. Based on slope alone, the Foley Creek basin has been identified as having the highest potential for mass failures due to the higher percentage of slopes in the 30-50% range (USFS, 1995).

The Trout Creek Watershed Analysis for USFS lands indicates there is evidence of historic slides on steep slopes underlain by soils consisting of ash and relic landslide debris (USFS, 1995). This land type (based on soil type) occupies approximately 27% of the Upper Trout Creek subbasin. It should be noted, however, that these relic slides occurred during periods of much higher precipitation when soil pore pressures were likely more conducive to slide initiation. In the 1995 Watershed Analysis, these slides were considered largely inactive (USFS, 1995). The geologist for the Ochoco National Forest, however, has noted indications of increased slide activity throughout the Trout Creek Watershed (Gordon, pers. comm.). She stated that other geologists working in central Oregon have noticed this trend, but no quantification of this theory has taken place. It is possible that as we enter a wetter climatic cycle, elevated groundwater levels may reactivate some dormant slides.

At this point, the USFS does not have an inventory of slides for their lands in the Upper Trout Creek subbasin (Gordon, pers. comm.). Within the next year, it is anticipated that landslide mapping efforts for the National Forest portion of the Trout Creek Watershed will be complete. The only inventory available for the Watershed is part of a statewide effort to categorize mass failures associated with four large storms occurring in 1996 and early 1997 (Hofmeister, 2000). The largest of these storms corresponded to an approximate 25-year event (Seymour, pers. comm.). This inventory lists eight slides in the Upper Trout Creek subbasin and one in the lower Mud Springs Creek subbasin. The location of these slides is shown on Figure 6-2 along with channel erosion information. Of the eight slides in the Upper Trout Creek subbasin, eight are in the Potlid Creek drainage, while Cartwright and Big Log Creeks have eight slides each. No information is available regarding slide type, size, or sediment delivery to the stream network. Discussions with the USFS geologist for the Ochoco National Forest indicate that currently, mass failures do not appear to be major suppliers of sediment to stream channels (Gordon, pers. comm.).

Figure 6-2. Channel erosion and mass failures.



6.5.1.6 Sediment from roads

In some watersheds, particularly those with a high density of roads in steep terrain, sediment delivery from roads can be a significant contributor to the overall sediment picture. The Trout Creek Watershed contains a well-developed road system, with a wide variety of road ages and types. An effort was made to determine if any road inventories with respect to stability and sediment have been conducted in the Trout Creek Watershed. Unfortunately, no such inventory exists at this time.

Within the next few months, however, the Ochoco National Forest will be finishing a roads analysis for a number of road systems on Forest Service land (Kubitza, pers. comm.) The focus of the analysis will be main "arterials" and not on smaller collector and local roads. While there are no arterial roads within the Trout Creek Watershed, the USFS will include in the evaluation approximately 33 miles of roads within the Trout Creek Watershed. Approximately one-half of these road miles are on the 2720 road that runs east-west through the upper portions of Auger, Trout, and Potlid Creeks. One of the goals of the USFS road analysis is to identify road related sediment problems and recommend solutions.

While road generated sediment has not been quantified in the basin, road associated sediment levels in the Upper Trout Creek subbasin are highest during periods of greatest road use. This occurs in relation to specific activities such as timber sales, hunting pressure, and road maintenance. On USFS lands, most roads are bladed every three to four years, with higher traffic roads such as the 2720 and 2730 road bladed every year (Kubitza, pers. comm.). While no specific problems related to general road instability in the Upper Trout Creek subbasin have been identified, the sediment contribution from unstable roads is unknown.

Given the overall lack of information concerning road sediment contribution in the watershed, a general assessment of the road system was undertaken. The first step in analyzing the importance of road related sediment is the development of a road layer for the project GIS database. The road layer is from the Bureau of Land Management (BLM) "Ground Transportation" layer dated June 8, 2001 with coverage at a 1:24,000 scale. Table 6-2 presents the miles of road within each of the subbasins.

Table 6-2. Miles of road

	Antelope Creek	Mud Springs Creek	Hay Creek	Upper Trout Creek	Lower Trout Creek	Entire Watershed
Miles of Road	209.9	262.0	219.6	430.0	209.8	1331.3

Road sediment production and delivery involves many factors and processes including road surface, width, profile, maintenance practices and use level, and proximity to a stream channel. In order to determine actual road sediment contribution, each of these factors must be evaluated for each road segment. Unless this information is available, intensive field analyses beyond the scope of this Watershed Analysis are necessary. In order to estimate the relative importance of road sediment contribution within each of the subbasins, a number of assumptions are made.

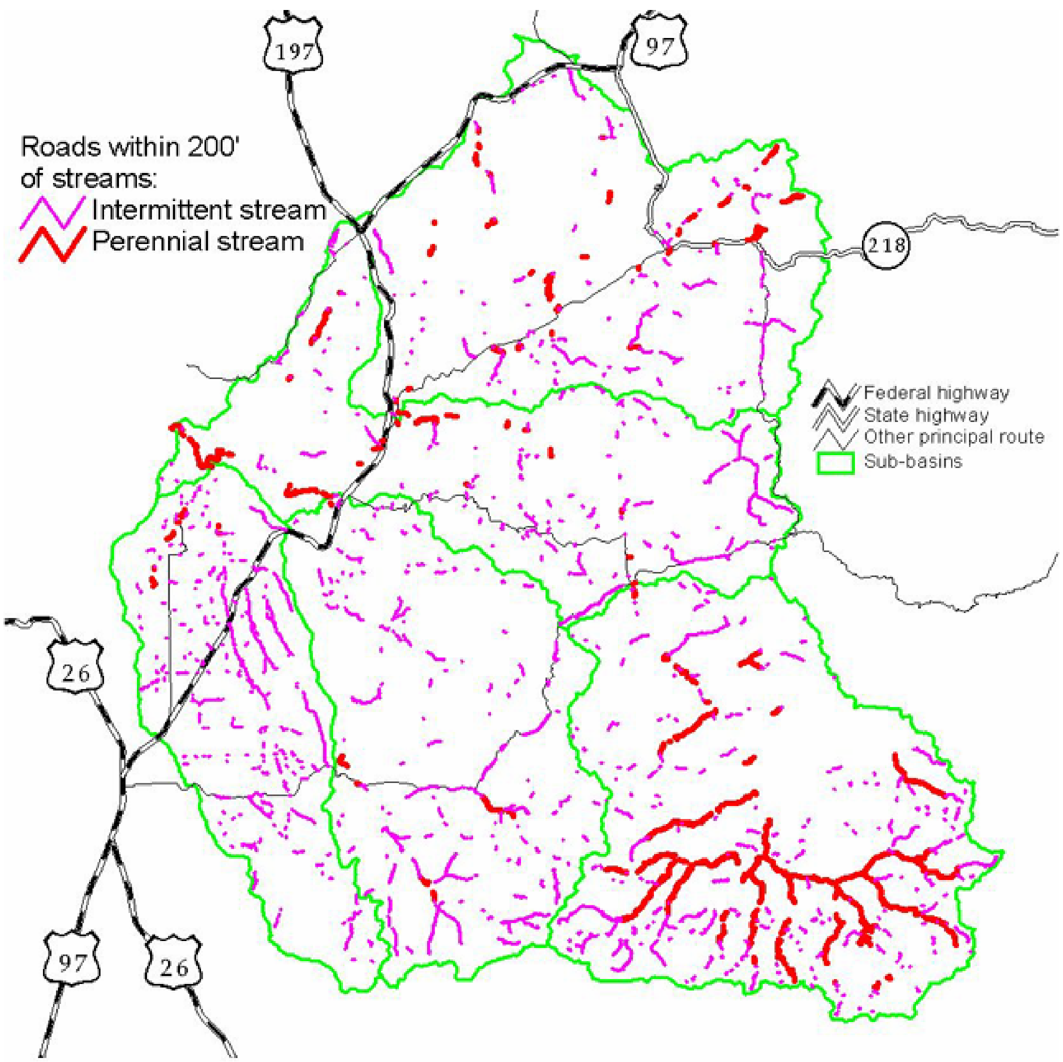
The first assumption deals with road surface and consists of combining all unpaved road surfaces into a single "unpaved" category. Obviously, there is considerable variability within this category, as gravel and rocked roads contribute considerably less sediment than dirt or native surface roads. All trails, paved roads, and closed roads are removed from the database under the assumption that these features would not likely produce significant quantities of sediment. Additionally, it is assumed that the greatest amount of sediment would be delivered from those road segments that are within 200 feet of a stream. While variation in this 200-foot distance will no doubt occur, it has been used as a logical "break point" to identify the road segments responsible for the bulk of sediment delivered (Seymour, pers. comm; OWEB; 1999, Washington Forest Practices Board, 1997).

Based on these assumptions, Table 6-3 presents the relative amount of unpaved road likely to introduce sediment to the stream network during periods of road runoff. Figure 6-3 displays the location of these road segments. Road mileage is further broken down into those segments draining into ephemeral versus perennial stream channels. This is done to recognize that sediment delivered to perennial streams would be immediately available for transport (if stream power is sufficient), while sediment delivered to ephemeral streams is less likely to be transported immediately, and may in fact be stabilized by vegetation.

Table 6-3. Unpaved road miles within 200 feet of a stream.

	Antelope Creek	Mud Springs Creek	Hay Creek	Upper Trout Creek	Lower Trout Creek	Entire Watershed
Intermittent Stream	29.5	50.3	47.7	64.1	37.6	229.2
Perennial Stream	9.1	1.4	2.9	57.5	8.9	79.8
Total	38.6	51.7	50.6	121.6	46.5	309.0

Figure 6-3. Unpaved road segments within 200 feet of a stream channel.



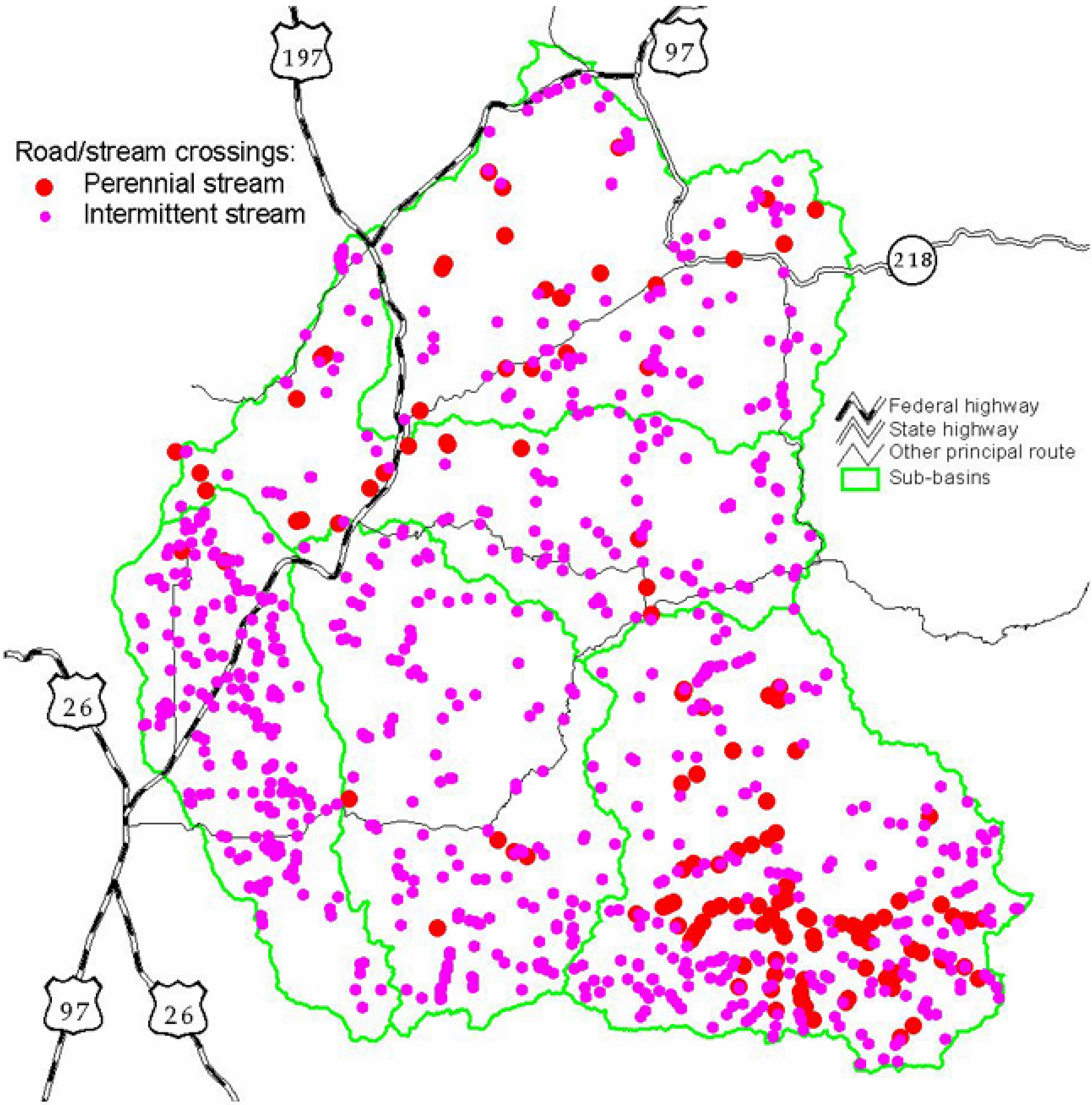
Based on the information provided in Table 6-3, the Upper Trout Creek subbasin has the greatest opportunity to provide road related sediment to the stream network. Approximately 72% of the road miles within 200 feet of perennial streams are located within the Upper Trout Creek subbasin. While trying to rank individual road segments as to the quantity of sediment delivered would require a road inventory, one section of road has been identified as producing and delivering a relatively high percentage of sediment (Nelson, pers. comm.). This 2.8 mile section of road is shown on Figure 6-2 and consists of approximately 0.9 miles of road along lower Foley Creek and approximately 0.9 miles of road along Trout Creek both upstream and downstream of the Foley/Trout Creek confluence.

Without a road inventory to estimate the relative sediment contribution of roads, the second analyses undertaken using the road GIS layer is to determine the number of stream crossings by unpaved roads. The assumption being that at each stream crossing, sediment generated by the road at a stream crossing, is very likely to enter the channel network. As with roads within 200 feet of the stream, information on road crossings is partitioned according to whether a stream is perennial or ephemeral. Table 6-4 presents the results of the road crossing information while Figure 6-4 presents the location of road crossings.

Table 6-4. Number of stream crossings by unpaved roads.

	Antelope Creek	Mud Springs Creek	Hay Creek	Upper Trout Creek	Lower Trout Creek	Entire Watershed
Intermittent Stream	96	192	164	261	109	822
Perennial Stream	20	2	6	89	18	135
Total	116	194	170	350	127	957

Figure 6-4. Stream crossings by unpaved roads.



As expected, the Upper Trout Creek subbasin contains the greatest number of road crossings, with approximately two-thirds of the crossings of perennial streams. Overall, Antelope Creek has relatively few road crossings and roads near channels, and would thus be unlikely to have significant quantities of road generated sediment delivered to the channel network.

Based on this road information, it appears that the Upper Trout Creek subbasin possesses the highest potential for road related sediment production and delivery. Actual delivery, however, may not be commensurate with the relatively high road density due to road maintenance practices within the headwater portions of the subbasin. The USFS has taken a number steps to reduce road sediment production and delivery in this area (Kubitza and Gordon, pers. comm.). Within the last six years, the USFS has closed approximately 19.3 miles of road and obliterated approximately 19.6 miles of road in the Upper Trout Creek subbasin (USFS, 2001). In addition, nine culverts were replaced to improve both fish and flow passage and reduce erosion. Three culverts in the Auger Creek subbasin were removed (USFS, 2001). While it is limited in the miles of road addressed, it is anticipated that the roads analysis scheduled for completion by the USFS in the spring of 2002 will contain additional recommendations for sediment reduction activities.

6.5.1.7 Channel erosion

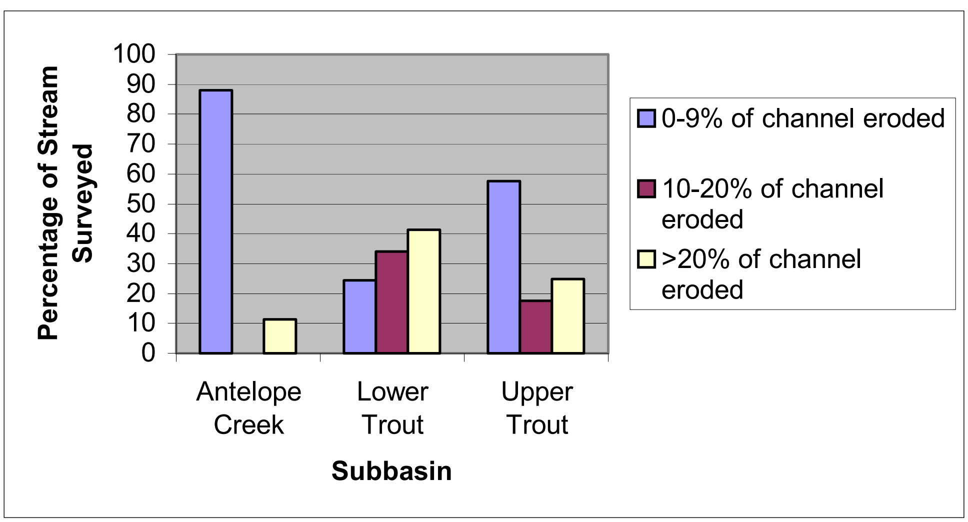
Channel erosion refers to sediment removed from the bed and banks of the channel as flows change and streams migrate laterally or incise vertically. Channel erosion is a natural process and can result in improved aquatic habitat conditions through the addition of spawning gravels and creation of refuge sites in the form of undercut banks. Excessive channel erosion, however, is extremely detrimental to the aquatic system. If the channel downcuts, nickpoints and headcuts may develop, possibly isolating the stream from its floodplain and lowering groundwater levels in adjacent riparian areas. If bed material is resistant, the stream will erode channel banks, resulting in a wide, shallow stream susceptible to increased solar input and heating. In addition, instream habitat complexity is reduced as pools become less frequent and shallower. In many cases, channel erosion adds excessive amount of fine sediment, resulting in fining of the channel bed and reducing the quality of spawning gravels. Numerous past studies in the Trout Creek Watershed have identified channel erosion and associated impacts as a major problem in the Watershed (Middle Deschutes Local Advisory Committee, 2001; USFS, 1995; Edlund and Penhollow, 1996; Northwest Biological Consultants, 1984). In addition, land owners have identified channel erosion as a high priority on a watershed wide basis (Graves, n.d.).

As stated, some channel erosion and bank cutting is expected, particularly in basins that experience a wide range of flows. The question then becomes one of determining when the process has gone beyond what might be considered outside of the natural range. The USFS has set a desired goal of no more than 10 % of the length of any stream reach will be considered to have eroded banks (USFS, 1995). The ODFW has also set this same goal for Trout Creek (Edlund and Penhollow, 1996).

Information concerning channel erosion is available from two major sources. The first of these is the 1995 Forest Service Watershed Analysis (USFS, 1995). Approximately 90% of the mapped streams on USFS land were surveyed in 1992, with information recorded as to amount of bank erosion rated as 0-10%, 10-20%, or over 20% of the channel. For streams outside of USFS lands, the ODFW records the percentage of eroding banks as part of their habitat inventory surveys. The most current data are from field surveys undertaken in the summer of 1998, and cover many of the Upper Trout Creek tributaries below USFS land as well a scattered reaches in the Trout Creek mainstem near Ashwood and Willowdale. Data for Ward Creek are also available. Figure 6-2 displays the location and severity expressed as percent of bank eroded from these surveys.

A total of approximately 108 miles of stream channel have been assessed for bank erosion, with the majority (68%) of the stream miles assessed located in the Upper Trout Creek subbasin. In order to present the bank erosion data in the most useful format, Figure 6-5 displays for each subbasin the percentage of stream miles assessed in each of the three bank erosion classes.

Figure 6-5. Channel erosion as a percentage of stream miles surveyed.



As indicated by Figure 6-5, all three subbasins surveyed exceed the goal of less than 10 percent of stream length eroded. In the Lower Trout Creek subbasin, over 75% of the streams surveyed had erosion problems over the 10% threshold, with over 40% of the reach miles surveyed displaying bank erosion over at least 20% of the length of the channel. While one can question the applicability of the 10% threshold to nonforested areas, it appears that bank erosion is a major concern in most of the areas surveyed. Based on the distribution of the eroded segments, it is likely that channel erosion is of concern in all channels except tightly confined bedrock reaches such as Ward Creek.

One of the questions these data invite is how channel erosion has changed over time. Is this pervasive channel erosion a natural occurrence, and how would these data compare with historical information about channel condition? Unfortunately, no comparable historical data concerning bank erosion could be located. For comparison, some data are available from 1984 where of the 40 stream reaches assessed, bank erosion was specifically identified in 19 reaches (Northwest Biological Consultants, 1984). The severity of the erosion was not noted.

6.5.2 Prioritize to the extent possible sediment reduction actions which would have the greatest water quality improvement effect within a 10 year completion deadline?

In order to prioritize actions that would be most beneficial with respect to sediment reduction, it is necessary to summarize the key sediment sources for each of the subbasins. The following discussion presents by subbasin the important sediment sources and actions that would be most effective in reducing sediment levels in the aquatic system.

6.5.2.1 Antelope Creek

Mass failures are not likely to be a significant sediment source in the majority of the Antelope subbasin. Given the steep canyon reaches of Ward Creek, delivery of sediment through dry ravel processes likely occurs, but the relatively good quality of fish habitat in this creek suggests that delivery is not excessive. In the remainder of the Antelope Creek subbasin, channel erosion and downcutting is an obvious source of sediment. In some reaches between Ward Creek and the town of Antelope, the channel has downcut 20 to 30 feet, with bank failures delivering a significant quantity of sediment to the channel. Much of the sediment is transported and deposited in the low gradient reaches of Trout Creek in the Willowdale area, exacerbating channel erosion problems in that area. While the limited fish use of most of the Antelope basin suggests that restoration efforts might be of greater benefit in the Trout Creek subbasins proper, control of channel erosion between the town of Antelope and Ward Creek would reduce sediment production and delivery to lower Trout Creek. Channel erosion conditions above the town of Antelope are unknown, but severe downcutting at the town suggests that channel erosion may also be a problem upstream. Control of channel erosion requires site specific information regarding channel and riparian conditions, but is likely to include riparian planting to improve bank root strength and grazing management practices that reduce trampling and destruction of riparian vegetation. Upland structures and vegetative cover to control sediment and flow would also help to reduce channel damage in the mainstem of Antelope Creek.

6.5.2.2 Hay Creek/Mud Springs Creek

Little information is available on sediment sources in these two basins. Low flows, channelization, and passage barriers limit fish use and resource diversity as well as past resource investigations. Based on topography and geology of the basins, sediment contributions from mass wasting and the road system are likely not significant. Dry ravel (rock slides) and shallow slides may contribute sediment to Wilson Creek in the Hay Creek subbasin.

Based on limited field investigation, it appears that the primary sources of sediment in these basins are channel erosion and surface erosion from range and pastureland adjacent to the channel. A number of channel segments in the upper Hay Creek above and below Brewer reservoir have downcut 5 to 10 feet, and possess nearly continuous eroding banks. In some cases, vegetation is becoming established in the new floodplain along the floor of the entrenched channel.

Due to the limited flow and aquatic habitat available in these basins, time and resources to control channel incision and associated problems might be better spent elsewhere in the Trout Creek Watershed. If efforts specific to Hay and Mud Springs Creeks were undertaken, riparian planting and control of livestock within the riparian zone would likely yield the greatest benefits to water quality. In addition, adapting grazing management practices that limit soil compaction and installation of sediment/flow basins in upland areas would be beneficial.

6.5.2.3 Upper Trout Creek

A wider range of sediment sources exists in the Upper Trout Creek subbasin than in the other subbasins. Although unquantified, sediment generated and delivered from the road system may be significant based on the prevalence of road crossings and valley floor roads. Surface runoff from compacted forestland may also be contributing significant sediment. Channel erosion, particularly in the Foley Creek drainage is identified as a problem. Unlike elsewhere in the Watershed, much of the Upper Trout Creek subbasin falls under one ownership, the USFS. This has allowed for some coordinated efforts to reduce sediment production, including road closures, culvert improvements, grazing adjustments, and improvement in timber harvest techniques. Similar to elsewhere in the Watershed, conditions with respect to soil loss appear to be improving. Maintenance of grazing management practices, sediment and flow control basins in ephemeral streams to stagger flood flows, and improved road condition and maintenance practices should be given high priority in this subbasin.

6.5.2.4 Lower Trout Creek

Based on the limited sediment source data available, it appears that the Lower Trout Creek subbasin has the highest percentage of eroded channels within the Trout Creek Watershed. Sediment generated within the channel and from riparian areas adjacent to the channel is likely a major sediment source. Sediment from erosion of the berms constructed in the mid 1960's adds to the problem. While considerable efforts have been undertaken to control bank erosion in the form of juniper rip rap and other instream projects, additional efforts identifying and addressing those areas where bank erosion is most severe should be undertaken. The relative success of the juniper bank protection efforts indicates that this type of activity could be applied elsewhere in the basin. This would include the Willowdale area, the area between Degner Canyon and Ashwood, and the area from Ashwood to Amity Creek. Erosion control measures should be part of a larger effort to improve channel conditions and restore geomorphic processes that have been altered by berming and other activities. A more complete discussion of this subject can be found in the recommendations section of the Channel Habitat Type chapter. As suggested for the other subbasins, upland activities to control sediment movement and reduce the "flashiness" of runoff events are highly recommended. Where these activities have been undertaken as part of Farm Plans, they have been successful in reducing resource damage. Juniper control efforts would also improve range condition through the increase in grass and forb cover.

6.6 DATA GAPS / RECOMMENDATIONS

The reply to the second critical question provides a summary of key sediment sources and the general types of activities that should help reduce sediment levels within the aquatic system. The information presented in this section identifies the primary sediment source data gaps and makes recommendations concerning those gaps.

- Investigate the sediment contribution from rangeland

The primary recommendation is to determine the role of rangeland in sediment production. While it is understood that range condition information is not a public matter, the fact that it remains an unknown with respect to sediment generation will continue to raise concern when trying to address resource issues in the basin.

- Investigate the sediment contribution from roads

While road related sediment contributions have likely declined over time due to road closures, culvert replacements, and better road maintenance efforts, the role of roads in the overall sediment picture is unknown. After the USFS completes their road analysis this spring, the Council should review the results and determine if additional emphasis should be placed on determining the importance of road generated sediment

- Develop an action plan to address channel erosion on a watershed scale

In all subbasins, channel erosion is one of the primary sources of sediment and degradation of aquatic systems. To the extent possible, problem areas not evaluated already should be documented. Once the full scope of the issue is known, a plan should be developed that addresses both the site specific problems in the channel as well as upland conditions that contribute to the problem.

- Investigate sediment from mass failures

This is a lower priority recommendation, but one that may not require the effort and expense of some of the other recommendations. Based on geologic mapping, there is a significant amount of land in the Trout Creek Watershed that is underlain by historic landslide debris. While casual observation suggests that current sediment delivery from these areas is likely not significant, future delivery could increase as we enter a wetter cycle. Within the next year, the geologist for the Ochoco National Forest will be completing an inventory of slides on USFS land in the Trout Creek headwaters. Replication of this effort (using geologic mapping, aerial photography, and ground verification) for the remainder of the Watershed should be considered, particularly if the USFS work indicates a potential problem.

- Monitor the effectiveness of sediment control efforts

While much has been done in the basin to control sediment sources and channel erosion problems, many of these efforts have not been monitored. Without monitoring, identifying and implementing those activities that yield the greatest benefit are difficult. In addition to monitoring specific sediment control actions, the Council should consider developing a plan to monitor instream sediment levels at a number of locations in the basin. This could take the form of substrate monitoring or monitoring of suspended sediment levels. The goal of this effort would be to identify which streams are responsible for the greatest sediment input and to track overall trends in Watershed sediment production. Any such plan should be coordinated with the USFS, which has been monitoring sediment and turbidity levels sporadically for about five years.

7.0 WATER QUALITY

7.1 INTRODUCTION

This section of the watershed analysis presents the results of the water quality assessment. The water quality assessment uses existing information to summarize what is known about water quality patterns in the Trout Creek Watershed. Finally, the assessment concludes with recommendations on future monitoring and steps that can be taken to improve water quality conditions.

Water quality – the biological, chemical, and physical properties of water – is an important indicator of the health of the watershed. Biological characteristics of water quality include factors such as quantity and quality of algae, bacteria, and the status of populations of aquatic insects and other organisms (macroinvertebrates). Physical and chemical characteristics of water quality include factors such as temperature, sedimentation, dissolved oxygen, and nutrients.

7.2 METHODS

The purpose of the water quality section is to summarize existing information sources and identify the key data gaps that may require further study. Ongoing monitoring in the Trout Creek Watershed by the Oregon Department of Fish and Wildlife (ODFW) and the Ochoco National Forest were the primary sources of information on water quality. The Oregon Department of Environmental Quality (DEQ) provided information on the importance of surface waters (beneficial uses) and the streams that are currently listed by the agency as "water quality limited". When appropriate, water quality characteristics are described in terms of existing state regulations. Finally, the report will identify specific actions that can be taken by the Council to address data gaps and improve water quality.

7.3 CRITICAL QUESTIONS

In order to guide the assessment, a number of critical questions were developed during project scoping:

- What are the designated beneficial uses for streams in the watershed?
- What are the water quality criteria that apply to streams in the watershed?
- Are there stream reaches that are identified as water quality limited on the State's 303(d) list?

- What do water quality studies or other data indicate about water quality?
- What are the key data/information gaps in water quality information?

7.4 RESULTS

The results of the water quality assessment are organized by the critical questions.

7.4.1 What are the designated beneficial uses for streams in the watershed?

A common source of confusion is the jargon used to describe water quality goals and measures. The key terms – *beneficial uses, water quality standards, water quality criteria, water quality limited*, etc. – have meanings derived from the federal Clean Water Act and incorporated into Oregon water quality regulations. The purpose of this section is to help define these terms and then describe their application to the Trout Creek Watershed.

Water Quality Standards include the list of beneficial uses of the stream, the criteria designed to protect those uses, and policies to implement the standards. *Beneficial uses* refer to a list of specific uses for which water is to be protected, such as livestock watering, fisheries, and recreation. Table 7-1 describes the beneficial uses designated for the Deschutes River Basin, including Trout Creek Watershed.

Table 7-1. Beneficial uses of water in the Deschutes River Basin.

Beneficial Uses: Deschutes River Basin (OAR 340-41-562)	
Public Domestic Water Supply*	Salmonid Fish Spawning
Private Domestic Water Supply*	Resident Fish & Aquatic Life
Industrial Water Supply	Wildlife & Hunting
Irrigation	Fishing
Livestock Watering	Boating
Anadromous Fish Passage	Water Contact Recreation
Salmonid Fish Rearing	Aesthetic Quality

* With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards. (DEQ, 2002).

The DEQ designates water quality factors (physical, chemical, and biological) that are necessary to support the beneficial uses. Table 7-2 provides a partial list of the beneficial water uses in the

Deschutes River Basin and the factors of concern that are evaluated to determine whether water quality supports each use. A limited number of factors – primarily water temperature, habitat, and stream flows – have had information collected and evaluated in the Trout Creek Watershed. Due to the focus of this assessment on the aquatic system, the water quality summary will focus on the beneficial uses related to steelhead and resident trout populations and habitat.

Table 7-2. A partial list of beneficial uses of waters in the Deschutes Basin and the water quality factors of concern (DEQ, 2002).

Beneficial use	Factors of concern
Livestock watering	Algae
Resident fish and aquatic life	Biological criteria Dissolved oxygen Habitat Habitat – flow pH Sedimentation Temperature Total dissolved gas Toxics Turbidity
Salmonid fish spawning and rearing	Dissolved oxygen Habitat Habitat – flow Sedimentation Temperature
Water supply	Algae Turbidity
Fishing	Algae Aquatic weeds Nutrients
Water contact recreation	Algae Aquatic weed Bacteria (fecal coliform Nutrients pH

7.4.2 What are the water quality criteria that apply to streams in the watershed?

Water quality criteria are defined to protect the beneficial uses of water. Water quality criteria are comprised of narrative statements and/or numeric criteria. Numeric criteria are established when it is feasible to identify specific limits that protect these uses across the basin. Narrative criteria are used when specific targets cannot be established at a regional or statewide level. For example, water quality criteria are specified that limit the amount of suspended solids and bacteria that can be present in drinking water. To protect steelhead and resident trout (salmonids) in streams, the criteria provide specific numeric limits for temperature, dissolved oxygen, and toxic agents. For other parameters, such nutrients and sedimentation, narrative statements provide general information on appropriate limits.

The federal Clean Water Act requires states to maintain a list of "*water quality limited streams*" that do not meet water quality standards. Streams on the list – called the "303(d) list" for the section of the Clean Water Act – may be studied further to determine if the listing was appropriate in the first place. If there is sufficient information, then a stream segment can be "delisted". For example, some stream segments in Oregon have been taken off the 303(d) list when new information on water temperature patterns demonstrated that a stream, or sections of the stream, meets water quality criteria (Stark, pers. comm.). The next section describes the water quality limited stream segments for the Trout Creek Watershed.

The beneficial uses and criteria identified in the Water Quality Standards provide the basis for the Total Maximum Daily Load (TMDL) for a stream segment. If the 303(d) listing is warranted, data are collected to calculate the TMDL. The TMDL is based on identifying the maximum pollutant input that can be supported and still meet water quality criteria. Pollutant loads, above the level that meet water quality criteria, are required to be reduced over time using pollution control technology for point sources, such as wastewater treatment plants, and using best management practices, for non-point sources, such as providing more stream side vegetation to shade streams and reduce water temperatures. The TMDL process is scheduled to begin in 2006 for the Trout Creek Watershed.

Table 7-3. Summary of water quality criteria applicable to steelhead and resident trout issues in the Trout Creek Watershed.

Parameter (Beneficial Use)	Criteria Type/ Measurement	Criteria *
Habitat & Flow Modification (Resident fish and aquatic life, salmonid spawning and rearing)	Narrative Criteria / Habitat measurements, flow assessment	Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities
Sedimentation (Resident fish and aquatic life, salmonid spawning and rearing)	Narrative Criteria	Formation of bottom deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry are not allowed
Turbidity (Resident fish and aquatic life, water supply, aesthetics)	Narrative Criteria / Turbidity (NTU)	Not greater than 10% increase over natural stream turbidity. Suggested screening criteria – 50 NTU (WPN 1999)
Temperature (Resident fish and aquatic life,	Numeric Criteria / Temperature	The 7-day moving average of the daily maximum water temperature shall not exceed the following

Parameter (Beneficial Use)	Criteria Type/ Measurement	Criteria *
salmonid spawning and rearing)		values: - Salmonid fish rearing: 64 ° F. - Salmonid spawning, egg incubation, spawning, and fry emergence: 55 ° F.
Bacteria – Fecal Coliform (Water contact recreation)	Numeric Criteria / Organism counts	A log mean of 200 fecal coliform organisms per 100 ml based on minimum of 5 samples in a 30-day period, with no more than 10 percent of the samples in a 30-day period exceeding 400 per 100 ml

* The criteria are abbreviated in this table. Most criteria have associated conditions and exceptions that apply. Obtain the full text of the regulations (DEQ, 2002) for specific applications.

7.4.3 Are there stream reaches that are identified as water quality limited on the State's 303(d) list?

Beginning in 1996, and updated in 1998, DEQ identified water quality limited stream segments throughout the state, including significant portions of the Trout Creek Watershed. All of these listings were based on existing information and there was minimal quality control of the original data. The entire length of Trout Creek and a number of tributaries are listed as water quality limited because they exceed the criteria for the following parameters:

- Temperature
- Habitat modification
- Sedimentation

Table 7-4 outlines the 303(d) listed streams and parameters for the Trout Creek Watershed. All streams are listed from their mouth (for example where a tributary discharges into Trout Creek) to the headwaters. For the most part, these water quality limited designations are based on data and other information collected and summarized by the USFS, primarily as provided in the Ochoco National Forest's 1995 Trout Creek Watershed Analysis (DEQ, 2002, USFS 1995). It is important to note that the DEQ listing status does not encompass all the potential water quality problems in the watershed. The water quality limited listings were determined for streams – primarily in the upper watershed – where monitoring was completed; the listings are not based on a systematic and comprehensive assessment of the water quality status of the entire Trout Creek Watershed. DEQ is currently updating the 3030(d) list and may use current monitoring data collected by ODFW and the USFS to add stream segments in the Trout Creek Watershed (DEQ, 2002). The following section provides a summary of the background information that was used to support the water quality limited listing.

Table 7-4. Streams in the Trout Creek Watershed designated as water quality limited by Oregon DEQ (2002).

Location		DEQ Water Quality Limited Status: + = Listed Stream		
Subbasin	**Stream (mouth to headwaters)**	**Temperature (7-day Max Deg. F)**	**Sedimentation**	**Habitat Modification**
Antelope Creek	Antelope	--	--	--
	Ward	+	--	--
Mud Springs Creek	Mud Springs	--	--	--
Hay Creek	Hay	--	--	--
Lower Trout	Trout	+	+	+
	Tenmile	+	--	--
Upper Trout	Auger	+	+	+
	Big Log	+	+	+
	Bull	+	+	+
	Cartwright	+	+	+
	Dick	+	+	+
	Ducthman	+	+	+
	Potlid	+	+	+

7.4.4 What do water quality studies or other data indicate about water quality?

Water quality is highly variable through time and across watersheds. Water temperature, for example, varies according to the season and location in the watershed, with headwater streams usually cooler than large rivers. Water quality is also affected by short and long-term climate patterns. As a consequence, a large amount of high quality information is required to make conclusive statements about the status of water quality in a landscape as diverse as the Trout Creek Watershed.

With the exception of monitoring completed by ODFW and the Ochoco National Forest, there is limited water quality data for the watershed. DEQ has not collected water quality data (Lamb, pers. comm.). Most of the systematic water quality monitoring done by ODFW and the USFS has emphasized stream temperatures. In addition, the USFS, focusing on their lands in the upper watershed, has collected some supporting information on sediment deposition, macroinvertebrate populations (e.g., aquatic insects), flow, and turbidity (Seymour pers. comm.).

The following sections focus on the listed parameters – sediment, habitat modification, and temperature – to summarize what existing data indicate about the status of water quality in the

Trout Creek Watershed. Because of the ongoing and extensive data collection effort, most of the water quality assessment will focus on water temperatures.

7.4.4.1 Sediment

It is difficult to quantify sediment deposition in streams and DEQ has not established numeric limits for sediment. The water quality narrative standard for sediment focuses on the somewhat subjective observation of the "formation of stream channel bottom deposits that are deleterious to fish or other aquatic life" (DEQ, 2002). All of the current water quality limited listings for sediment in the Trout Creek Watershed are based on information from 1994 stream habitat surveys as summarized in the Ochoco National Forest's Trout Creek Watershed Analysis (USFS, 1995). Because the analysis focused on National Forest lands, all of the evidence used for DEQ's water quality limited listing is for the upper watershed, including portions of Trout Creek and major tributary streams. The analysis' conclusions were based on observations of fine sediment deposition in the stream channel and associated measurements such as cobble embeddedness in all of the streams surveyed. Here are examples of some of the statements used to support the 303(d) listing for sediment deposition:

Bull Creek: "Spawning and incubating habitats are limited and of poor quality because of very high sediment load" (USFS, 1995, p.111).

Dick Creek: "Spawning and incubating habitats are lacking due in part to high cobble embeddedness" (USFS, 1995, p.110).

Trout Creek: "The particle composition of the streambed (dominant = cobble, subdominant = gravel) has the potential to provide quality spawning areas, however, high substrate embeddedness and low pool frequencies are diminishing the quality of spawning habitats" (USFS, 1995, p.110).

Potlid Creek: "Spawning and incubating habitats are limited and of poor quality because of high stream substrate embeddedness" (USFS, 1995, p.111).

While there is limited quantitative support for the extent or severity of sediment deposition in stream channels throughout the Trout Creek Watershed, the sediment sources (Chapter 6) and stream channel habitat type classification and modification (Chapter 3) assessments also support the conclusion that human-caused factors are contributing to higher levels of erosion, sediment transport, and deposition in the stream channels. Other supporting information on potential sediment delivery is in development. The USFS is completing an inventory of roads in the upper watershed, including potential for sediment delivery (Seymour, pers. comm.). This inventory is significant because the upper Trout Creek subbasin, with the highest density of roads in the entire watershed, has a high potential for road-related sediment production and delivery (Chapter 6). In addition, the USFS is conducting automated sampling of flows, total suspended solids (TSS), and turbidity in Trout, Cartwright and Dutchman Creeks at sites near the Ochoco National Forest boundary. Limited monitoring data collected from 1997 through 2001 for these sites indicates that turbidity levels (a rough indication of fine sediment transport) never exceeded 45 NTUs during a storm event, which is a fairly moderate level (Seymour, pers. comm.). The Ochoco National Forest will produce a report in 2002 summarizing the flow, turbidity, and TSS data and other water quality monitoring results (Seymour, pers. comm.).

7.4.4.2 Habitat Modification

The water quality standard for habitat modification, similar to the standard for sediment, is a narrative statement: stream habitat "will be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities" (DEQ, 2002). All of the water quality limited listings for habitat modification were from summaries for the Upper Trout Creek subbasin presented in the USFS Watershed Analysis (USFS, 1995). Other surveys and studies have noted stream habitat modifications in other subbasins within the Trout Creek Watershed. The stream channel modification (Chapter 3) and fisheries (Chapter 8) assessments examine existing information to provide additional summaries on the status of stream habitat and documented habitat modifications.

7.4.4.3 Temperature

There is extensive water temperature monitoring information for Trout Creek and key tributary streams. ODFW began collecting water temperature information with continuous monitoring devices in 1988 and currently maintains data collection at 17 sites throughout the watershed (Nelson, pers. comm.). The USFS started to collect continuous water temperature monitoring data in 1989 and will continue monitoring at sites near the Ochoco National Forest Boundary for upper Trout Creek and five tributary streams (Seymour, pers. comm.). In addition to these sites, Oregon Water Resources Department (OWRD) monitors water temperatures at their stream flow gauge located in lower Trout Creek near the mouth of Sagebrush Creek. Figures 7-1 and 7-2 provide the locations for current water temperature monitoring sites.

7.4.4.3.1 Water Temperature Summary and Data Analysis

Monitoring data have demonstrated that Trout Creek and tributary streams have summer water temperatures that exceed the DEQ water quality standards for salmonids (DEQ, 2002). The DEQ water quality standard for temperature is based on sustained high temperature impacts on sensitive stages – rearing or spawning – in resident trout, salmon, and steelhead development. As a way to measure sustained periods of high temperatures, the standard is based on the 7-day moving average of the daily maximum water temperatures. According to the standard, the 7-day moving average of the daily maximum water temperature will not exceed the following values for each life history stage:

- Salmonid fish rearing: 64 ° F
- Salmonid spawning, egg incubation, spawning, and fry emergence: 55 ° F

For the purpose of this analysis, water temperatures were examined for the late spring and summer period that steelhead and resident trout are rearing in the Trout Creek Watershed, which corresponds to the DEQ standard of 64 ° F. for the 7-day moving average of the daily maximum water temperatures.

Figure 7-3 illustrates the typical yearly water temperature pattern (expressed as the 7-day moving average of the daily maximum water temperatures) for the lower portion of the watershed for Trout and Sagebrush creeks (approx. elevation 1400 feet). As the graph illustrates, by late May (in 2000 and 2001) maximum sustained water temperatures exceed the 64 ° F standard, maintaining this level through the summer until mid-September.

Figure 7-1. USFS and ODFW water temperature monitoring sites, upper Trout Creek Watershed. ODFW sites where there is detailed data analysis are highlighted.

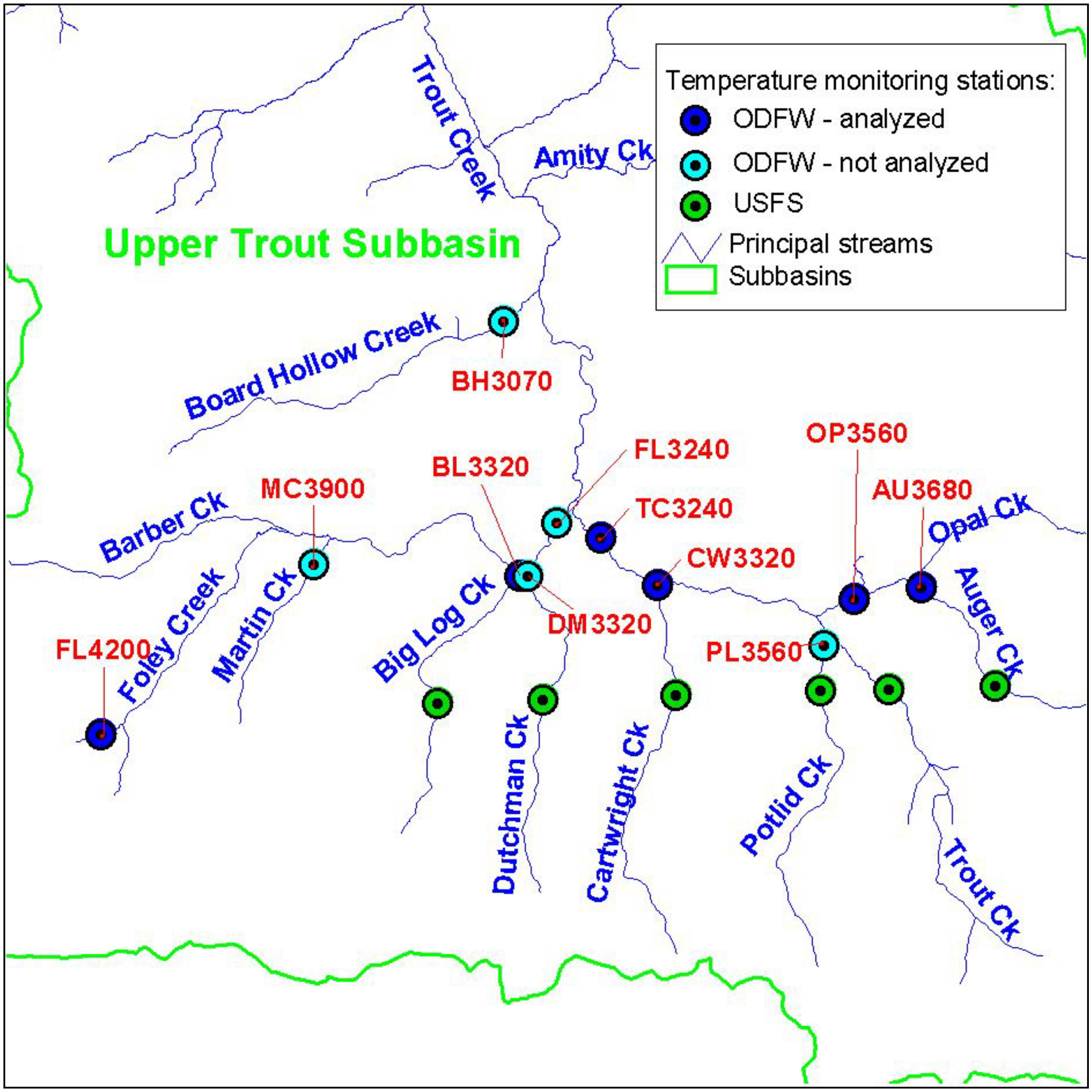


Figure 7-2. ODFW water temperature monitoring sites, lower Trout Creek Watershed. ODFW sites where there is detailed data analysis are highlighted.

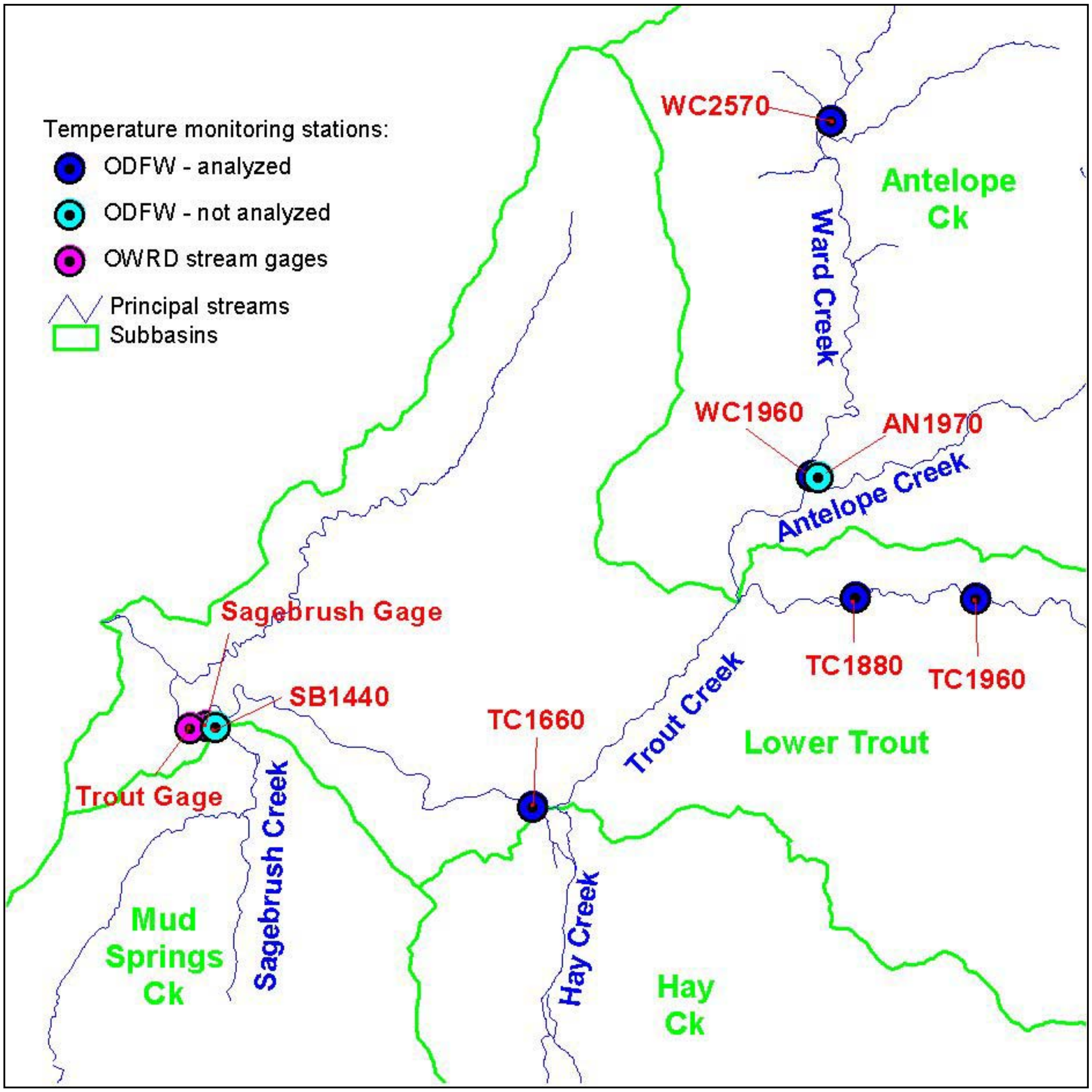
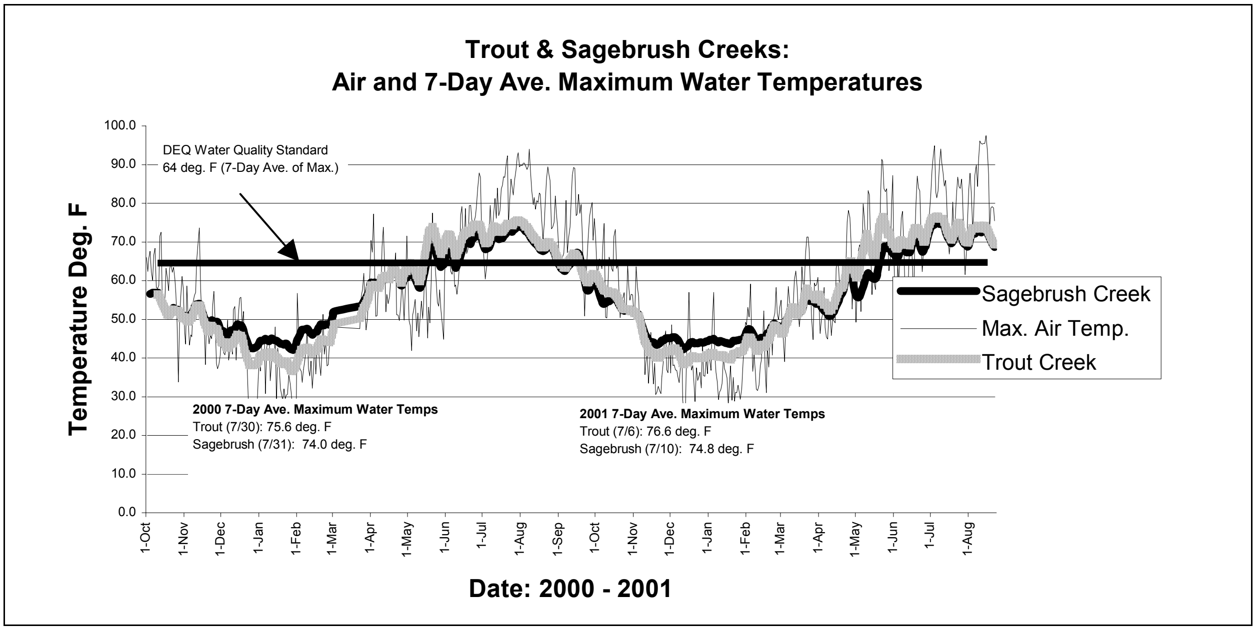


Figure 7-3. Water (7-day average maximum) and air temperature patterns (continuous) for Trout and Sagebrush Creek (approx. 1400 feet elevation) in the lower watershed, 2000 – 2001 (Oregon Water Resources Department 2001).



Similar stream temperature patterns are observed at the monitoring sites maintained by the USFS at the Ochoco National Forest Boundary. This monitoring indicates that water temperatures exceed the 64 ° F standard even in the forested areas in the upper watershed. In almost continuous monitoring since 1992, all of these sites (above 3000 feet elevation) on Trout Creek and tributary streams have exceeded the standard, with many instances where the water temperatures exceed 70 ° F (Table 7-5). Of the streams draining off of the National Forest, Auger Creek has consistently registered the lowest water temperatures (Seymour pers. comm.).

An extensive analysis was completed for a subset (11 locations) of the sites where ODFW monitors water temperature data (Table 7-6, Figures 7-1 and 7-2). To capture a range of weather and flow conditions, the analysis of water temperatures focused on three years: 1998, 2000, and 2001 (Tables 7-7 and 7-8). (Except where noted, the data were note examined for quality control issues.) With over 15 inches of rain (as measured in Redmond), 1998 was an extremely wet year with a warm summer. 2000 was an average year for both precipitation and summer air temperatures. In contrast, 2001 was a drought year with slightly over 4-inches of rain, and summer air temperatures that were relatively mild. There is limited data for the upper areas in the Trout Creek Watershed, but it is estimated that annual precipitation is approximately 16 inches, with most of the precipitation as rain with limited storage in the snowpack (U.S. Bureau of Reclamation, 1999). The Oregon Department of Forestry (ODF) maintains a metrological station at Board Hollow in the upper portion of the watershed (Tom Nelson, pers. comm.). Metrological data from the Board Hollow site were not analyzed.

With the exception of Cartwright and Foley Creeks (2000 and 2001 data only), ODFW collected continuous water temperatures at all 11 sites for the three years (Table 7-6). In each of the three years, all of the monitored streams exceeded the standard, with some sustained maximum water temperatures in excess of 80 ° F (Table 7-6).

To evaluate the seasonal pattern of water temperatures over the three years for the 11 sites, the 7-day average of the maximum water temperatures were summarized for the period of April 1 through October 14 (Figures 7-4 to 7-14). The graphs illustrate a consistent pattern of warming in excess of the 64 ° F standard by late May, and then maintaining high temperatures through June, July, August, and part of September. This pattern of warming in the late spring is evident for almost all of the streams regardless of elevation, including the Foley Creek, which at 4,200 feet is the highest elevation of the monitored sites. The exception to this pattern is Auger Creek (elevation 3680 feet), where water temperatures warming in excess of the 64 ° F standard is delayed until late June. Air temperatures and precipitation does influence the water warming patterns. For most of the sites, 1998's relatively wet and cool spring delayed the onset of water temperatures in excess of the standard.

Table 7-5. Maximum water temperatures for streams monitored at the Ochoco National Forest Boundary, 1992 to 2001 (USFS, 2002).

Stream (Elevation)	7-Day Maximum Water Temperature, deg. F									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Auger (4010)	66.1	66.8	71.0	N.D.	67.1	63.1	68.9	63.8	63.6	*
Big Log (3625)	71.8	68.4	72.1	66.1	71.3	69.2	69.9	N.D.	72.9	67.7
Cartwright (3610)	72.1	68.9	73.9	70.5	71.8	70.0	69.7	68.4	76.4	68.9
Dutchman (3620)	N.D.	N.D.	73.3	68.2	69.9	69.7	70.5	67.1	70.8	72.7
Potlid (3720)	N.D.	N.D.	69.9	67.9	70.3	68.3	70.9	68.0	67.8	68.1
Trout (3630)	68.3	63.6	73.1	69.0	70.3	66.8	67.8	66.5	70.1	67.9

***Auger Creek channel went dry at the monitoring site**

Table 7-6. Maximum water temperature for streams monitored by the Oregon Department of Fish and Wildlife, 1998, 2000 and 2001 (ODFW, 2002).

Stream (Elevation)	7-Day Maximum Water Temperature, deg. F		
	1998	**2000**	**2001**
Auger (3680)	68.9	80.1	80.0
Big Log (3320)	73.7	69.1	93.1*
Cartwright (3320)	N.D.	71.7	70.8
Foley (4200)	N.D.	74.7	92.1*
Opal (3560)	80.2	83.3	76.3
Trout (1660)	85.0	82.5	80.5
Trout (1880)	78.5	75.4	70.8
Trout	75.4	78.6	78.4

Stream (Elevation)	7-Day Maximum Water Temperature, deg. F		
	1998	2000	2001
(1960)			
Trout (3240)	62.9	74.8	75.6
Ward (1960)	75.3	78.6	78.4
Ward (2570)	75.6	69.1	75.6

*** It is probable that the temperature gauge was registering air temperatures.**

Table 7-7. Total yearly precipitation at Redmond, 1999, 2000, and 2001 (Oregon Climate Service, 2002).

Year	Total Precipitation (inches)			
	June	July	August	Year Total
1998	0.46	1.33	0.21	15.46
2000	0.02	0.64	0.00	9.48
2001	0.49	0.38	0.16	4.17

Table 7-8. Monthly average high temperatures at Redmond, 1999, 2000, and 2001 (Oregon Climate Service, 2002).

Year	Monthly Average High Temperature (deg. F)		
	June	July	August
1998	78.13	92.9	92.3
2000	82.03	88.3	88.16
2001	74.67	84.52	88.77

Figure 7-4. Auger Creek (elevation 3680 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (OFDW data).

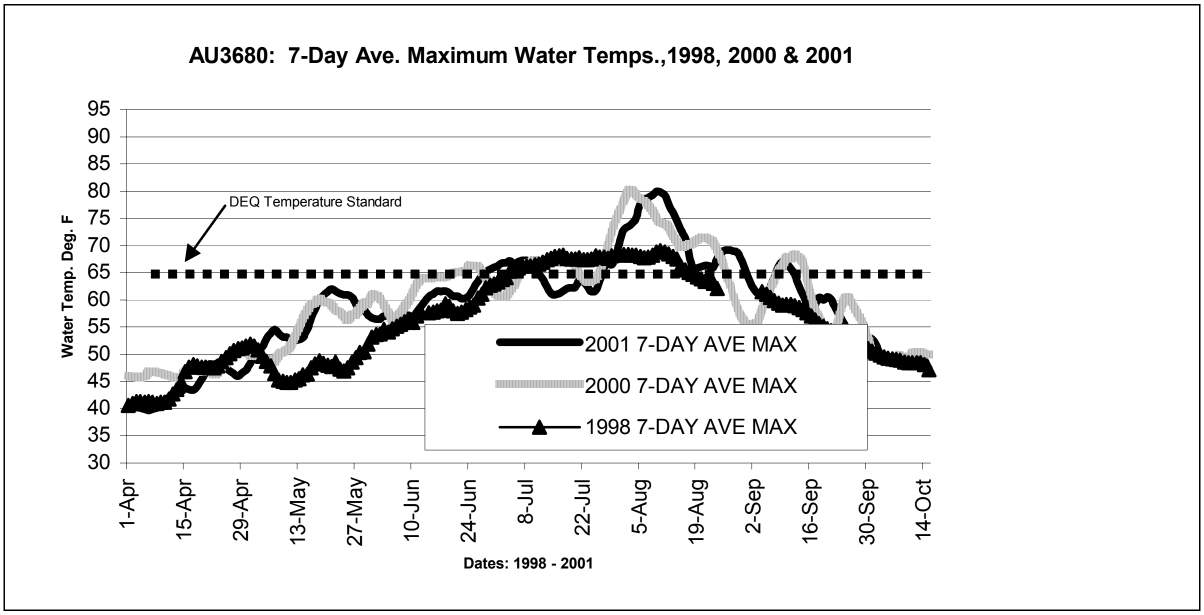
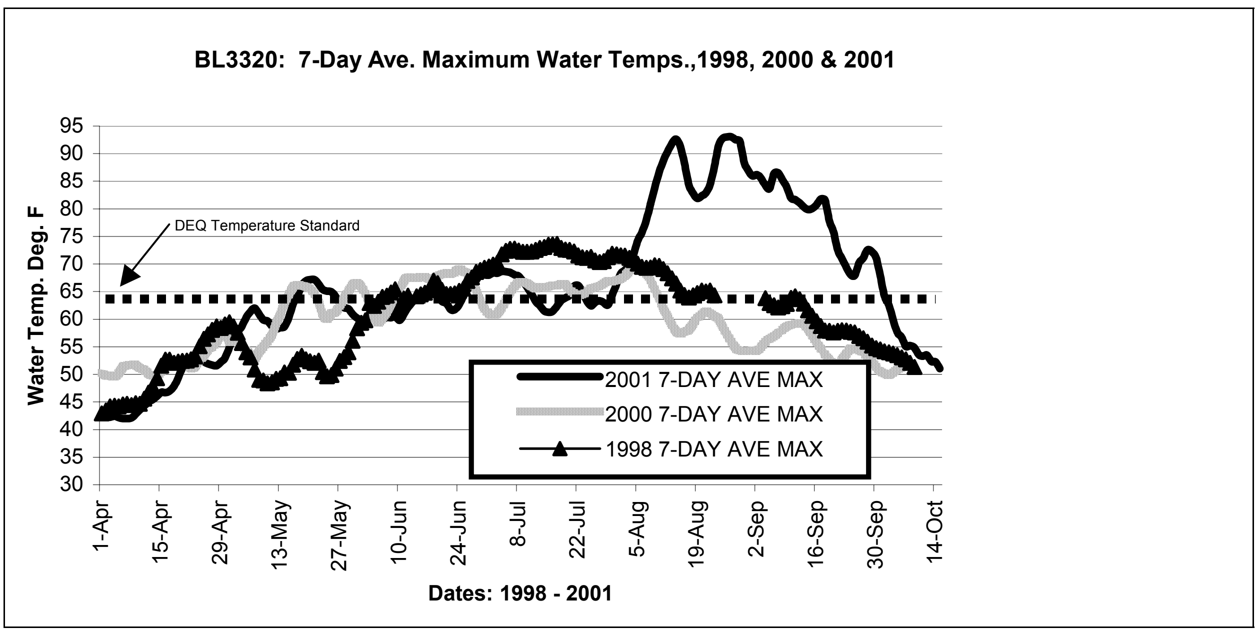


Figure 7-5. Big Log Creek (elevation 3320 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (OFDW 2002).



(Note: There may be a quality control issue with the data – temperatures in excess of 85 ° F could indicate that the thermograph was exposed to the air.)

Figure 7-6. Cartwright Creek (elevation 3320 ft.) 7-day average maximum water temperatures: 2000 and 2001 (ODFW data).

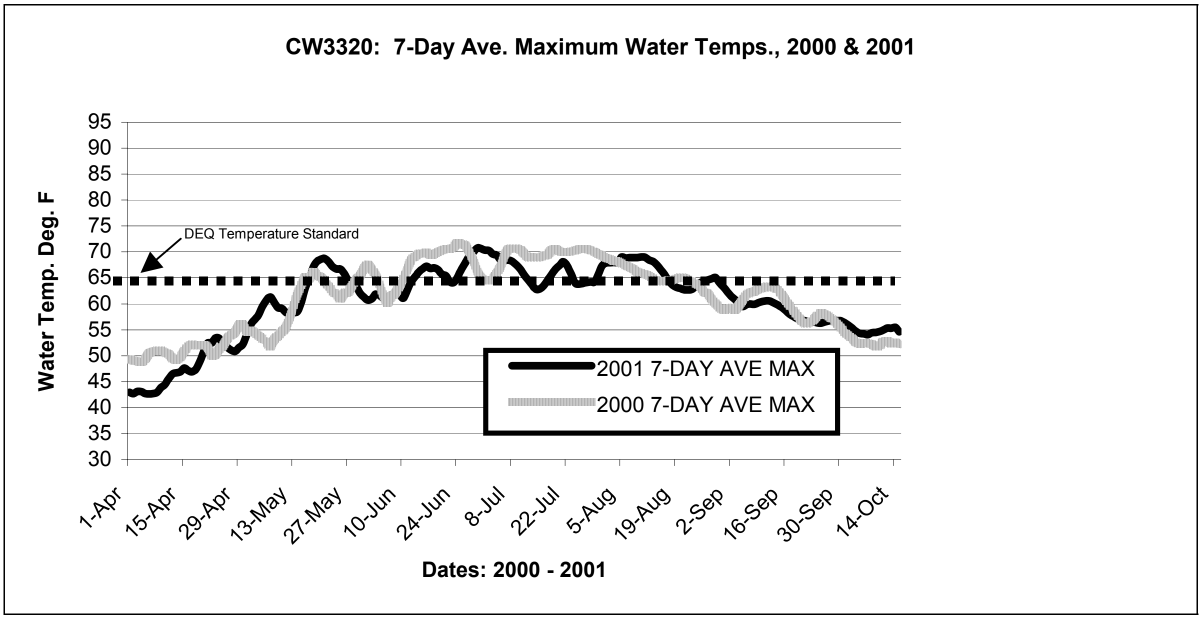
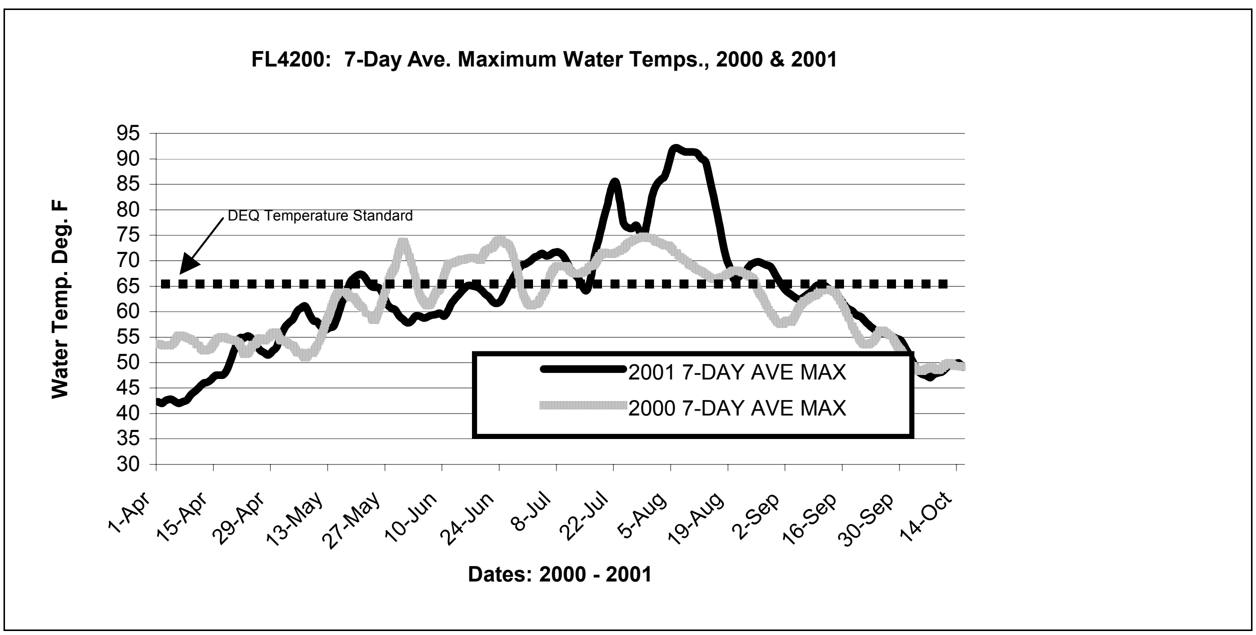


Figure 7-7. Foley Creek (elevation 4200 ft.) 7-day average maximum water temperatures: 2000 and 2001 (ODFW data).



(Note: There may be a quality control issue with the data – temperatures in excess of 85 ° F could indicate that the thermograph was exposed to the air.)

Figure 7-8. Opal Creek (elevation 3560 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (ODFW data).

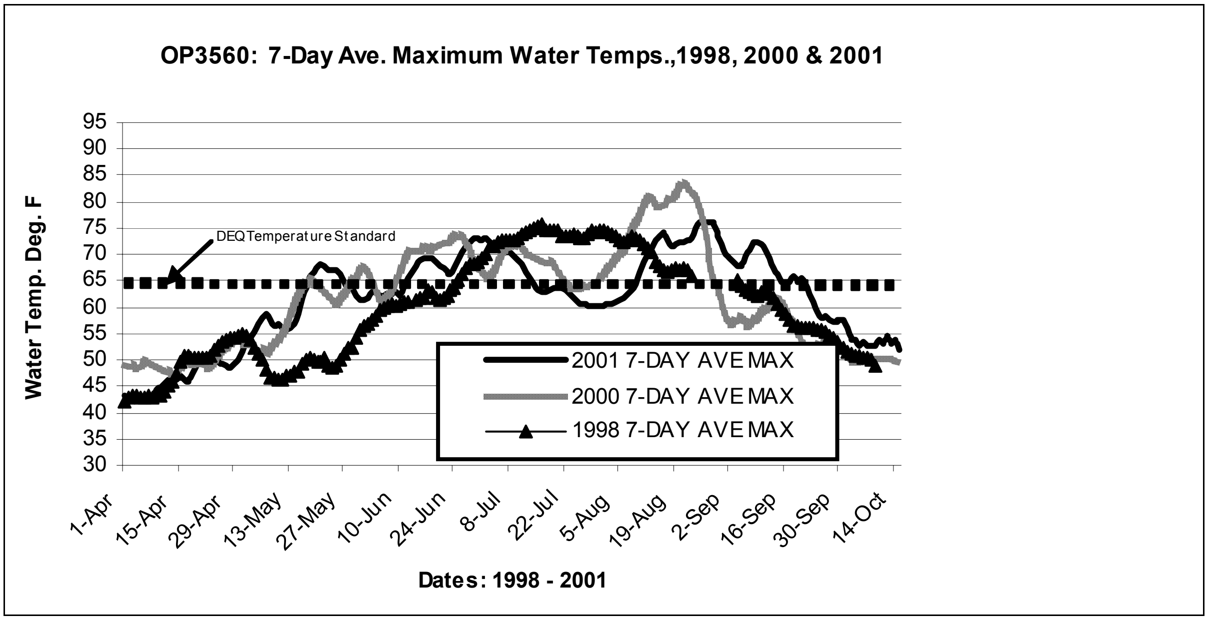


Figure 7-9. Trout Creek (elevation 1660 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (ODFW data).

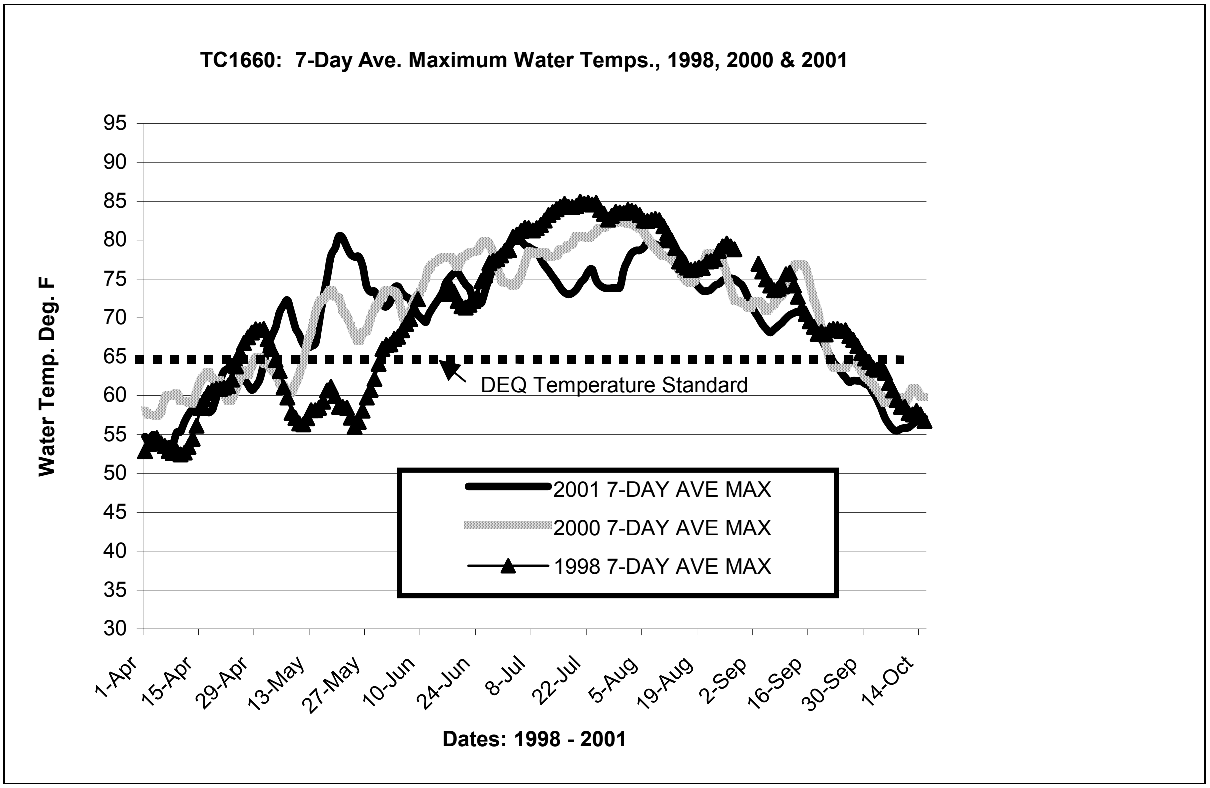


Figure 7-10. Trout Creek (elevation 1880 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (ODFW data).

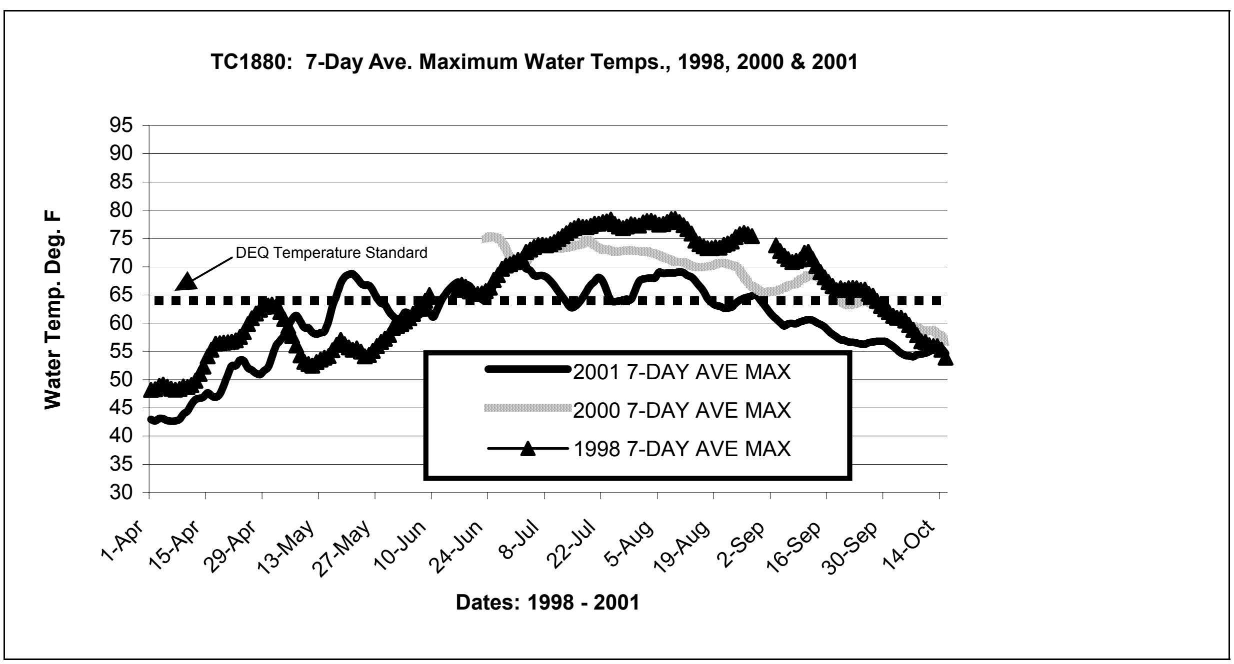


Figure 7-11. Trout Creek (elevation 1960 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (ODFW data).

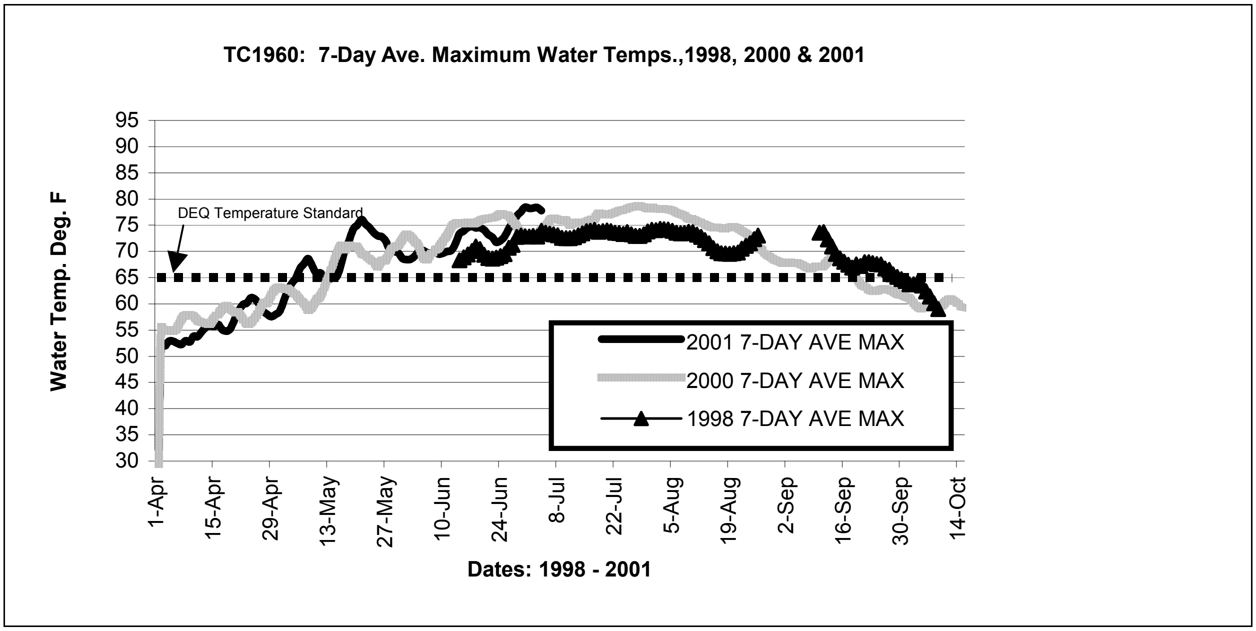


Figure 7-12. Trout Creek (elevation 3240 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (ODFW data).

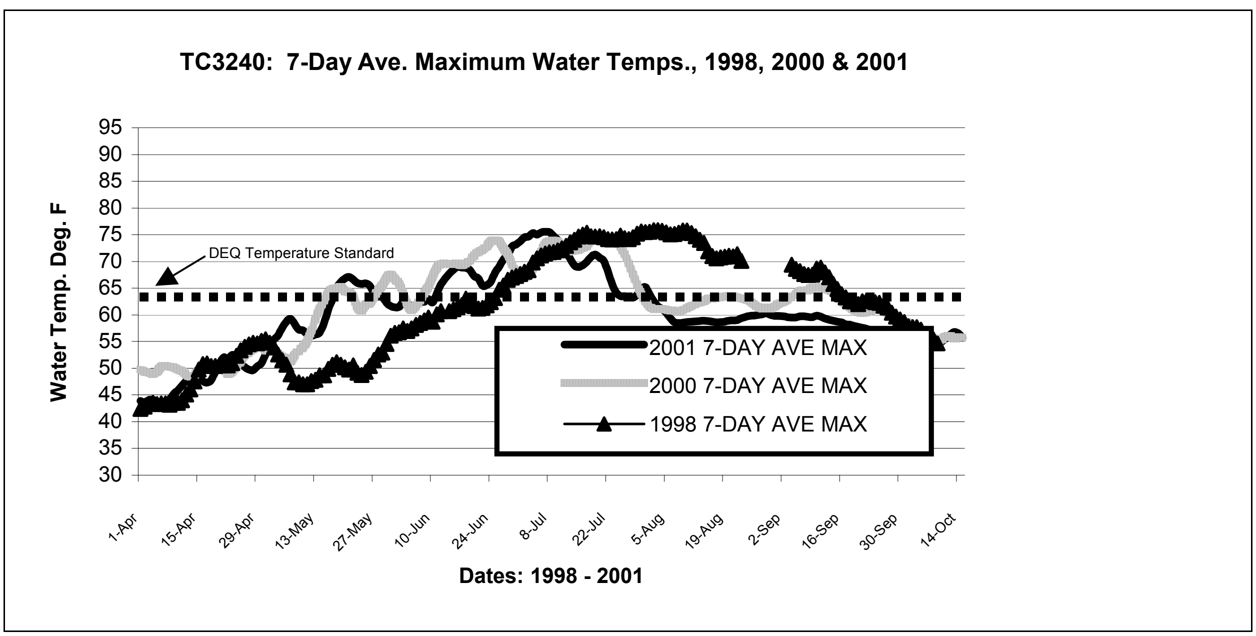


Figure 7-13. Ward Creek (elevation 1960 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (ODFW data).

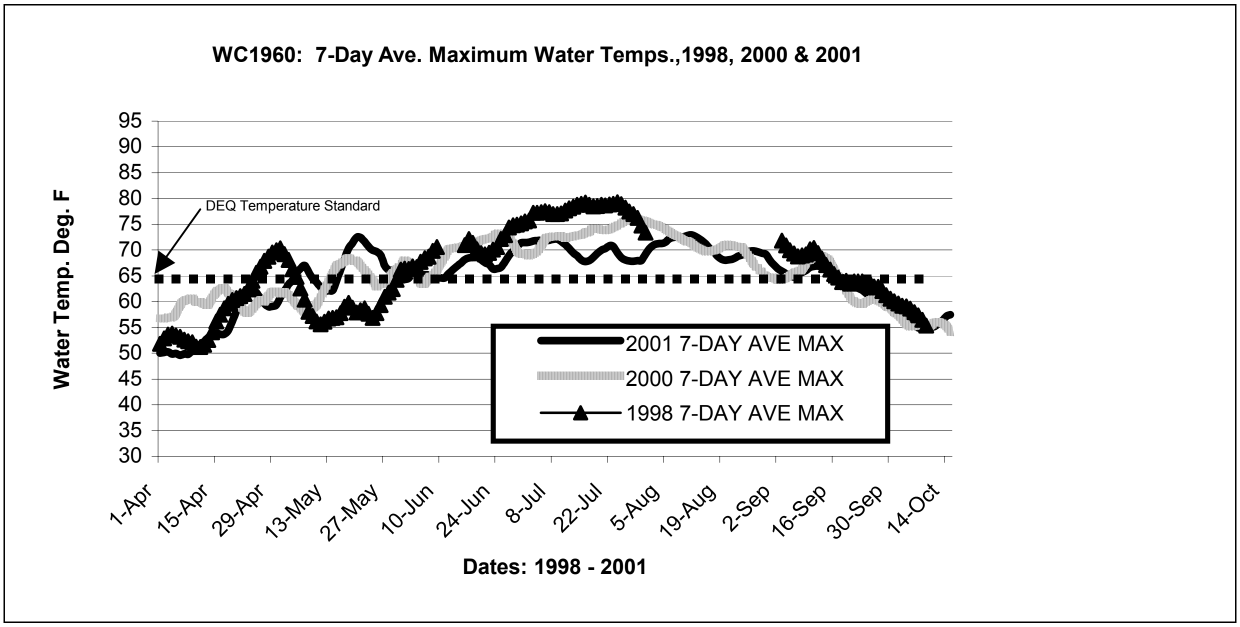
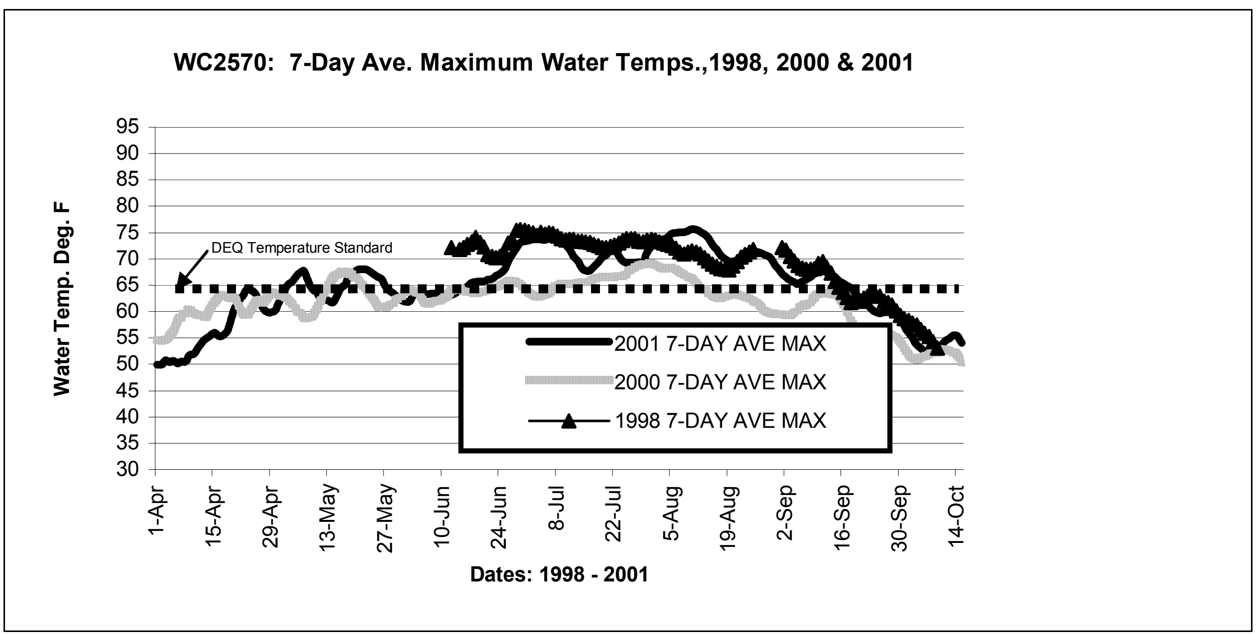


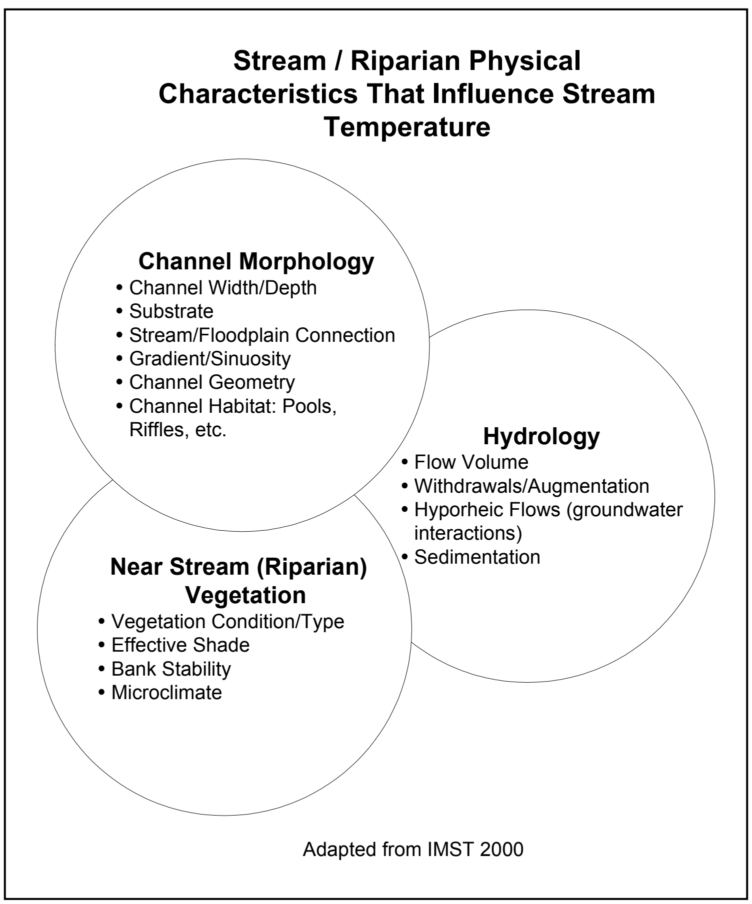
Figure 7-14. Ward Creek (elevation 2570 ft.) 7-day average maximum water temperatures: 1998, 2000, and 2001 (ODFW data).



7.4.4.4 Water Quality Discussion

Human actions in the Trout Creek Watershed have decreased water in streams, increased erosion, and reduced riparian vegetation. Cumulatively these actions have affected water quality in the watershed and in turn impacted steelhead and resident trout by raising water temperatures, covering spawning and rearing areas with sediment, and reducing the extent, and connection between, areas of quality fish habitat. This section will evaluate the factors that are contributing to increased water temperatures.

Stream temperature patterns are the product of complex interactions between, geomorphology, soil, hydrology, vegetation, and climate within a watershed. Figure 7-15 illustrates some of the watershed characteristics that contribute to stream temperature warming. With the complexity of watershed processes, it is difficult to determine the historical “natural” water temperature patterns in the Trout Creek Watershed. Changes to stream temperatures due to human impacts are often hard to quantify. Stream temperatures associated with increased risk to steelhead and resident trout populations might occur relatively frequently in some stream reaches under “natural” conditions (Poole et al., 2001).



To understand how stream temperature patterns have been modified in the Trout Creek Watershed, this section will examine the three basic interrelated components influencing water temperatures:

- Riparian vegetation and shade
- Channel morphology; and
- Hydrology

Figure 7-15. Some of the watershed characteristics that influence stream temperature patterns.

The influence of riparian vegetation on stream temperature is cumulative and complex, varying by site, over time, and across the watershed. Riparian vegetation directly affects stream temperature by intercepting solar radiation and reducing stream heating. In addition to providing shade, riparian vegetation can also indirectly affect stream temperature by influencing microclimate, affecting channel morphology, affecting stream flow, influencing wind speed, affecting humidity, affecting soil temperatures, using water, influencing air temperature, enhancing infiltration, and influencing thermal radiation (IMST, 2000).

Riparian shade levels in the Trout Creek Watershed are probably reduced from historic levels and this has contributed to increased water temperatures throughout the watershed (see Chapter 5, Riparian / Wetland Habitat Conditions, USFS 1995). Current riparian shade levels are very low (less than 40%) over most of the watershed, including the mainstem of Trout Creek and many tributary streams (Chapter 5). Limited shade levels can increase the difference between the daily maximum and minimum water temperatures: limited canopy cover contributes to temperatures that are higher due to increased intercepted solar radiation and lower because there is no cover to insulate during cooling at night. There is evidence that increases in riparian shade levels over time in the upper watershed are affecting water temperature patterns. The difference (or flux) between daily water temperature maximums and minimums is decreasing at the USFS monitoring site on Trout Creek, which could mean that riparian shade is increasing (Seymour pers. comm.). Riparian shade levels are the highest in the upper Trout Creek Subbasin, but opportunities remain to increase riparian shade levels that were impacted from past management practices (USFS, 1995).

Stream channel shape (morphology) can contribute to increases in water temperatures though changes in factors such as the width and depth of the active channel. Changes in channel width can modify the surface area of the stream, which determines the area exposed to the atmosphere and solar radiation. A wide, shallow stream will increase water temperatures more rapidly than a stream of the same volume that is narrow and deep (Moore and Miner, 1997).

Increases in sediment deposition, decreases in large wood in the channel and associated pools, and loss of riparian vegetation are all factors that have contributed to widening stream channels and decreasing water depths for some stream segments within the Trout Creek Watershed (Chapters 4 and 7). These factors that have affected channel width and water depths, especially in the lower portions of the watershed where stream temperatures were probably naturally elevated, have contributed to higher water temperatures.

Changes in stream volume can affect water temperatures. Streams with smaller volumes of water increase temperature faster than streams with larger volumes of water (Moore and Miner, 1997). The flow regime in Trout Creek watershed has been modified through a number of actions. Late spring and summer flows have decreased through diversions, loss of upland storage by wetlands, and decreased flows from juniper encroachment (Chapter 5, U.S. Bureau of Reclamation, 1999). Decreases in stream flows, in combination with channel modifications and loss of riparian shade, are contributing to higher water temperatures in the Trout Creek Watershed.

7.4.5 What are the key data/information gaps in water quality information?

There are a number of key data gaps that need to be addressed to gain a better understanding of water quality issues and remedies in the Trout Creek Watershed. These data gaps fall into two broad categories: 1) Information to supplement the current water temperature monitoring that will provide a better evaluation of thermal regimes; and 2) systematic information on the other water quality parameters, especially sediment deposition. The project recommendation section will provide detailed information on approaches to address these monitoring issues.

7.5 DATA GAPS / RECOMMENDATIONS

- Gather spatially detailed information on water temperature patterns

There are limitations to the water temperature data that have been collected at points along the stream network in the Trout Creek Watershed. This information provides extensive detail on the water temperature regime over time but does not offer complete resolution on the temperature patterns along the stream network. This is significant because water temperatures do not always change in a consistent manner. There can be areas of relatively cold water between warm points. For example, in a study of water temperature patterns on the Middle and North Forks of the John Day River concluded that temperatures did not decrease in a consistent pattern from the top of the watershed to the mouth. Cool patches in these streams were attributed to lateral groundwater inputs in some unconstrained alluvial valley areas (Torgersen et al.,1999).

It is important to understand spatial patterns of water temperatures, especially for locating cold areas that offer "thermal refugia" for steelhead and resident trout (Torgersen et al.,1999). Airborne thermal infrared remote sensing provides a tool for assessing water temperature patterns throughout the watershed. FLIR (Forward-Looking Infrared) technology (carried on a helicopter) could be used to map water temperature patterns throughout the Trout Creek Watershed (Torgersen et al., 2001). Continuous mapping of water temperatures on key stream segments will augment the information collected at the current monitoring points.

The FLIR system could be used to collect data for one or several days during the July through mid-August period, which coincides with low flow conditions, maximum daily stream temperatures, and high sun angles to limit shadows. Data collected by the current water temperature monitoring network would provide a "field check" on the accuracy of the FLIR thermal data. Most of the stream network could be thermally mapped up to bankfull channel widths of approximately six feet (Torgersen et al., 2001).

- Gather key data and information associated with water temperatures

Additional data on some of the factors that influence water temperature is necessary to interpret water temperature monitoring data. Some additional stream data are collected at the USFS monitoring sites (Seymour, pers. comm.). There is a need, however, for a coordinated approach for collecting water temperature and associated information throughout the Trout Creek Watershed. A consistent protocol should be developed and implemented to collect flow, riparian shade, and channel (width and depth) characteristics for a distance upstream (at least 1000 feet) for each of the water temperature monitoring sites.

- Fill in key data gaps on other water quality parameters

As pointed out in the Sediment Sources Chapter, the Trout Creek Watershed Council should consider developing an approach for monitoring sediment levels at a number of locations along the stream network. Due to the extreme natural variability in sediment delivery to stream channels, gaining an understanding of sediment patterns throughout the watershed will require a number of sites and a long-term commitment to consistent data collection.

Macroinvertebrate (aquatic insects and other organisms) sampling at key locations in the watershed could provide additional data to support the sediment and water temperature monitoring efforts. Consistent sampling of macroinvertebrates through time could provide additional data for evaluating the success of watershed-wide restoration efforts. For example, changes in the numbers and distribution of sediment-tolerant taxa, in combination with sediment data, could provide supporting evidence for reductions in sediment delivery to the stream channel.

- Restore water temperature regimes

There are three broad, and interrelated, approaches for restoring stream temperature regimes that apply to the Trout Creek Watershed (Moore and Miner, 1999):

- Keep it shaded.
- Keep it narrow.
- Keep it flowing.

Restoration of water temperature regimes will need to address the amount and distribution of both cooler areas and "hot spots" and their association with other characteristics of stream habitat. This will require an integrated approach to restoring shade, flow, and channel characteristics: protecting high quality habitat (primarily in the Upper Trout Creek Subbasin) and a strategic approach to restoration of degraded habitat, while recognizing that some naturally warm reaches are part of the aquatic landscape (Poole et al. 2001). The mapping of water temperature patterns with FLIR data, in addition to riparian, hydrologic, and stream channel information presented in this report, provides a framework for identifying important areas to target water temperature restoration actions.

8.0 FISHERIES

CONTRIBUTED BY TOM NELSON, OREGON DEPARTMENT OF FISH AND WILDLIFE AND ADAM HAARBERG, JEFFERSON COUNTY SWCD

8.1 INTRODUCTION

This section of the watershed analysis presents information on the fish species present in the basin, fish passage barriers, road crossings, and the channel habitat condition within the Trout Creek Watershed. The Trout Creek Watershed currently supports anadromous summer steelhead (*O. mykiss*) and resident redband trout (*O. mykiss*) populations. There are approximately 140 miles of perennial streams in the watershed, with 113 miles of current summer steelhead distribution. Historically, it is estimated that there were approximately 170 stream miles available for summer steelhead use. Mid Columbia Summer Steelhead ESU were federally listed as threatened in March 1999. This listing includes the Trout Creek Basin population.

8.2 METHODS

Fish presence in the basin was taken from ODFW screw trap data. This information was collected at RM 3.5 and only serves to illustrate the populations that occur in the lower basin during the spring operation of the trap. Basin upper limit and temporal distribution of all species except (*O.mykiss*) are not fully understood. *O.mykiss* distribution data is the compilation of accounts of several different people over several different years. Summer steelhead population estimates are derived from mark and recapture technique. Fish barriers on current steelhead distribution were all field verified. Road crossings were obtained from BLM GIS stream and road layers. The stream and road GIS layers were modified to reflect the major stream tributaries and roads. Present summer steelhead distribution was based on ODF&W's GIS summer steelhead distribution layer, modified to reflect observed field conditions. Historical fish distributions were based on professional judgment, looking at flow and potential habitat conditions.

8.3 CRITICAL QUESTIONS

- What are the fish species present in the watershed?
- What is the status of federally listed species in the basin?

- What is the distribution of the listed species?
- What is the status of fish passage?
- What is the habitat condition of the stream reaches that contain listed fish species?

8.4 FISH SPECIES AND LIFE HISTORY

Table 8-1. Fish Species presence in the Trout Creek Basin at river mile 3.5. During annual spring operation of 5' screw trap. Data Source: ODFW (2001b).

Fish species	Scientific name	Native/ Exotic	Abundance	Distribution
Summer steelhead	*Oncorhynchus mykiss*	Native	Abundant	Basin wide
Redband Trout	*Oncorhynchus mykiss*	Native	Common	Basin wide
Chinook Salmon Fall	*Oncorhynchus tshawytscha*	Native	Not present	NA
Chinook Salmon Spring	*Oncorhynchus tshawytscha*	Native	Not present	NA
Bull Trout	*Salvelinus confluentus*	Native	Not present	NA
Brown Trout	*Salmo trutta*	Exotic	Not present	NA
Adult bridgelip sucker	*Catostomus columbianus,*	Native	Very abundant	Mainstem & Major tribs.
Adult large-scale sucker	*Catostomus macrocheilus*	Native	Very abundant	Mainstem & Major tribs
Speckled dace	*Rhinichthys osculus*	Native	Abundant	Mainstem & Major tribs
Long nose dace	*Rhinichthys cataractae*	Native	Abundant	Mainstem & Major tribs
Red side shiner	*Richardsonius balteatus*	Native	Common	Mainstem & Major tribs
Mountain Whitefish	*Prosopium williamsoni*	Native	Rare	Seasonally only in lower Mainstem
Chiselmouth	*Acrocheilus alutaceus*	Native	Abundant	Mainstem & Major tribs
Northern pike minnow	*Ptychocheilus oregonensis*	Native	Common	Mainstem & Major tribs
Small Mouth bass	*Micropertes salmoniodies*	Exotic	Rare	Unknown
Brown bullhead	*Ictalurus nebulosus*	Exotic	Rare	Unknown

Table 8-2. Life History pattern for ESA Listed and state sensitive species. Data Source: ODFW (2002).

Fish species	A = Anadromous R = Resident	Location	Spawning	Outmigration
Summer steelhead	A- Summer	Mainstem Trout Creek and most tributaries.	Trout Creek Basin Late February to End of May Peak Mid March to Mid April	1 to 3 years in freshwater Outmigration of smolts: March – June Peak: April - May
Chinook Salmon Fall	A- Fall	Not present in Trout Creek Watershed due to current flow regime.	Present in Mainstem Deschutes	NA

Fish species	A = Anadromous R = Resident	Location	Spawning	Outmigration
Chinook Salmon Spring	*A- Spring*	Not present in Trout Creek Watershed due to current flow regime	Present in Mainstem Deschutes	NA
Bull Trout	R	No observed presence in Trout Creek Watershed, but seasonal presence possible.	Present in Mainstem Deschutes	NA
Redband Trout	R	Mainstem and most tributaries	April to Mid June	NA

8.4.1 Summer steelhead (*Oncorhynchus mykiss*)

Redd counts from ODFW from the past 12 years have indicated an increasing trend in the abundance redds per mile surveyed in the basin. Part of this increase is probably due to the increased frequency of the surveys and increased miles of stream surveyed in a given year. In recent years ODFW has noted spawning that was occurring later in the year than previously thought. Utilizing this information ODFW moved redd counts to later dates and repeated reach surveys if numerous adult steelhead were observed. Even with these changes in sampling techniques the trend for redds has increased tremendously over the past 12 years. This trend is similar to increases in numbers of steelhead returning to the Columbia and to the counts over Sherars Falls on the Deschutes River. Steelhead smolt trapping near the mouth of Trout Creek has yielded varying population estimates; however direct comparison between years is difficult due to variation in dates of operation due to low flow conditions.

8.4.1.1 Distribution

Summer steelheads are found in every subbasin in the watershed. However, the majority of the distribution is located in Upper Trout (49%), Lower Trout (34%) and Antelope Creek (15%) subbasins totaling 98 percent of the entire watershed. Figure 8-2 is a map that shows summer steelhead distribution, both present and historical. The lines on the map reflect both adults and/or juveniles. Present summer steelhead distribution was based on ODF&W's GIS summer steelhead distribution layer, modified to reflect observed field conditions. Historical fish distributions were based on professional judgment, looking at flow and potential habitat conditions. Table 8-6 lists all of the streams by subbasin that summer steelhead occur.

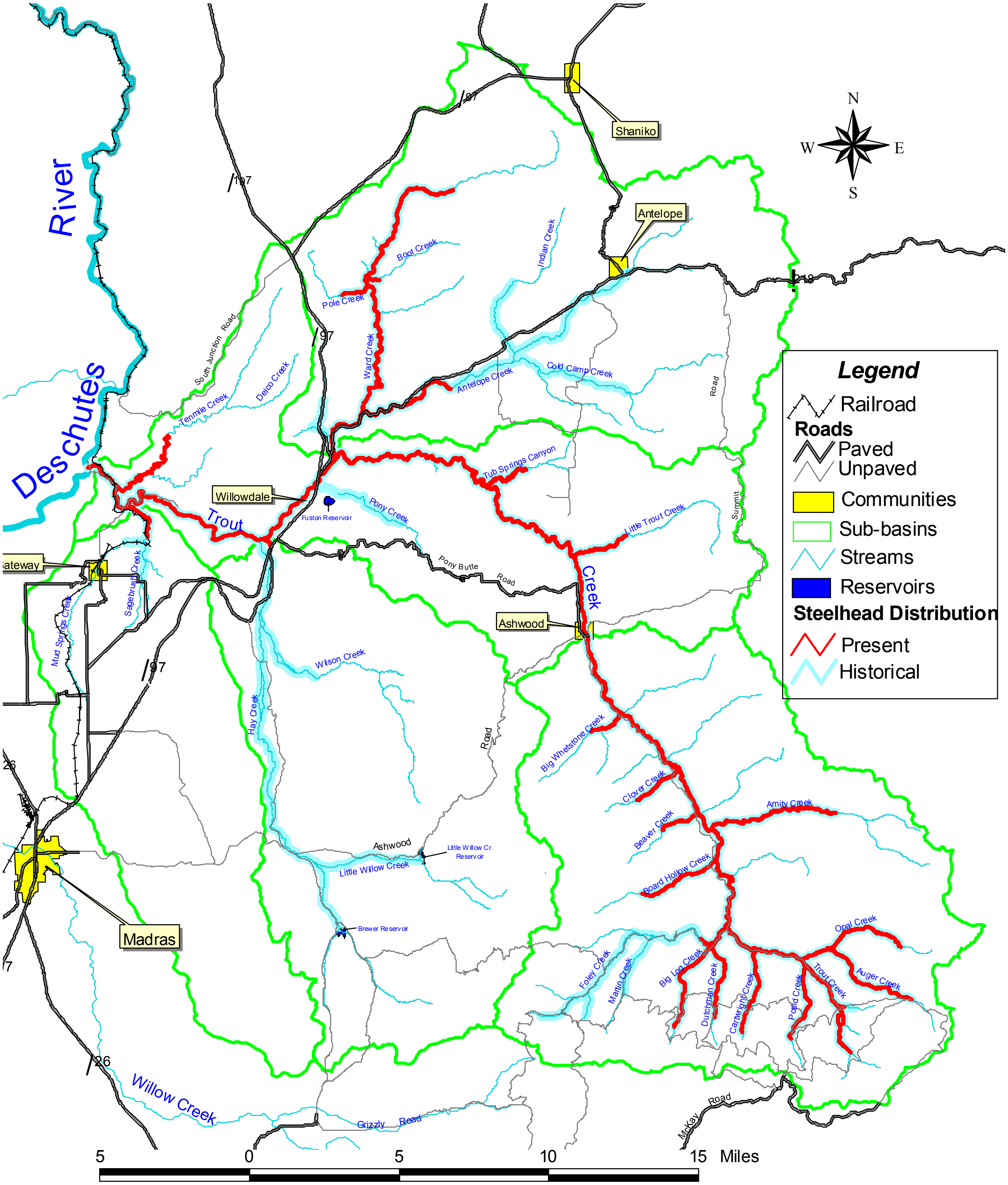


Figure 8-2. Summer Steelhead Distribution. Present distribution was based on ODFW's GIS summer steelhead distribution layer, modified to reflect observed field conditions. Historical fish distributions were based on professional judgment, looking at flow and potential habitat conditions.

Table 8-6. Summer Steelhead Distribution.

Subbasin	Stream Name	Present Distribution (Miles)	Historical Distribution (Miles)	Percent of Historical Use
Antelope Creek	Antelope Creek	2.9	11.2	26%
Antelope Creek	Boot Creek	0.6	0.6	100%
Antelope Creek	Bull Canyon Creek	0	0.2	0%
Antelope Creek	Cold Camp Creek	0	4.6	0%
Antelope Creek	Cow Canyon Creek	0	1.6	0%
Antelope Creek	Indian Creek	0	3.0	0%
Antelope Creek	Pole Creek	2.2	2.2	100%
Antelope Creek	Ward Creek	11.3	11.3	100%
Antelope Creek	**Total**	**17.1**	**34.8**	**49%**
Hay Creek	Hay Creek	0.4	17.6	2%
Hay Creek	Little Willow Creek	0	3.8	0%
Hay Creek	Wilson Creek	0	2.9	0%
Hay Creek	**Total**	**0.4**	**24.3**	**1%**
Lower Trout	Little Trout Creek	2.2	2.2	100%
Lower Trout	Pony Creek	0	3.7	0%
Lower Trout	Tenmile Creek	4.1	1.1	379%
Lower Trout	Trout Creek	29.8	29.8	100%
Lower Trout	Tub Springs Canyon	2.1	2.1	100%
Lower Trout	**Total**	**38.3**	**38.9**	**98%**
Mud Springs Ck	Mud Springs Creek	1.6	2.9	28%
Mud Springs Ck	Sagebrush Creek	0	1.3	0%
Mud Springs Ck	Unn Trib to Sagebrush Ck	0	0.2	0%
Mud Springs Ck	**Total**	**1.6**	**4.4**	**22%**
Upper Trout	Amity Creek	5.2	5.2	100%
Upper Trout	Auger Creek	3.7	3.7	100%
Upper Trout	Beaver Creek	1.5	1.5	100%
Upper Trout	Big Log Creek	3.6	3.6	100%
Upper Trout	Big Whetstone Creek	1.3	1.3	100%
Upper Trout	Board Hollow Creek	3.0	3.0	100%
Upper Trout	Cartwright Creek	3.1	3.1	100%
Upper Trout	Clover Creek	2.2	2.2	100%
Upper Trout	Dick Creek	0.3	0.3	100%
Upper Trout	Dutchman Creek	2.8	2.8	100%
Upper Trout	East Fork Foley Creek	0	0.8	0%
Upper Trout	Foley Creek	1.4	7.6	19%
Upper Trout	Martin Creek	0	2.3	0%
Upper Trout	Opal Creek	4.1	4.1	100%
Upper Trout	Potlid Creek	2.8	2.8	100%
Upper Trout	Trout Creek	20.5	20.5	100%
Upper Trout	Unn Trib to Trout Creek	0.3	0.3	100%
Upper Trout	**Total**	**55.7**	**65.0**	**86%**
Trout Creek Watershed Total		**113.0**	**167.4**	**68%**

8.4.1.2 Redd Counts and Smolt Trapping

Table 8-3. ODFW Trout Creek Watershed Summer Steelhead Redd counts 1988-2002. Data Source: ODFW (2002a).

Year	Miles Surveyed	# Fish	# Redds	Fish/Mile	Redds/Mile
1988	9.4	17	23	1.8	2.5
1989	10.5	24	23	2.8	2.2
1990	14.4	22	42	1.5	2.9
1991	16.9	3	16	0.2	1.1
1992	16.4	6	6	0.4	0.4
1993	28.2	4	15	0.1	0.5
1994	16.25	0	0	0.0	0.0
1995	18.25	0	8	0.0	0.4
1996	21.75	4	5	0.2	0.2
1997	23.6	21	50	0.9	2.1
1998	28	13	44	0.5	1.6
1999	28.65	12	59	0.4	2.1
2000*	54.1	39	461	0.7	8.5
2001	36.6	56	595	1.5	16.3
2002	65.2	95	866	1.5	13.3

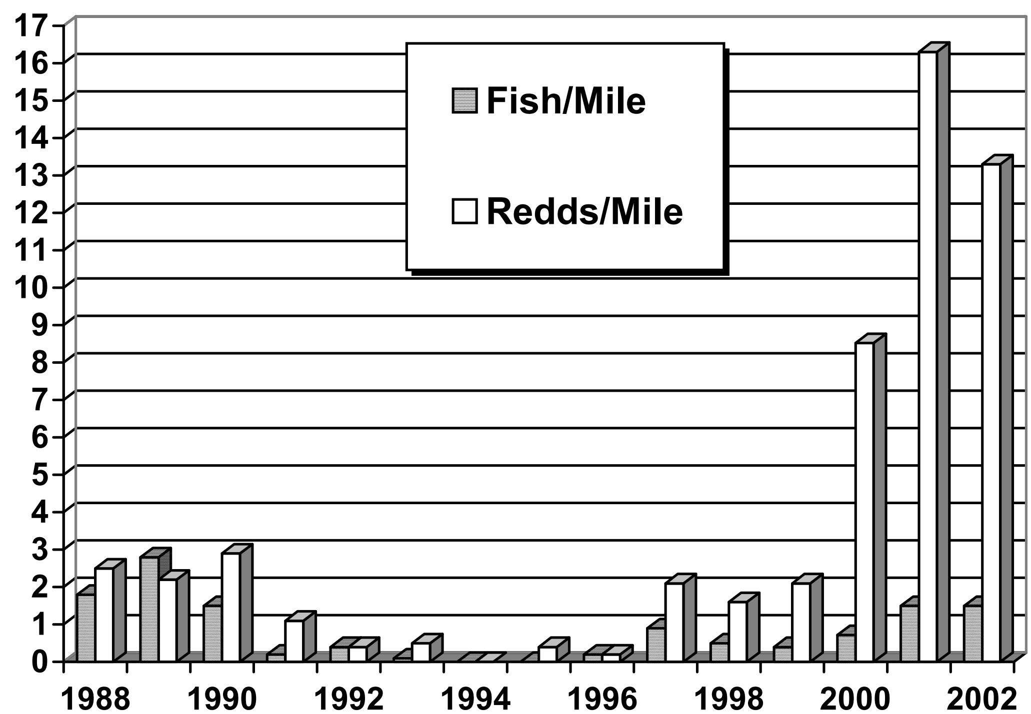


Figure 8-1. Trout Creek Basin redd counts. Data Source: ODFW (2002a).

Table 8-4. Trout Creek smolt trap population estimate at River Mile 3.5. Data Source: ODFW (2002b).

	1998*	1999	2000	2001	2002
Total Days Fished	47	99	80	23	38
Dates of operation	3/20 - 5/20	3/9 - 6/11	3/2 - 5/20	4/24 - 5/16	4/3 - 5/10
Total Number Smolts Caught	12,263	5,063	4,042	2,827	2,027
Population estimate	76,417	17,756	27,341	21,400	9,685
95% Confidence Interval (+-)	13,659	1,698	5,525	5,315	1,958

Table 8-5. Trout Creek smolt trap 1998 – 2001 population estimate comparison at River Mile 3.5. Data Source: ODFW (2001b).

	1998*	1999	2000	2001
Days Trap Operated	23	23	23	23
Dates of Comparison	4/24 - 5/16	4/24 - 5/16	4/24 - 5/16	4/24 - 5/16
Total Smolts Captured	6,882	1,910	2,882	2,827
Smolt Estimate	47,070	9,213	19,012	21,400
95% Confidence Interval (+-)	12,623	1,112	4,122	5,315

- 2001 trap operation limited to 23 days due to drought (shortest trapping period to date)
- * Trap not operated every day during this period

Below are observations by ODFW staff resulting from knowledge gained from the four years of smolt trap operation and from 12+ years of redd counts.

1) Spawning starts in lower basin and progresses upstream. This could be a temperature related issue, more than a distance related issue. Adults have been seen at river mile 11 spawning on February 14. Spawning has also been observed in the Opal creek (confluence with Trout Creek at RM 46) in mid May.

2) Preliminary results from smolt trapping indicate that survival from egg to smolt in Trout Creek is highly variable. Scale information from smolts has indicated the presence of very strong year classes and very weak year classes. While variability in year class strength is not unusual in wild fish populations, the range in variability in Trout Creek summer steelhead might be beyond what would be expected historically.

3) Smolt trapping scale age analysis reveals that the age structure of steelhead smolt out migration has varied widely between sampling years. Age of steelhead smoltification in the Trout Creek basin can vary from 1 to 3 years. The percentage of age one, two and three year old smolts as a total for the outmigration year varies widely from year to year. Sample size for analysis is n=660 in 1998, n=540 in 1999, n=638 in 2000, and n=320 in 2001. Possible factors

are 1) Exceptionally strong egg to fry survival rates resulting in high densities of fry triggering early smoltification or 2) Opportunistic smoltification due to better than average flow conditions.

8.4.1.3 Trout Creek Summer Steelhead Population Status In Relation to the Deschutes River.

There is limited information relative to the past or present abundance of adult and smolt production in the Trout Creek Basin. Several different estimates have been used for both wild returning adults and for smolt production. The most recent published smolt production estimate was in US v Oregon where Trout Creek was estimated to produce 15,698 smolts, (US v Oregon 1987). Using 1998-2001 ODFW smolt trap estimates, which only estimate for the period of operation, every year has resulted in estimates above the US v Oregon estimate.

In an attempt to put the Trout Creek Summer steelhead adult escapement population in relation to the total Deschutes population estimated over Sherars Falls, several parameters used were based on the best available information/knowledge. Therefore, the Trout Creek estimates are not statistically valid, but represent an approximate figure. There are two major factors that account for redd count inaccuracy: 1) The year to year variability of water clarity during redd counts resulting in the increased possibility of missed redds and 2) Prior to 2000, redd counts were limited to single pass early in the spawning season, and thereby increasing the possibility of missing late season spawning. Starting in 2001, redd counts have been done with multiple passes later into the year. Present spawning distribution is estimated at 75 stream miles, and is based on several years of redd count observations.

Multiplying the annual redds/mile by the 75 stream miles of spawning distribution, the estimated number of redds in the Trout Creek Watershed has ranged from 0 redds in 1994 to 1223 redds in 2001. Multiplying the total redds by an average of 2.5 adults per redd (Pribyl S personel communication), the estimated number of adult steelhead in the Trout Creek Watershed ranges from 0 adults in 1994 to 3,075 adults in 2001.

To better understand the percentage of wild adults in the Deschutes basin that utilize the Trout Creek watershed it is necessary to recognize the percentage of hatchery adults that make up the total estimate in Trout Creek. The percentage of hatchery adults that make up the Trout Creek run is difficult estimate based on the limited available information. Observations from redd counts over the past 14 years seem to indicate that a higher percentage of hatchery fish spawn below Degner Canyon than in the upper basin above Amity Creek. Hatchery adults that are observed during redd counts (unless lifeless) are difficult to distinguish out of basin strays from Round Butte stock. The best guess for the hatchery component in Trout Creek would range from 15-40% of the total run. Out of this range the very limited smolt trap data suggests that there is about a 50/50 split between Round Butte Hatchery fish and out of basin strays. The 50/50 split data comes from kelts captured in the smolt trap and very few adults that are positively identified in the field. This apparent 50/50 split is interesting because since the mid 1990's out of basin strays estimated above Sherars falls has out numbered Round Butte hatchery fish by 2 – 4 times. (ODFW, 2001d)

Given the estimate over Sherars Falls and a crude estimate of adults in Trout Creek based on redd counts it appears that Trout Creek is the spawning destination for up to 20-30% of the returning wild Deschutes Summer Steelhead that pass over Sherars Falls.

8.4.1.4 Hatchery/Wild-Stock Interactions

Currently in the Deschutes basin only one hatchery (Round Butte) is releasing summer steelhead smolts into the Deschutes River. There is currently no active stocking program of any fish species in the Trout Creek Watershed. Historical records indicate that there was only one stocking in the Trout Creek basin. This stocking of summer steelhead smolts was in the upper watershed above Ashwood. The purpose of this stocking was to gain information on the time it took a smolt to migrate out of the basin to the Deschutes River. In the Trout Creek Watershed, during smolt trap operations and annual redd counts, both Round Butte hatchery stock and out of basin strays have been observed. Preliminary data suggests that a higher percentage of hatchery fish spawn in the lower portions of Trout Creek, while a higher percentage of wild fish are observed in the upper basin above Ashwood. The percentage of out of basin strays is unknown. However, out of basin (ad only) steelhead have represented 65% of the hatchery fish caught in the smolt trap. The amount of hatchery genetic introgression into the native population has yet to be established. During smolt trapping operation for 2000 and 2001 genetic samples were collected and preserved from smolts and adults. This information has not been analyzed, but will be available to assist in the eventual determination of hatchery introgression into the wild population. Adult hatchery strays (out of basin) are an issue of concern in the Deschutes Basin. The ramification from hatchery genetic introgression is unclear at this time. Several proposals have been submitted to address this issue, but meaningful results are several years away.

A study designed to assess the hatchery component and interaction with the wild population is needed. Are a large percentage of the hatchery adults out of basin strays or closely related Round Butte stock? This needs to be answered, since 25% of the out of basin stray adults are known to test positive for whirling disease (Mark Engleking, personal communication).

8.4.2 Redband Trout (*Oncorhynchus mykiss*)

Resident redband trout population is assumed to be low in the Trout Creek Watershed. There are three sources of data to support this hypothesis. One is due to the low number of resident fish observed at the smolt trap. Two is from the low number of redband observed spawning in the Trout Creek Watershed. However, 4" – 6" trout have been seen constructing redds during steelhead redd counts. All observations of redband spawning have been in the upper basin tributaries such as Cartwright, Big Log, and Dutchman Creeks. Three, due to the rather high number of steelhead smolts estimated emigrating from the basin, it is assumed that the number of resident (*O. mykiss*) is low. This hypothesis is somewhat supported by a study in the lower Trout Creek Basin that found in one tributary where there was steelhead spawning the percent of steelhead progeny redband was 96% (Zimmerman, 2000).

8.4.3 Bull Trout (*Salvelinus confluence*)

Since 1960 bull trout have not been documented in the Trout Creek system. However, bull trout are documented in the Deschutes River at the confluence with Trout Creek (ODFW 1995). Given the large numbers of juvenile sucker and salmonids emigrating form Trout Creek, the potential exists for limited seasonal migration (February - April) into Trout Creek before water temperatures rise above the tolerance level for Bull Trout.

8.4.4 Chinook (Fall and Spring) (*Oncorhynchus tshawytscha*)

With the present hydrologic flow regime in the Trout Creek basin the possibility for Spring or Fall Chinook in the basin is extremely remote. Extremely low stream flow during the spawning period, and the lack of quality adult holding habitat, precludes Chinook from utilizing the Trout Creek Watershed.

8.4.5 Northern Pike Minnow (*Ptychocheilus oregonensis*)

During the spring trapping season there are juvenile northern pike minnow that are migrating out of the basin. Adult fish have been observed to make a spawning run for about one week in the spring. The number of adults trapped is usually around 45, but the efficiency of the trap is unknown. There is probably a large seasonal pike minnow presence in Trout Creek. Pike minnow have been observed in schools of 40-60 fish near the mouth.

8.4.6 Exotic Species

8.4.6.1 Brown Trout (*Salmo trutta*)

No brown trout have been documented in the Trout Creek system. However, brown trout are documented in the Deschutes River at the confluence with Trout Creek. The potential exists for limited seasonal migration into Trout Creek.

8.4.6.2 Brown Bullhead (*Ictalurus nebulosus*)

During operation of the smolt one or two brown bullhead are annually captured during the spring smolt trapping season. It is unknown the range or extent of this population in Trout Creek, but from direct observation it is assumed that there are few brown bullhead in the system. The most likely source for this species is from farmers' ponds or possible downstream migrants from the Pelton Round butte complex.

8.4.6.3 Smallmouth bass (*Micropertes salmoniodies*)

During operation of the smolt one or two small mouth bass are captured during the trapping season. It is unknown the range or extent of this population in Trout Creek, but from direct observation it is assumed that there are few small mouth bass in the system. The likely source for these fish is downstream migrants from the Pelton Round butte complex, or from farmers' stock ponds.

8.4.6.4 Fish species relative abundance captured during smolt trap operation.

Fish species captured	Scientific name	1999	2000
Summer steelhead/redband	*O.mykiss*	5,063	4,243
Summer steelhead (Kelts)	*O.mykiss*	29	22
Adult bridgelip sucker	*Catostomus columbianus,*	3,511	2,845
Adult large-scale sucker	*Catostomus macrocheilus*	1,922	752
Juvenile suckers	*Catostomus columbianus,*	3,957	4,643
Speckled dace	*Rhinichthys osculus*	2,030	841
Long nose dace	*Rhinichthys cataractae*	1,770	691
Red side shiner	*Richardsonius balteatus*	551	312
Mountain Whitefish	*Prosopium williamsoni*	3	45
Chiselmouth	*Acrocheilus alutaceus*	3,288	1,972
Adult Northern pike minnow	*Ptychocheilus oregonensis*	41	26
Juvenile Northern pike minnow	*Ptychocheilus oregonensis*	50	2,635
Small Mouth bass	*Micropertes Salmoniodies*	0	1
Brown bullhead	*Ictalurus nebulosus*	2	1
	TOTAL	**24,802**	**17,686**

8.5 FISH PASSAGE BARRIERS

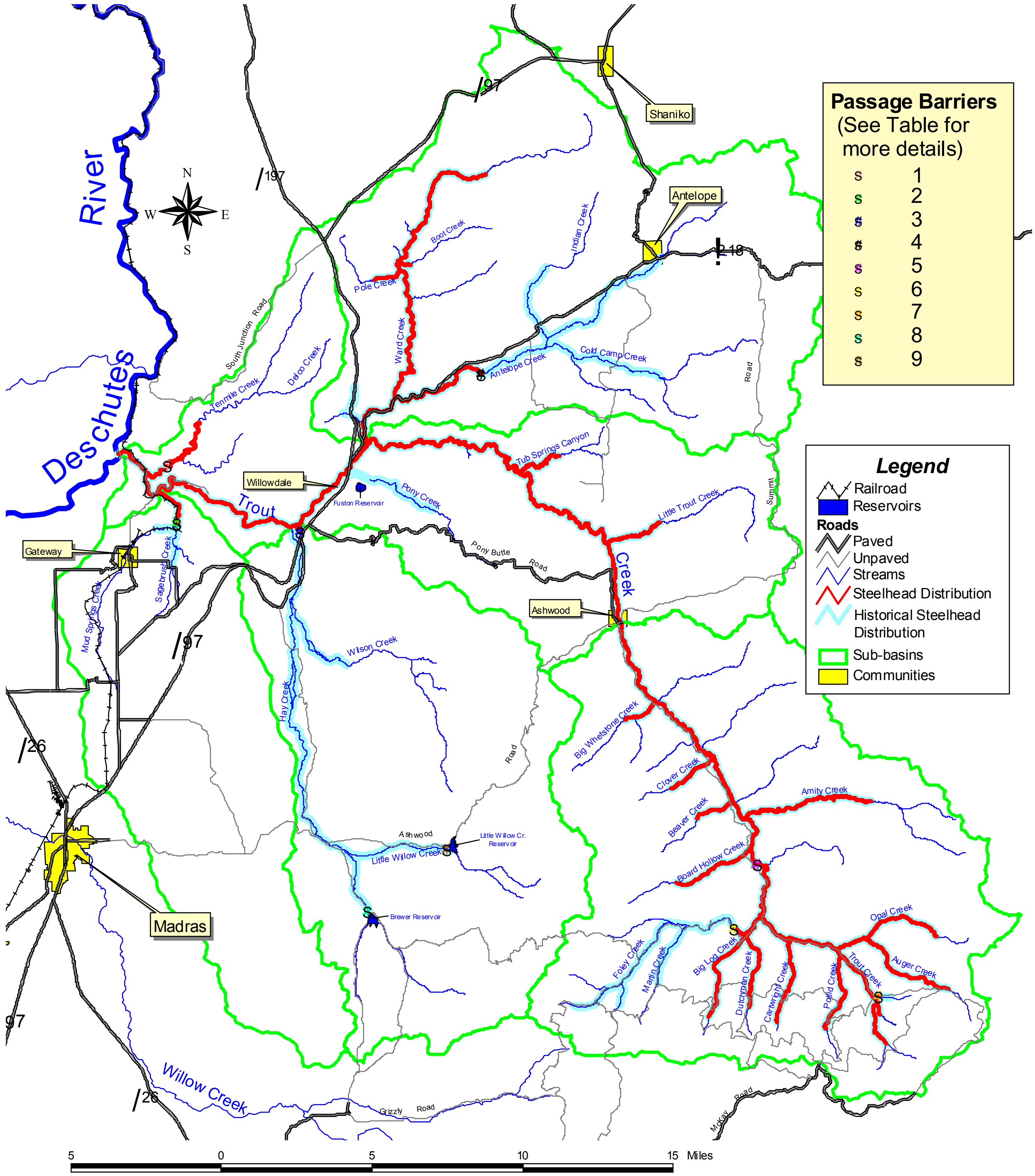


Figure 8-3. Fish Passage Barrier Map. Data Source: ODFW staff.

Table 8-7. Fish Passage Barriers

ID	Stream	River Mile	Description of Barrier	Upstream Habitat
1	Tenmile Creek	1	Natural Falls through basalt bedrock, three 5 foot step pools created in 1988, seasonal adult passage in high flows only.	2.9 miles of good habitat located upstream of falls. Adult steelhead have been rumored to pass above falls in the past.
2	Mud Springs Creek	1.5	Railroad crossing, 12 foot falls out of concrete culvert.	3.9 miles of Mud Springs Creek (fair/poor habitat) and 1.5 miles of Sagebrush Creek (fair/good habitat) upstream of barrier. One possible barrier on sagebrush, five possible on Mud Springs (Railroad Crossings)
3	Hay Creek	0.5	Natural Falls (60 deg slope, 20 feet long). Channel created in 1950's. Located 100 yards downstream of Hwy 97.	Data gap on upstream habitat.
4	Antelope Creek	5.8	Rumored passage barrier, not varified (Head Cut). Creek passable and surveyed by ODFW to river mile 5.	Data gap on upstream habitat.
5	Trout Creek	40.1	Natural Falls. Four foot tall bedrock shelf across Trout Creek. Adult steelhead can pass this barrier.	Upstream habitat is good, majority of steelhead spawing and rearing in the basin occurs above this barrier to other fish.
6	Foley Creek	1.4	Giant boulders and woody debris form barrier. Barrier created in 1996 during flood. Barrier to all fish.	5.9 miles of Foley Creek (good-excellent habitat), 2.1 miles of Martin Creek (good habitat), and 0.8 miles of E. Fork Foley Creek (good habitat) historical habitat.
7	Dick Creek	0.3	Four to five foot drop hanging culvert, 100 feet long, 50 foot of road fill over top of culvert.	Approximately 1 mile of good habitat located upstream of barrier. Good habitat, but small stream. Probable historic use.
8	Hay Creek	13.5	Brewer Reservoir Dam	Unknown upstream fish distribution and habitat condition.
9	Little Willow Cr	3.7	Little Willow Creek Dam	Unknown upstream fish distribution and habitat condition.

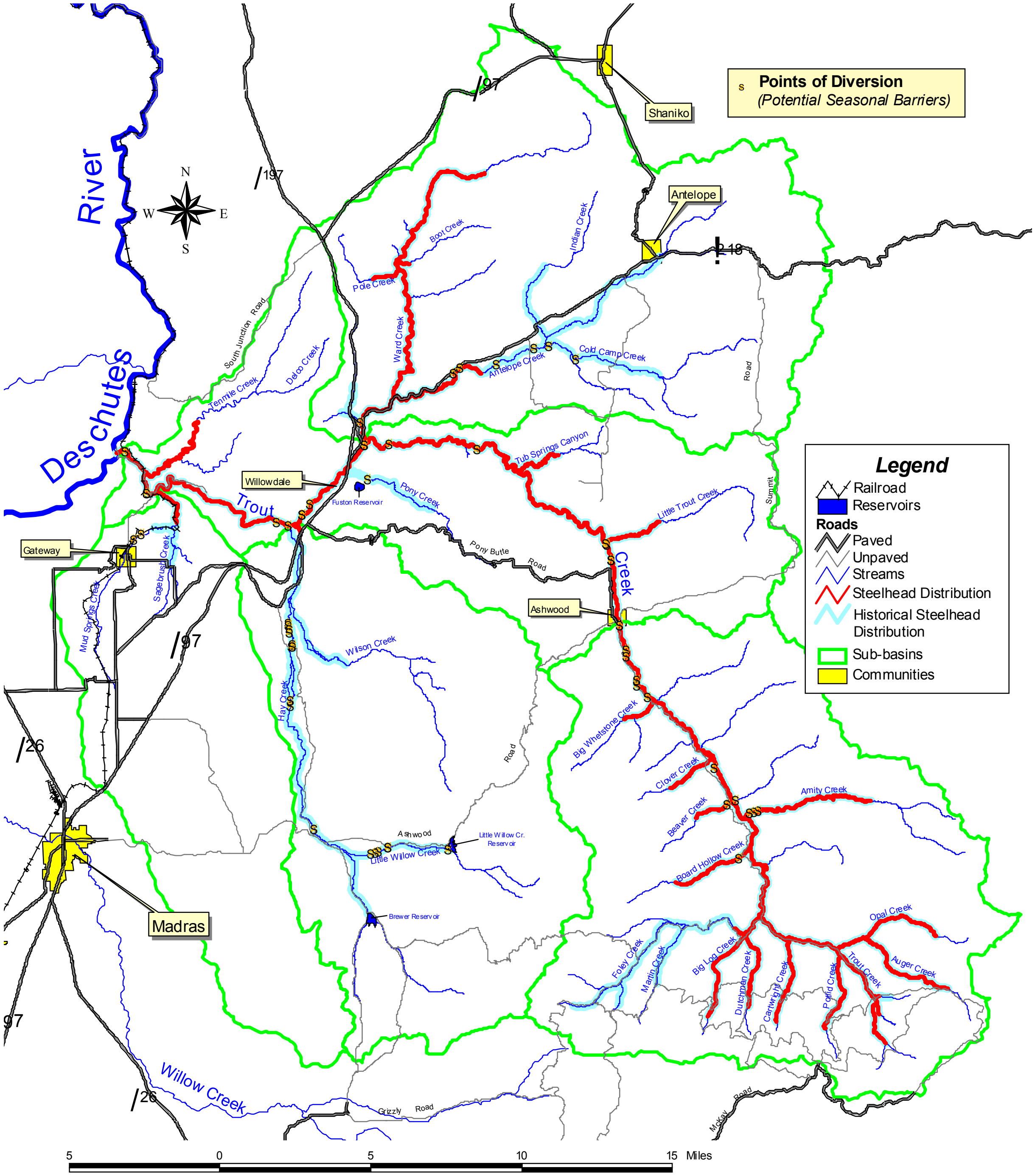


Figure 8-4. Point of Irrigation Diversions Map. Data Sources: OWRD (2001a) Points of diversion converted from gravel pushup dams to infiltration galleries or flashboard structures with fish ladders were eliminated from this data set.

8.6 STREAM CROSSINGS

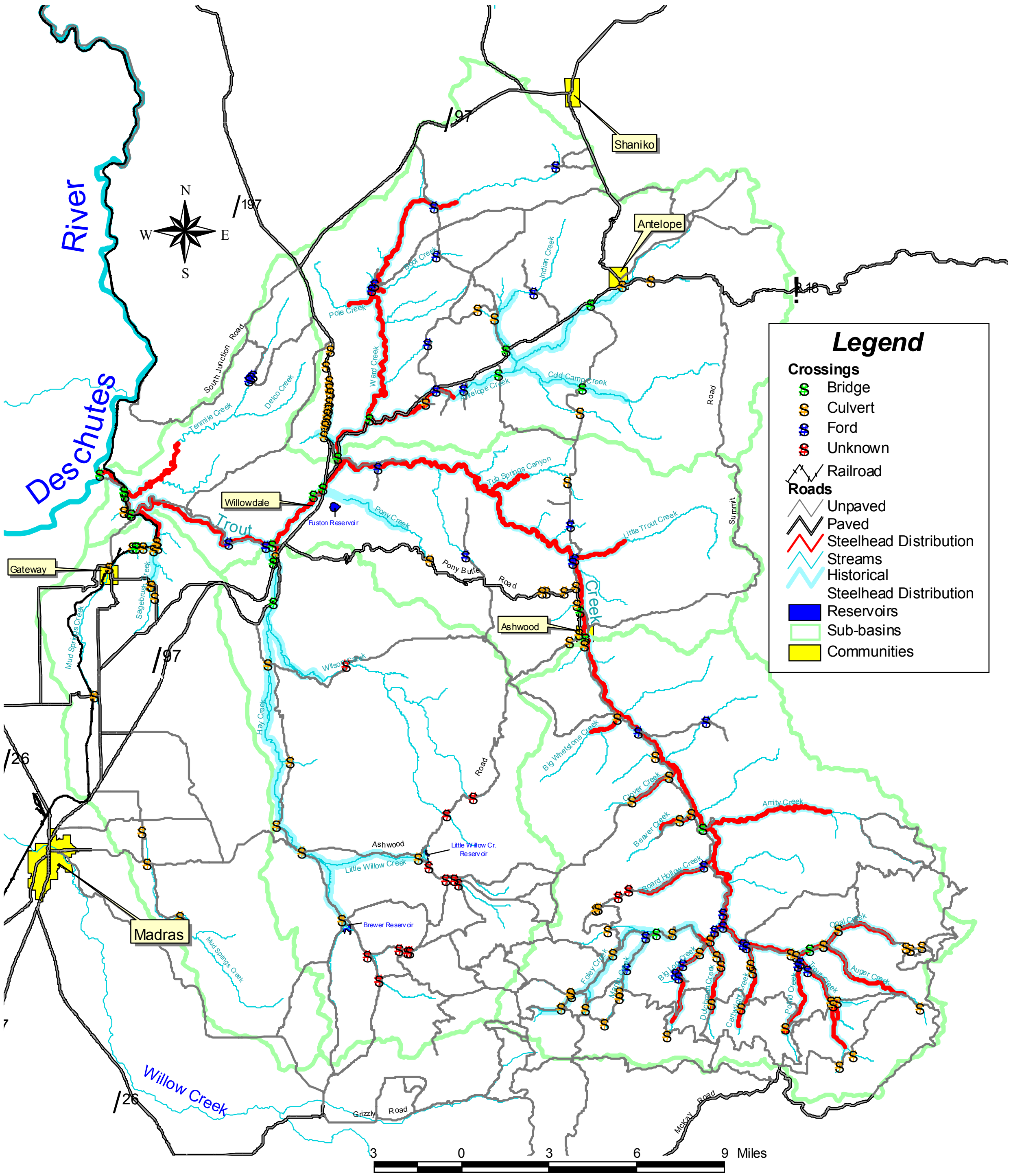


Figure 8-5. Trout Creek Watershed Stream Crossings Map. Data Source: BLM (2001). Crossing types were identified from field knowledge of ODFW and SWCD staff.

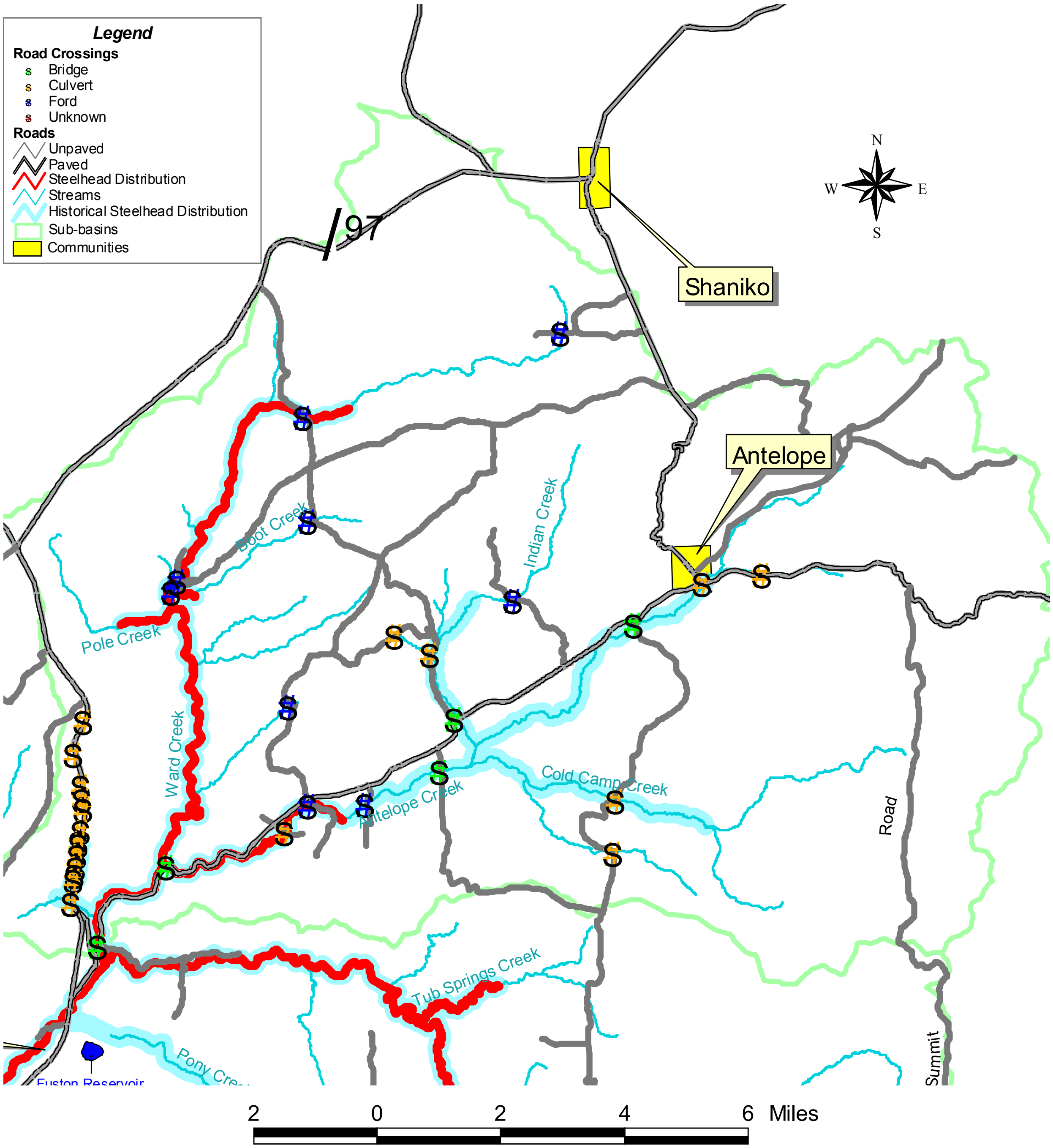


Figure 8-6. Antelope Subbasin Stream/Road Crossing Map.

Table 8-8. Antelope Subbassin Stream/Road Crossings.

Stream Name	Stream Type	Crossing Type	Steelhead Presence		Barrier?
			Historical	Present	
Antelope Creek	Perennial stream	Bridge	Yes	Yes	No
Antelope Creek	Perennial stream	Culvert	Yes	Yes	No
Antelope Creek	Perennial stream	Ford	Yes	No	No
Antelope Creek	Perennial stream	Ford	Yes	Yes	No
Antelope Creek	Perennial stream	Bridge	Yes	No	No
Antelope Creek	Perennial stream	Culvert	Yes	No	Unknown
Antelope Creek	Perennial stream	Bridge	Yes	No	No
Antelope Creek	Perennial stream	Bridge	Yes	Yes	No
Boot Creek	Perennial stream	Ford	Yes	Yes	No
Boot Creek	Perennial stream	Ford	Yes	Yes	No
Cold Camp Creek	Perennial stream	Culvert	Yes	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	No	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	No	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	No	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	No	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	No	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	No	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	Yes	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	Yes	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	Yes	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	Yes	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	Yes	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	Yes	No	Unknown
Cow Canyon Creek	Intermittent stream	Culvert	No	No	Unknown
Deadmans Canyon Creek	Intermittent stream	Ford	No	No	No
Grub Hollow Creek	Perennial stream	Culvert	No	No	Unknown
Indian Creek	Perennial stream	Bridge	Yes	No	No
Indian Creek	Perennial stream	Ford	No	No	No
King Creek	Intermittent stream	Culvert	No	No	Unknown
Unn Trib to Indian Creek	Perennial stream	Culvert	No	No	Unknown
Unn Trib to Indian Creek	Perennial stream	Culvert	No	No	Unknown
Unn Trib to Ward Creek	Intermittent stream	Ford	No	No	No
Ward Creek	Perennial stream	Ford	Yes	Yes	No
Ward Creek	Perennial stream	Ford	Yes	Yes	No

Table 8-9 Antelope Subbasin Stream/Road Crossings Summary.

Stream Name	Stream Type		Crossing Type				Located in Steelhead Distribution Area		Passage Barrier		
	Int.	Per.	Bridge	Culvert	Ford	Unknown	Historical	Present	Yes	No	Unknown
Antelope Creek	0	8	4	2	2	0	8	4	0	7	1
Boot Creek	0	2	0	0	2	0	2	2	0	2	0
Cold Camp Creek	0	1	0	1	0	0	1	0	0	0	1
Cow Canyon Creek	13	0	0	13	0	0	6	0	0	0	13
Deadmans Canyon Creek	1	0	0	0	1	0	0	0	0	1	0
Grub Hollow Creek	0	1	0	1	0	0	0	0	0	0	1
Indian Creek	0	2	1	0	1	0	1	0	0	2	0
King Creek	1	0	0	1	0	0	0	0	0	0	1
Unn Trib to Indian Creek	0	2	0	2	0	0	0	0	0	0	2
Unn Trib to Ward Creek	1	0	0	0	1	0	0	0	0	1	0
Ward Creek	0	2	0	0	2	0	2	2	0	2	0
Totals	**16**	**18**	**5**	**20**	**9**	**0**	**20**	**8**	**0**	**15**	**19**

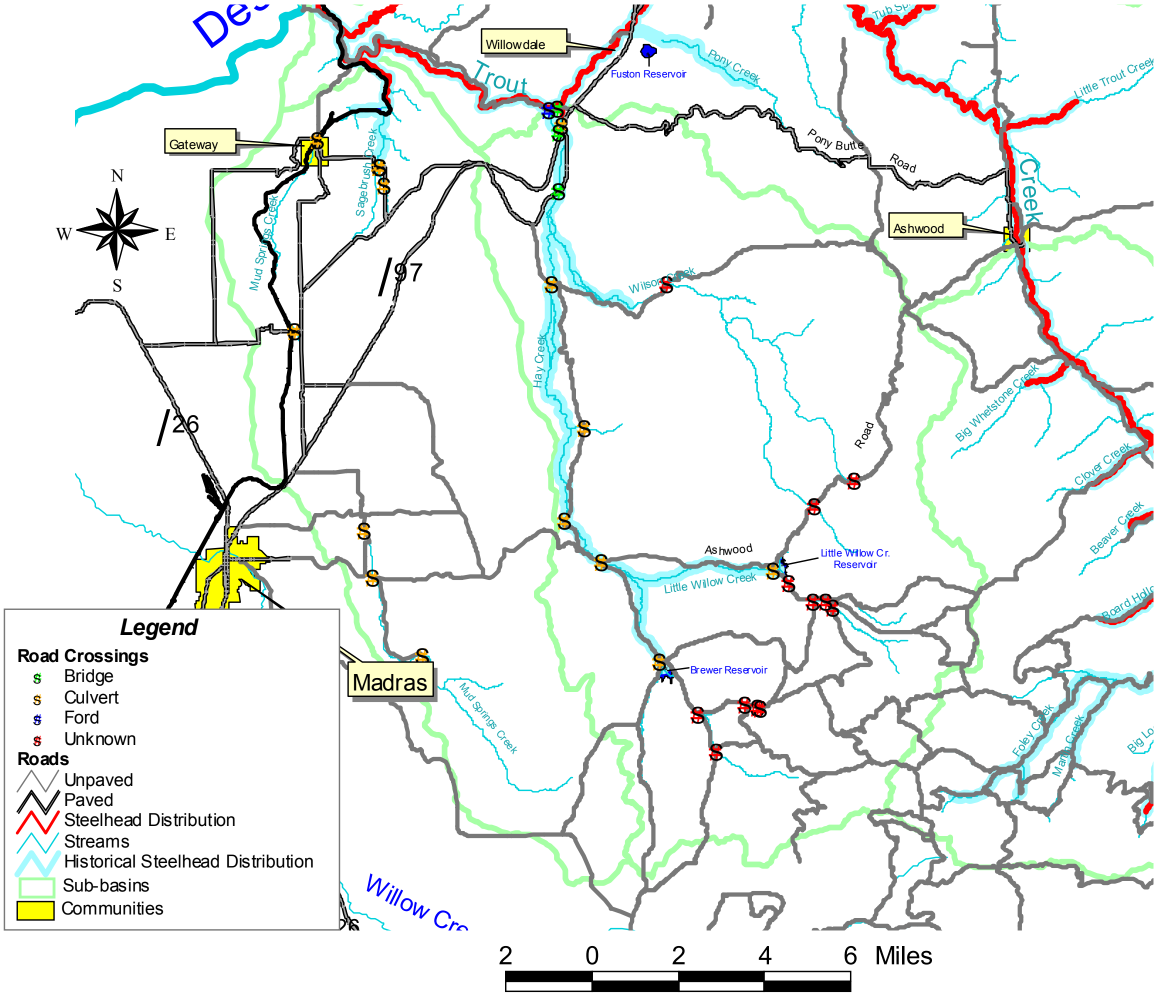


Figure 8-7. Hay Creek/Mud Springs Creek Subbasins Road/Stream Crossings Map.

Table 8-10. Hay Creek Subbasin Road/Stream Crossings

Stream Name	Stream Type	Crossing Type	Steelhead Distribution		Barrier?
			Historical	Present	
Awbrey Creek	Perennial stream	Unknown	No	No	Unknown
Awbrey Creek	Intermittent stream	Unknown	No	No	Unknown
Dry Creek (Hay Ck trib)	Intermittent stream	Culvert	No	No	Unknown
Hay Creek	Intermittent stream	Bridge	Yes	Yes	No
Hay Creek	Perennial stream	Ford	Yes	No	No
Hay Creek	Intermittent stream	Culvert	No	No	Unknown
Hay Creek	Intermittent stream	Bridge	Yes	No	No
Hay Creek	Intermittent stream	Bridge	Yes	No	No
Hay Creek	Intermittent stream	Culvert	Yes	No	Unknown
Hay Creek	Perennial stream	Culvert	Yes	No	Unknown
Hay Creek	Intermittent stream	Culvert	Yes	No	Unknown
Hay Creek	Intermittent stream	Culvert	Yes	No	Unknown
Jim Creek (Awbrey Ck trib)	Intermittent stream	Unknown	No	No	Unknown
Jim Creek (Awbrey Ck trib)	Intermittent stream	Unknown	No	No	Unknown
Jim Creek (Little Willow Ck trib)	Intermittent stream	Unknown	No	No	Unknown
Jim Creek (Awbrey Ck trib)	Intermittent stream	Unknown	No	No	Unknown
Little Willow Creek	Perennial stream	Unknown	No	No	Unknown
Little Willow Creek	Perennial stream	Unknown	No	No	Unknown
Little Willow Creek	Intermittent stream	Culvert	Yes	No	Unknown
Little Willow Creek	Perennial stream	Unknown	No	No	Unknown
Teller Creek	Intermittent stream	Unknown	No	No	Unknown
Wilson Creek	Intermittent stream	Unknown	No	No	Unknown
Wilson Creek	Intermittent stream	Unknown	No	No	Unknown

Table 8-11. Hay Creek Subbasin Road/Stream Crossings Summary.

Stream Name	Stream Type		Crossing Type				Located in Steelhead Distribution Area		Passage Barrier		
	Int.	Per.	Bridge	Culvert	Ford	Unknown	Historical	Present	Yes	No	Unknown
Awbrey Creek	1	1	0	0	0	2	0	0	0	0	2
Dry Creek (Trout Ck trib)	1	0	0	1	0	0	0	0	0	0	1
Hay Creek	7	2	3	5	1	0	8	1	0	4	5
Jim Creek (Awbrey Ck trib)	3	0	0	0	0	3	0	0	0	0	3
Jim Creek (Little Willow Ck trib)	1	0	0	0	0	1	0	0	0	0	1
Little Willow Creek	1	3	0	1	0	3	1	0	0	0	4
Teller Creek	1	0	0	0	0	1	0	0	0	0	1
Wilson Creek	2	0	0	0	0	2	0	0	0	0	2
Totals	**17**	**6**	**3**	**7**	**1**	**12**	**9**	**1**	**0**	**4**	**19**

Table 8-12. Mud Springs Creek Subbasin Road/Stream Crossings.

Stream Name	Stream Type	Crossing Type	Steelhead Presence		Barrier
			Historical	Present	
Mud Springs Creek	Intermittent stream	Culvert	No	No	Unknown
Mud Springs Creek	Intermittent stream	Culvert	No	No	Unknown
Mud Springs Creek	Perennial stream	Culvert	No	No	No
Mud Springs Creek	Intermittent stream	Culvert	No	No	Unknown
Mud Springs Creek	Intermittent stream	Culvert	No	No	Unknown
Unn Trib to Sagebrush Creek	Perennial stream	Culvert	No	No	Unknown
Unn Trib to Sagebrush Creek	Intermittent stream	Culvert	No	No	Unknown
Unn Trib to Sagebrush Creek	Intermittent stream	Culvert	No	No	Unknown

Table 8-13. Mud Springs Creek Subbasin Road/Stream Crossings Summary.

Stream Name	Stream Type		Crossing Type				Located in Steelhead Distribution Area		Passage Barrier		
	Int.	Per.	Bridge	Culvert	Ford	Unknown	Historical	Present	Yes	No	Unknown
Mud Springs Creek	4	1	0	5	0	0	0	0	0	1	4
Unn Trib to Sagebrush Creek	2	1	0	3	0	0	0	0	0	0	3
Total	**6**	**2**	**0**	**8**	**0**	**0**	**0**	**0**	**0**	**1**	**7**

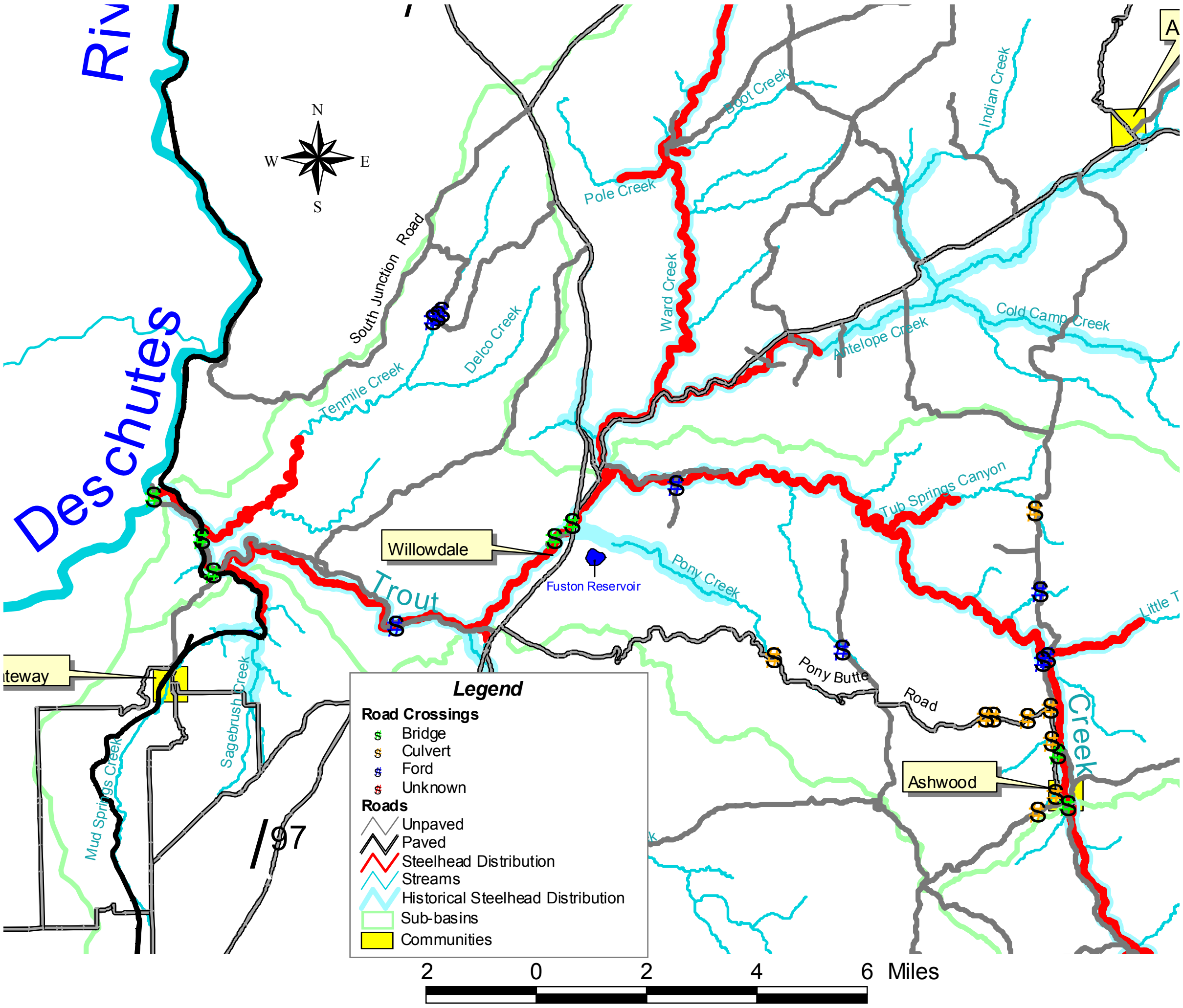


Figure 8-8. Lower Trout Creek Subbasin Road/Stream Crossings Map.

Table 8-14. Lower Trout Creek Subbasin Road/Stream Crossings.

Stream Name	Stream Type	Crossing Type	Steelhead Presence		Barrier?
			Historical	Present	
Blind Canyon Creek	Intermittent stream	Ford	No	No	No
Dry Creek (Trout Ck trib)	Intermittent stream	Culvert	No	No	Unknown
Juniper Creek	Intermittent stream	Ford	No	No	No
Kirkbride Canyon Creek	Intermittent stream	Culvert	No	No	Unknown
Little Trout Creek	Intermittent stream	Ford	Yes	Yes	No
Pony Creek	Intermittent stream	Culvert	No	No	Unknown
Tenmile Creek	Perennial stream	Ford	No	No	No
Tenmile Creek	Perennial stream	Ford	No	No	No
Tenmile Creek	Perennial stream	Ford	No	No	No
Timber Culture Gulch	Intermittent stream	Culvert	No	No	Unknown
Timber Culture Gulch	Intermittent stream	Culvert	No	No	Unknown
Timber Culture Gulch	Intermittent stream	Culvert	No	No	Unknown
Timber Culture Gulch	Intermittent stream	Culvert	No	No	Unknown
Trout Creek	Intermittent stream	Bridge	Yes	Yes	No
Trout Creek	Intermittent stream	Ford	Yes	Yes	No
Trout Creek	Intermittent stream	Bridge	Yes	Yes	No
Trout Creek	Perennial stream	Ford	Yes	Yes	No
Trout Creek	Perennial stream	Bridge	Yes	Yes	No
Trout Creek	Perennial stream	Ford	Yes	Yes	No
Trout Creek	Perennial stream	Bridge	Yes	Yes	No
Trout Creek	CL-Perennial stream	Bridge	Yes	Yes	No
Trout Creek	CL-Perennial stream	Bridge	Yes	Yes	No
Trout Creek	CL-Perennial stream	Bridge	Yes	Yes	No
Woods Hollow Creek	Intermittent stream	Culvert	No	No	Unknown
Woods Hollow Creek	Intermittent stream	Culvert	No	No	Unknown

Table 8-15. Lower Trout Creek Subbasin Road/Stream Crossings Summary.

Stream Name	Stream Type		Crossing Type				Located in Steelhead Distribution Area		Passage Barrier		
	Int..	Per.	Bridge	Culvert	Ford	Unknown	Historical	Present	Yes	No	Unknown
Blind Canyon Creek	1	0	0	0	1	0	0	0	0	1	0
Dry Creek (Trout Ck trib)	1	0	0	1	0	0	0	0	0	0	1
Juniper Creek	1	0	0	0	1	0	0	0	0	1	0
Kirkbride Canyon Creek	1	0	0	1	0	0	0	0	0	0	1
Little Trout Creek	1	0	0	0	1	0	1	1	0	1	0
Pony Creek	1	0	0	1	0	0	0	0	0	1	0
Tenmile Creek	0	3	0	0	3	0	0	0	0	0	3
Timber Culture Gulch	4	0	0	4	0	0	0	0	0	0	4
Trout Creek	3	7	7	0	3	0	10	10	0	10	0
Woods Hollow Creek	2	0	0	2	0	0	0	0	0	0	2
Totals	**13**	**10**	**7**	**8**	**8**	**0**	**11**	**11**	**0**	**13**	**10**

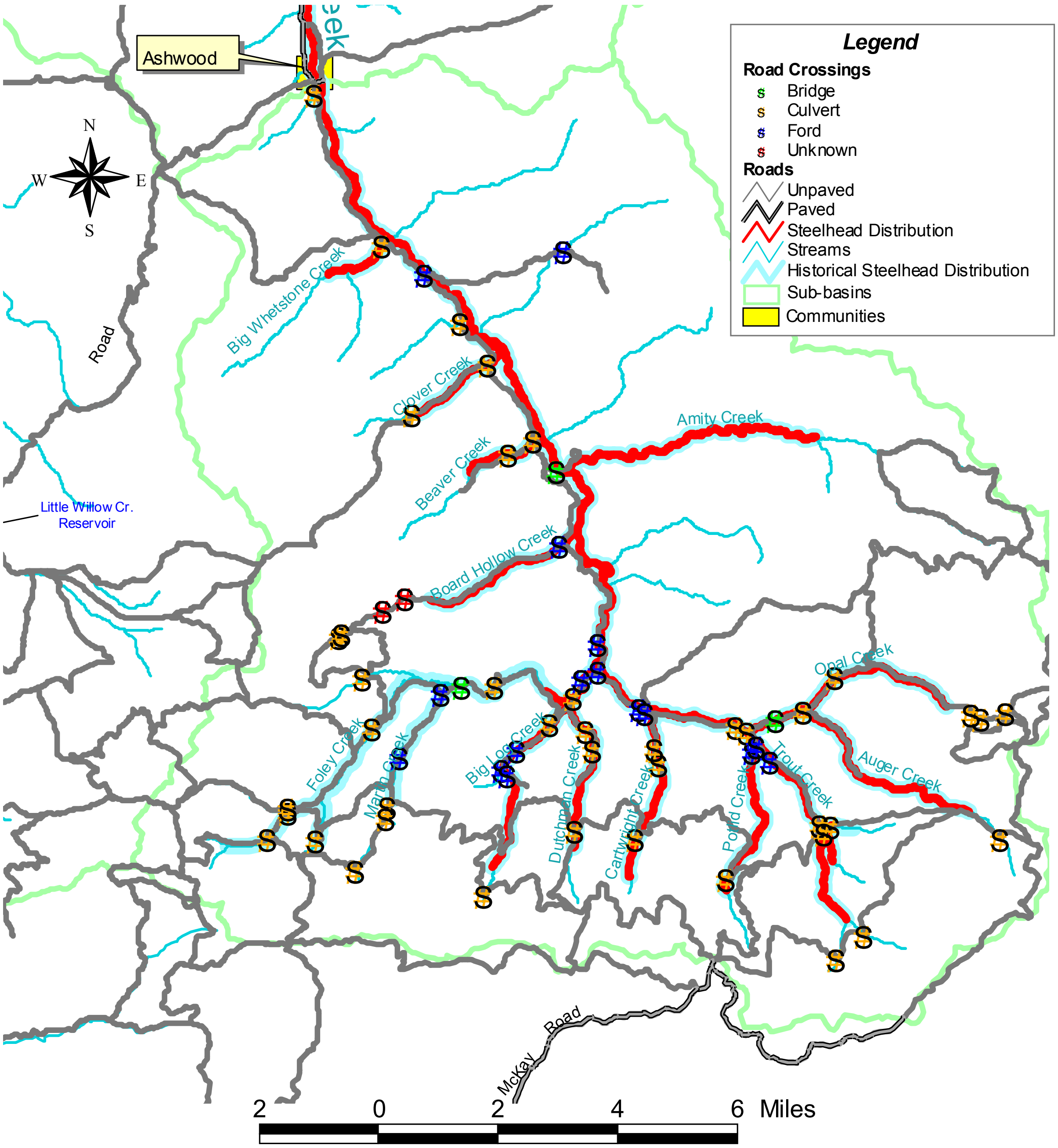


Figure 8-9. Upper Trout Creek Subbasin Road/Stream Crossings Map.

Table 8-16. Upper Trout Creek Subbasin Road/Stream Crossings.

Stream Name	Stream Type	Crossing Type	Steelhead Presence		Barrier
			Historical	Present	
Auger Creek	Perennial stream	Culvert	Yes	Yes	No
Auger Creek	Perennial stream	Culvert	Yes	Yes	No
Auger Creek	Perennial stream	Culvert	No	No	Yes
Barber Creek	Perennial stream	Culvert	No	No	Unknown
Beaver Creek	Intermittent stream	Ford	Yes	Yes	No
Beaver Creek	Intermittent stream	Culvert	Yes	Yes	No
Big Log Creek	Perennial stream	Ford	Yes	Yes	No
Big Log Creek	Perennial stream	Ford	Yes	Yes	No
Big Log Creek	Perennial stream	Culvert	Yes	Yes	No
Big Log Creek	Intermittent stream	Culvert	No	No	Unknown
Big Whetstone Creek	Perennial stream	Culvert	Yes	Yes	No
Board Hollow Creek	Perennial stream	Unknown	No	No	Unknown
Board Hollow Creek	Perennial stream	Unknown	No	No	Unknown
Board Hollow Creek	Intermittent stream	Culvert	No	No	Unknown
Board Hollow Creek	Intermittent stream	Culvert	No	No	Unknown
Board Hollow Creek	Perennial stream	Ford	Yes	Yes	No
Cartwright Creek	Perennial stream	Culvert	Yes	Yes	No
Cartwright Creek	Perennial stream	Culvert	Yes	Yes	No
Cartwright Creek	Perennial stream	Culvert	Yes	Yes	No
Cartwright Creek	Perennial stream	Ford	Yes	Yes	No
Clover Creek	Perennial stream	Culvert	No	No	Unknown
Clover Creek	Perennial stream	Culvert	Yes	Yes	No
Dick Creek	Perennial stream	Culvert	Yes	Yes	Yes
Dick Creek	Perennial stream	Culvert	Yes	Yes	No
Dutchman Creek	Perennial stream	Culvert	Yes	Yes	No
Dutchman Creek	Perennial stream	Culvert	Yes	Yes	No
Dutchman Creek	Perennial stream	Culvert	Yes	Yes	No
Dutchman Creek	Perennial stream	Culvert	Yes	Yes	No
East Fork Foley Creek	Intermittent stream	Culvert	Yes	No	No
Foley Creek	Intermittent stream	Culvert	Yes	No	Yes
Foley Creek	Perennial stream	Culvert	Yes	No	No
Foley Creek	Perennial stream	Bridge	Yes	No	No
Foley Creek	Perennial stream	Culvert	Yes	No	No
Foley Creek	Intermittent stream	Culvert	Yes	No	No
Martin Creek	Perennial stream	Ford	Yes	No	No
Martin Creek	Perennial stream	Ford	Yes	No	No
Martin Creek	Intermittent stream	Culvert	Yes	No	No
Martin Creek	Intermittent stream	Culvert	No	No	No
Opal Creek	Perennial stream	Culvert	Yes	Yes	No

Table 8-16. (Cont.) Upper Trout Creek Subbasin Road/Stream Crossings.

Stream Name	Stream Type	Crossing Type	Steelhead Presence		Barrier
			Historical	Present	
Opal Creek	Perennial stream	Culvert	No	No	No
Opal Creek	Perennial stream	Culvert	No	No	Yes
Opal Creek	Perennial stream	Culvert	No	No	No
Opal Creek	Perennial stream	Culvert	Yes	Yes	No
Opal Creek	Perennial stream	Bridge	Yes	Yes	No
Potlid Creek	Perennial stream	Culvert	Yes	Yes	No
Potlid Creek	Perennial stream	Ford	Yes	Yes	No
Slaughterhouse Gulch	Intermittent stream	Culvert	No	No	Unknown
Thompson Creek	Perennial stream	Ford	No	No	No
Tin Can Draw Creek	Intermittent stream	Culvert	No	No	Unknown
Trout Creek	Perennial stream	Ford	Yes	Yes	No
Trout Creek	Perennial stream	Ford	Yes	Yes	No
Trout Creek	Perennial stream	Culvert	Yes	Yes	No
Trout Creek	Perennial stream	Ford	Yes	Yes	No
Trout Creek	Perennial stream	Ford	Yes	Yes	No
Trout Creek	Perennial stream	Culvert	Yes	Yes	No
Trout Creek	Perennial stream	Culvert	No	No	Yes
Trout Creek	Perennial stream	Ford	No	No	No
Trout Creek	Perennial stream	Bridge	Yes	Yes	No
Trout Creek	Perennial stream	Ford	Yes	Yes	No
Unn trib to Big Log Creek	Intermittent stream	Ford	Yes	Yes	No
Unn Trib to Foley Creek	Intermittent stream	Culvert	No	No	Yes
Unn Trib to Martin Creek	Intermittent stream	Unknown	No	No	Yes
West Fork Trout Creek	Perennial stream	Culvert	No	No	No

Table 8-17. Upper Trout Creek Subbasin Road/Stream Crossings Summary.

Stream Name	Stream Type		Crossing Type				Located in Steelhead Distribution Area		Passage Barrier		
	Intermittent	Perennial	Bridge	Culvert	Ford	Unknown	Historical	Present	Yes	No	Unknown
Auger Creek	0	3	0	3	0	0	2	2	1	2	0
Barber Creek	0	1	0	1	0	0	0	0	0	0	1
Beaver Creek	2	0	0	1	1	0	2	2	0	2	0
Big Log Creek	1	3	0	2	2	0	3	3	0	3	1
Big Whetstone Creek	0	1	0	1	0	0	1	1	0	1	0
Board Hollow Creek	2	3	0	2	1	2	1	1	0	1	4
Cartwright Creek	0	4	0	3	1	0	4	4	0	4	0
Clover Creek	0	2	0	2	0	0	1	1	0	1	1
Dick Creek	0	2	0	2	0	0	2	2	1	1	0
Dutchman Creek	0	4	0	4	0	0	4	4	0	4	0
East Fork Foley Creek	1	0	0	1	0	0	1	0	0	1	0
Foley Creek	2	3	1	4	0	0	5	2	1	4	0
Martin Creek	2	2	0	2	2	0	3	0	0	4	0
Opal Creek	3	3	1	5	0	0	3	3	1	5	0
Potlid Creek	0	2	0	1	1	0	2	2	0	2	0
Slaughterhouse Gulch	1	0	0	1	0	0	0	0	0	0	1
Thompson Creek	0	1	0	0	1	0	0	0	0	1	0
Tin Can Draw Creek	1	0	0	1	0	0	0	0	0	0	1
Trout Creek	0	10	1	3	6	0	8	8	1	9	0
Unn Trib to Foley Creek	1	0	0	1	0	0	0	0	1	0	0
Unn Trib to Martin Creek	1	0	0	1	0	0	0	0	1	0	0
Unn Trib to Big Log Ck	1	0	0	0	1	0	1	1	0	1	0
West Fork Trout Creek	0	1	0	1	0	0	0	0	0	1	0
Total	**18**	**45**	**3**	**42**	**16**	**2**	**43**	**36**	**7**	**47**	**9**

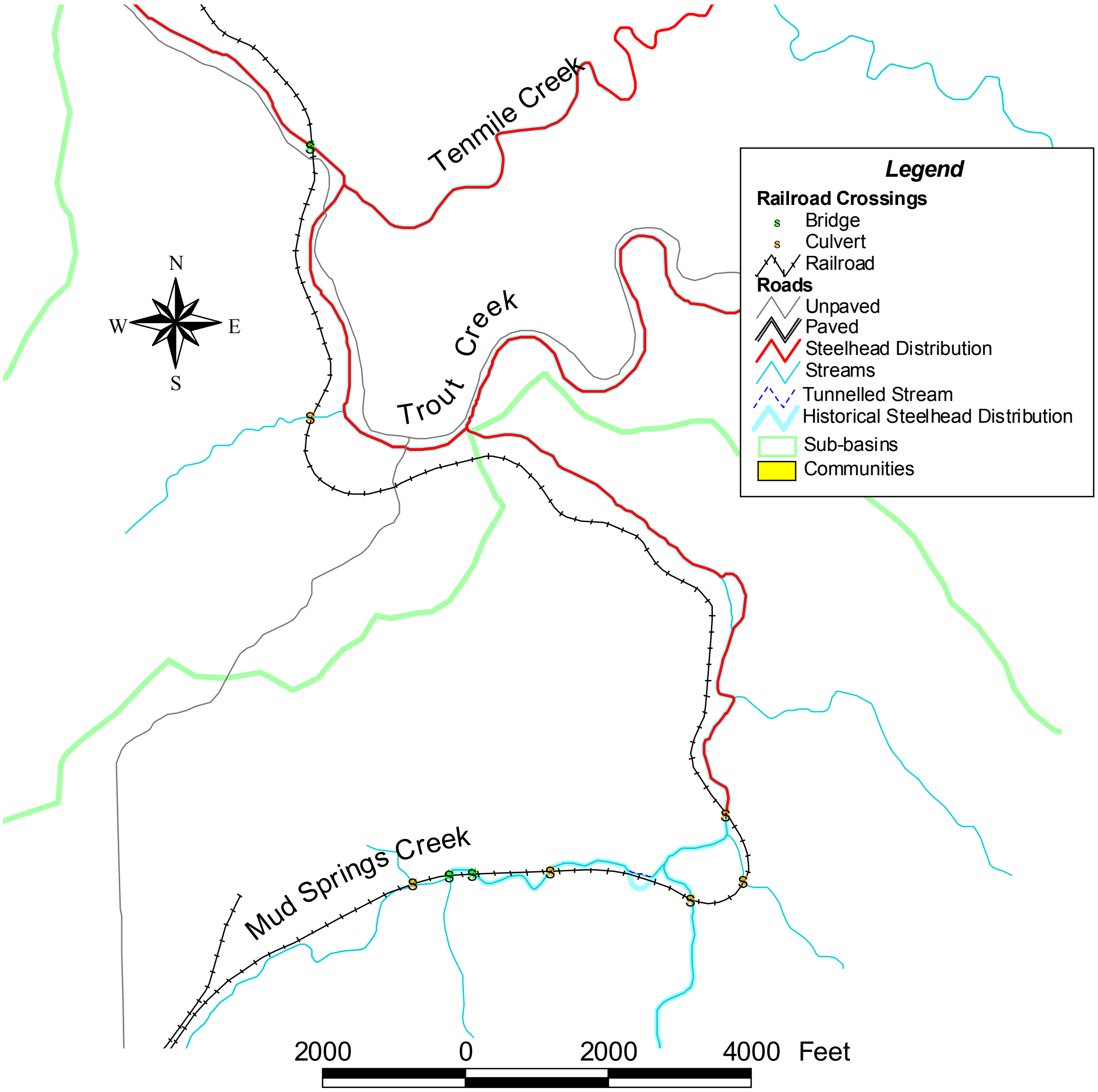


Figure 8-10. Trout Creek Watershed Railroad/Stream Crossings Map.

Table 8-18. Trout Creek Watershed Railroad/Stream Crossings.

Stream Name	Subbasin	Stream Type	Crossing Type	Steelhead Presence		Barrier?
				Historical	Present	
Mud Springs Ck	Mud Springs Ck	Perrenial	Culvert	Yes	Yes	Yes
Mud Springs Ck	Mud Springs Ck	Perrenial	Culvert	Yes	No	Unknown
Mud Springs Ck	Mud Springs Ck	Perrenial	Bridge	Yes	No	No
Mud Springs Ck	Mud Springs Ck	Perrenial	Bridge	Yes	No	No
Sagebrush Creek	Mud Springs Ck	Perrenial	Culvert	Yes	No	Unknown
Trout Creek	Lower Trout Ck	Perrenial	Bridge	Yes	Yes	No
Unn Trib to Mud Springs Ck	Mud Springs Ck	Intermittent	Culvert	No	No	Unknown
Unn Trib to Mud Springs Ck	Mud Springs Ck	Intermittent	Culvert	No	No	Unknown
Unn Trib to Trout Creek	Lower Trout	Intermittent	Culvert	No	No	Unknown

Table 8-19. Trout Creek Watershed Railroad/Stream Crossings Summary.

Stream Name	Stream Type		Crossing Type			Located in Steelhead Distribution Area		Passage Barrier		
	Intermittent	Perenial	Bridge	Culvert	Unknown	Historical	Present	Yes	No	Unknown
Mud Springs Ck	0	4	2	2	0	4	1	1	2	1
Sagebrush Creek	0	1	0	1	0	1	0	0	0	1
Trout Creek	0	1	1	0	0	1	1	0	1	0
Unn Trib to Mud Springs Creek	1	0	0	1	0	0	0	0	0	1
Unn Trib to Mud Springs Creek	1	0	0	1	0	0	0	0	0	1
Unn Trib to Trout Creek	1	0	0	1	0	0	0	0	0	1
Totals	**3**	**6**	**3**	**6**	**0**	**6**	**2**	**1**	**3**	**5**

8.7 HABITAT RATING FOR PHYSICAL HABITAT PARAMETERS

Present habitat conditions were derived from the 1998 ODFW physical habitat survey. Habitat rating, or *Habrate* was developed by Jen Burke (ODFW, 2001c). The physical habitat parameter rating system for *habrate* is based on existing peer reviewed literature. It is important to remember that *habrate* only considers the instream physical habitat parameters, and not other critical parameters such as stream temperature, stream flow, and the riparian vegetative component.

The following set of maps and corresponding tables represent the instream physical habitat conditions from the 1998 ODFW Physical Habitat Survey. The instream physical habitat conditions for summer steelhead were rated on the following life history stages; spawning, summer rearing (age 0+), winter rearing (age 0+, 1+), and summer rearing (age 1+).

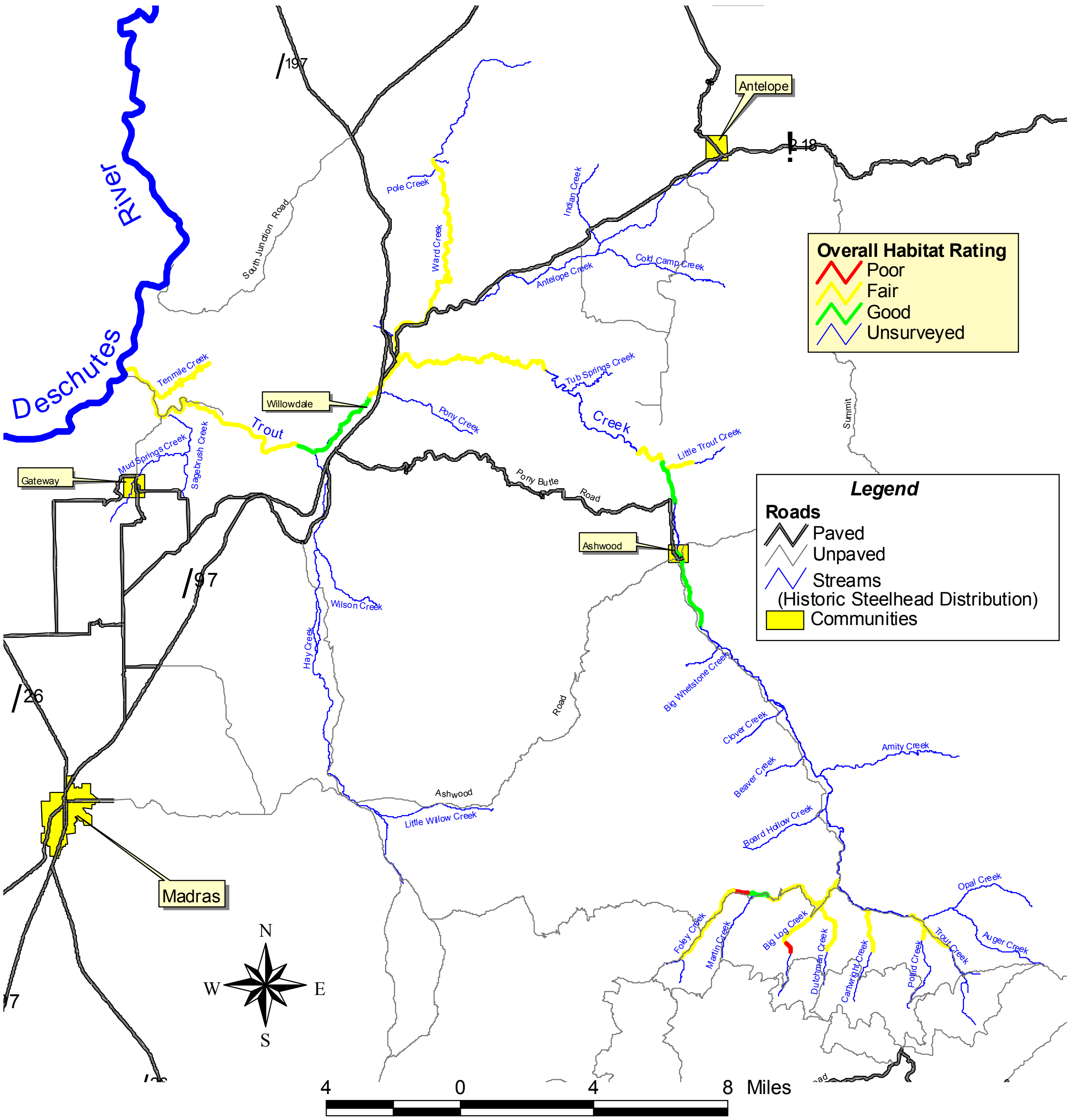


Figure 8-11. Summer Steelhead Instream Habitat Conditons, Spawning. Data Sources: ODFW (1998, 2001, 2001c). *Habrate* only considers the instream physical habitat parameters, and not other critical parameters such as stream temperature, stream flow, and the riparian vegetative component.

Table 8-20. Summer Steelhead Instream Habitat Conditons, Spawning. Data Sources: ODFW (1998, 2001c).

Stream	Reach	River Mile	Substrate	Morphology	Overall Habitat Rating
TROUT CREEK	1	0-2.2	3	2	**2**
TROUT CREEK	2	2.2-8.1	3	2	**2**
TROUT CREEK	3	8.1-11.3	3	3	**3**
TROUT CREEK	4	11.3-12.8	3	2	**2**
TROUT CREEK	5	12.8-14.9	3	2	**2**
TROUT CREEK	6	14.9-18.5	3	2	**2**
TROUT CREEK	*UNS 7	18.5-23.9	x	x	**X**
TROUT CREEK	8	23.9-25.2	3	2	**2**
TROUT CREEK	9	25.2-26.6	3	3	**3**
TROUT CREEK	*UNS 10	26.6-28.2	x	x	**X**
TROUT CREEK	11	28.2-30.7	3	3	**3**
TROUT CREEK	*UNS 12	30.7-44.4	x	x	**X**
TROUT CREEK	13	44.4-44.7	3	2	**2**
TROUT CREEK	14	44.7-45.0	3	2	**2**
TROUT CREEK	15	45.0-45.9	3	2	**2**
ANTELOPE CREEK	1	0-1.7	2	2	**2**
ANTELOPE CREEK	2	1.7-2.3	2	2	**2**
WARD CREEK	1	0-5.2	2	3	**2**
TENMILE CREEK	1	0-1.4	3	2	**2**
TENMILE CREEK	2	1.4-2.3	3	2	**2**
POTLID CREEK	1	0-0.5	3	2	**2**
POTLID CREEK	2	0.5-0.7	3	2	**2**
CARTWRIGHT CREEK	1	0-0.2	3	2	**2**
CARTWRIGHT CREEK	2	0.2-1.0	3	2	**2**
CARTWRIGHT CREEK	3	1.0-1.4	3	2	**2**
DUTCHMAN CREEK	1	0-0.1	3	2	**2**
DUTCHMAN CREEK	2	0.1-0.7	3	2	**2**
DUTCHMAN CREEK	3	0.7-1.6	3	2	**2**
BIG LOG CREEK	1	0-0.6	3	2	**2**
BIG LOG CREEK	2	0.6-2.0	3	2	**2**
BIG LOG CREEK	3	2.0-2.1	3	1	**1**
FOLEY CREEK	1	0-0.4	3	2	**2**
FOLEY CREEK	2	0.4-1.3	3	2	**2**
FOLEY CREEK	3	1.3-2.4	3	2	**2**
FOLEY CREEK	4	2.4-3.1	3	2	**2**
FOLEY CREEK	5	3.1-3.9	3	3	**3**
FOLEY CREEK	6	3.9-4.3	1	2	**1**
FOLEY CREEK	7	4.3-5.1	3	2	**2**
FOLEY CREEK	8	5.1-7.5	3	2	**2**
FOLEY CREEK	9	7.5-7.6	3	2	**2**
LITTLE TROUT CREEK	1	0-0.9	3	2	**2**

*** Unsurveyed Reach 1=Poor, 2=Fair, 3=Good**

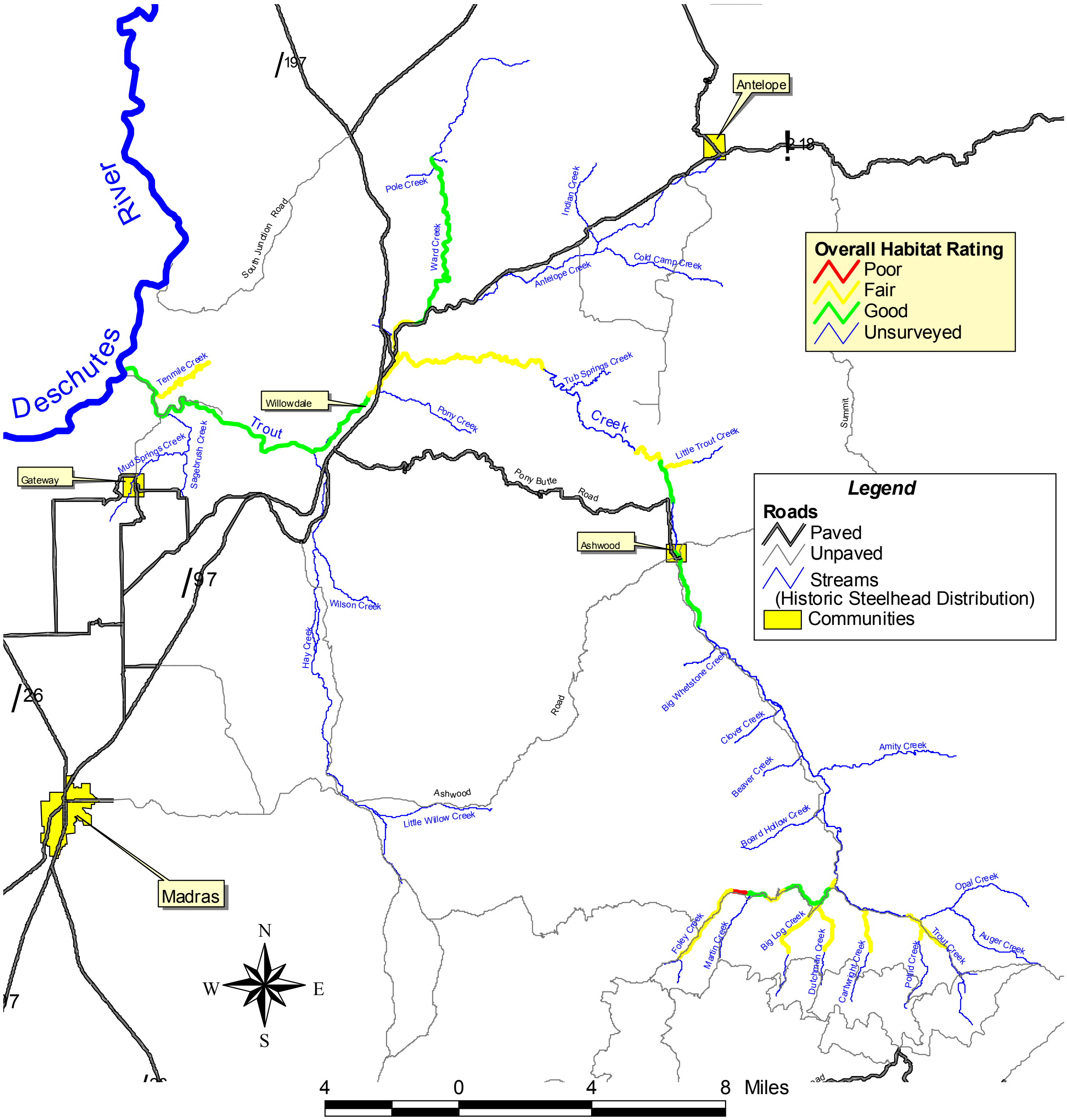


Figure 8-12. Summer Steelhead Instream Habitat Conditons, Summer Rearing (Age 0+). Data Sources: ODFW (1998, 2001, 2001c). ***Habrate*** **only considers the instream physical habitat parameters, and not other critical parameters such as stream temperature, stream flow, and the riparian vegetative component.**

Table 8-21. Summer Steelhead Instream Habitat Conditons, Summer Rearing (Age 0+). Data Sources: ODFW (1998, 2001c).

Stream	Reach	River Mile	Substrate	% Pools	Channel Roughness	Overall Habitat Rating
TROUT CREEK	1	0-2.2	3	2	3	**3**
TROUT CREEK	2	2.2-8.1	3	2	3	**3**
TROUT CREEK	3	8.1-11.3	3	3	2	**3**
TROUT CREEK	4	11.3-12.8	3	2	2	**2**
TROUT CREEK	5	12.8-14.9	3	2	2	**2**
TROUT CREEK	6	14.9-18.5	3	2	2	**2**
TROUT CREEK	*UNS 7	18.5-23.9	x	x	x	**x**
TROUT CREEK	8	23.9-25.2	3	1	3	**2**
TROUT CREEK	9	25.2-26.6	3	3	2	**3**
TROUT CREEK	*UNS 10	26.6-28.2	x	x	x	**x**
TROUT CREEK	11	28.2-30.7	3	3	2	**3**
TROUT CREEK	*UNS 12	30.7-44.4	x	x	x	**x**
TROUT CREEK	13	44.4-44.7	3	1	3	**2**
TROUT CREEK	14	44.7-45.0	3	1	3	**2**
TROUT CREEK	15	45.0-45.9	3	1	3	**2**
ANTELOPE CREEK	1	0-1.7	3	1	3	**2**
ANTELOPE CREEK	2	1.7-2.3	3	2	3	**3**
WARD CREEK	1	0-5.2	3	3	3	**3**
TENMILE CREEK	1	0-1.4	3	1	3	**2**
TENMILE CREEK	2	1.4-2.3	3	1	3	**2**
POTLID CREEK	1	0-0.5	3	1	3	**2**
POTLID CREEK	2	0.5-0.7	3	1	3	**2**
CARTWRIGHT CREEK	1	0-0.2	3	1	3	**2**
CARTWRIGHT CREEK	2	0.2-1.0	3	1	3	**2**
CARTWRIGHT CREEK	3	1.0-1.4	3	1	3	**2**
DUTCHMAN CREEK	1	0-0.1	3	1	3	**2**
DUTCHMAN CREEK	2	0.1-0.7	3	1	3	**2**
DUTCHMAN CREEK	3	0.7-1.6	3	1	3	**2**
BIG LOG CREEK	1	0-0.6	3	2	2	**2**
BIG LOG CREEK	2	0.6-2.0	3	1	3	**2**
BIG LOG CREEK	3	2.0-2.1	3	1	2	**2**
FOLEY CREEK	1	0-0.4	3	1	3	**2**
FOLEY CREEK	2	0.4-1.3	3	2	3	**3**
FOLEY CREEK	3	1.3-2.4	3	2	3	**3**
FOLEY CREEK	4	2.4-3.1	3	1	3	**2**
FOLEY CREEK	5	3.1-3.9	2	3	3	**3**
FOLEY CREEK	6	3.9-4.3	1	1	2	**1**
FOLEY CREEK	7	4.3-5.1	2	1	2	**2**
FOLEY CREEK	8	5.1-7.5	2	2	2	**2**
FOLEY CREEK	9	7.5-7.6	2	2	2	**2**
LITTLE TROUT CREEK	1	0-0.9	3	2	2	**2**

*** Unsurveyed Reach** **1=Poor, 2=Fair, 3=Good**

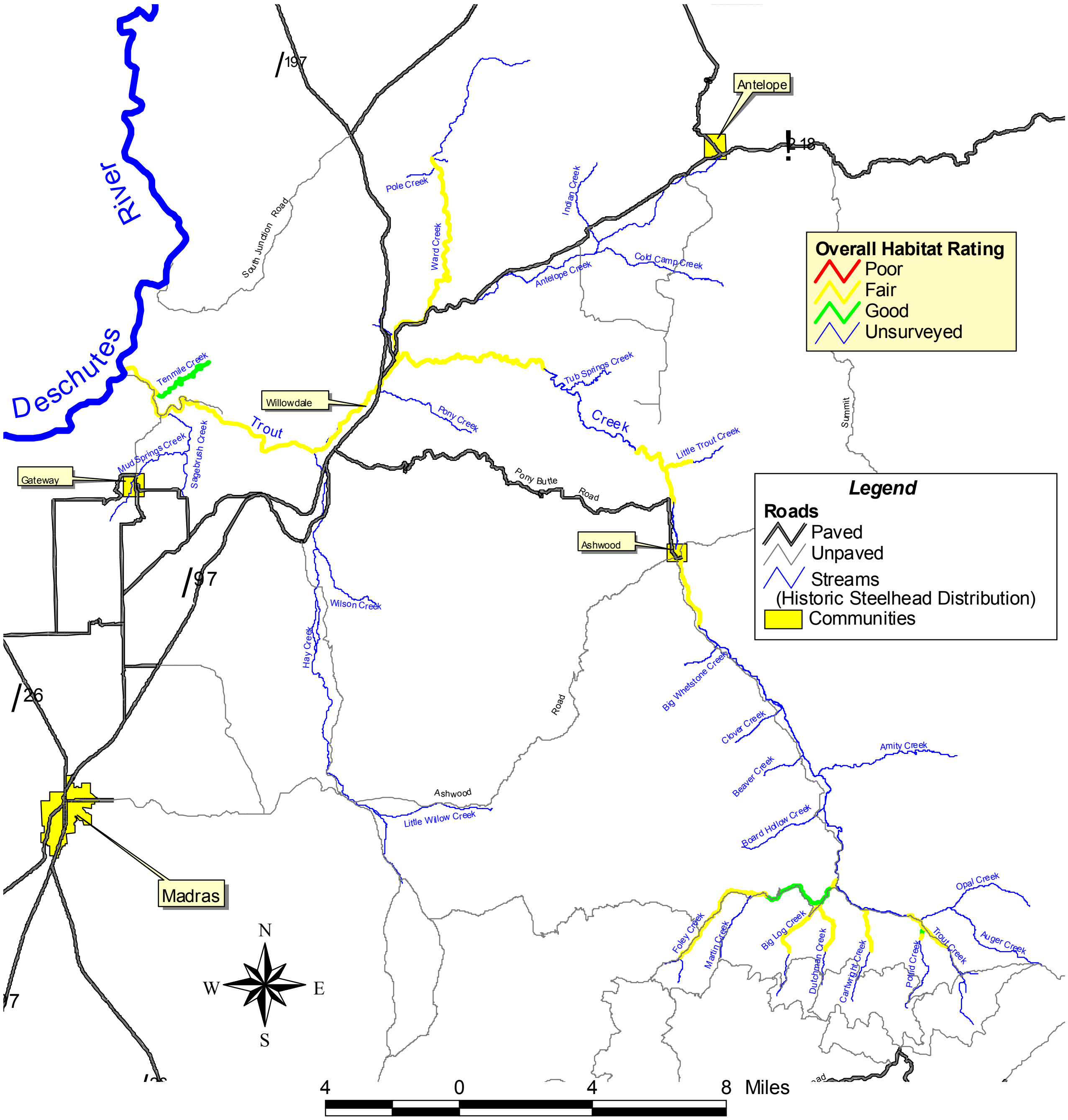


Figure 8-13. Summer Steelhead Instream Habitat Conditons, Winter Rearing (Age 0+, 1+). Data Sources: ODFW (1998, 2001, 2001c). *Habrate* only considers the instream physical habitat parameters, and not other critical parameters such as stream temperature, stream flow, and the riparian vegetative component.

Table 8-22. Summer Steelhead Instream Habitat Conditons, Winter Rearing (Age 0+, 1+). Data Sources: ODFW (1998, 2001c).

Stream	Reach	River Mile	Interstices	Total Cover	Pool Habitat	Overall Habitat Rating
TROUT CREEK	1	0-2.2	2	2	2	**2**
TROUT CREEK	2	2.2-8.1	2	2	2	**2**
TROUT CREEK	3	8.1-11.3	2	2	2	**2**
TROUT CREEK	4	11.3-12.8	2	2	2	**2**
TROUT CREEK	5	12.8-14.9	2	2	2	**2**
TROUT CREEK	6	14.9-18.5	2	2	2	**2**
TROUT CREEK	*UNS 7	18.5-23.9	x	x	x	**x**
TROUT CREEK	8	23.9-25.2	2	2	2	**2**
TROUT CREEK	9	25.2-26.6	2	2	2	**2**
TROUT CREEK	*UNS 10	26.6-28.2	x	x	x	**x**
TROUT CREEK	11	28.2-30.7	2	2	2	**2**
TROUT CREEK	*UNS 12	30.7-44.4	x	x	x	**x**
TROUT CREEK	13	44.4-44.7	3	3	1	**2**
TROUT CREEK	14	44.7-45.0	2	2	2	**2**
TROUT CREEK	15	45.0-45.9	3	3	1	**2**
ANTELOPE CREEK	1	0-1.7	2	2	2	**2**
ANTELOPE CREEK	2	1.7-2.3	2	2	2	**2**
WARD CREEK	1	0-5.2	2	2	3	**2**
TENMILE CREEK	1	0-1.4	3	3	2	**3**
TENMILE CREEK	2	1.4-2.3	3	3	2	**3**
POTLID CREEK	1	0-0.5	3	3	2	**3**
POTLID CREEK	2	0.5-0.7	3	3	1	**2**
CARTWRIGHT CREEK	1	0-0.2	3	3	1	**2**
CARTWRIGHT CREEK	2	0.2-1.0	3	3	1	**2**
CARTWRIGHT CREEK	3	1.0-1.4	3	3	1	**2**
DUTCHMAN CREEK	1	0-0.1	2	2	1	**2**
DUTCHMAN CREEK	2	0.1-0.7	2	2	1	**2**
DUTCHMAN CREEK	3	0.7-1.6	3	3	1	**2**
BIG LOG CREEK	1	0-0.6	2	2	2	**2**
BIG LOG CREEK	2	0.6-2.0	3	3	1	**2**
BIG LOG CREEK	3	2.0-2.1	2	2	1	**2**
FOLEY CREEK	1	0-0.4	2	2	1	**2**
FOLEY CREEK	2	0.4-1.3	3	3	2	**3**
FOLEY CREEK	3	1.3-2.4	3	3	2	**3**
FOLEY CREEK	4	2.4-3.1	3	3	2	**3**
FOLEY CREEK	5	3.1-3.9	2	2	2	**2**
FOLEY CREEK	6	3.9-4.3	1	2	1	**2**
FOLEY CREEK	7	4.3-5.1	2	2	1	**2**
FOLEY CREEK	8	5.1-7.5	2	2	2	**2**
FOLEY CREEK	9	7.5-7.6	2	2	2	**2**
LITTLE TROUT CREEK	1	0-0.9	2	2	2	**2**

*** Unsurveyed Reach** **1=Poor, 2=Fair, 3=Good**

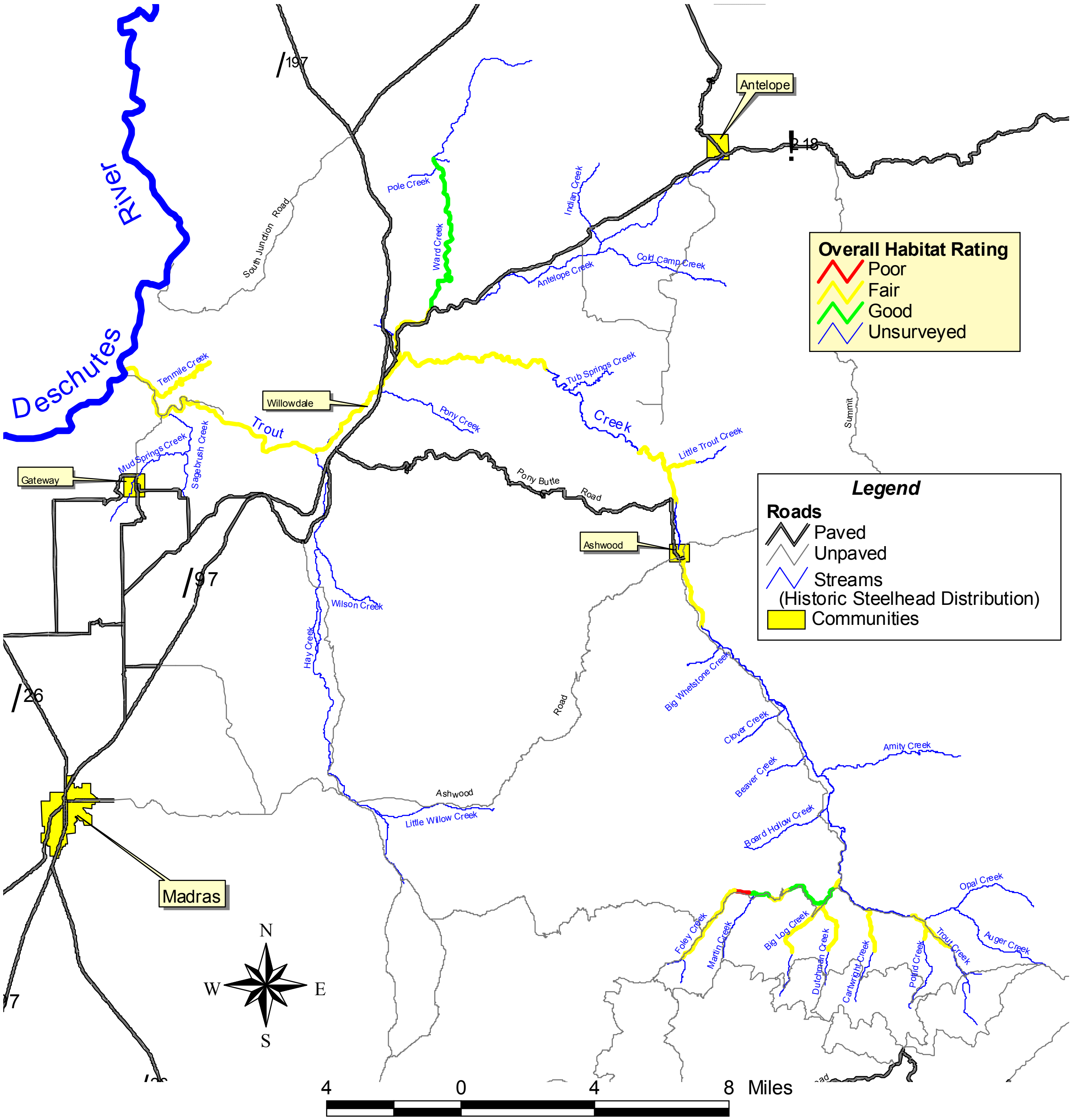


Figure 8-14. Summer Steelhead Instream Habitat Conditons, Summer Rearing (Age 1+). Data Sources: ODFW (1998, 2001, 2001c). *Habrate* only considers the instream physical habitat parameters, and not other critical parameters such as stream temperature, stream flow, and the riparian vegetative component.

Table 8-23. Summer Steelhead Instream Habitat Conditons, Summer Rearing (Age 1+). Data Sources: ODFW (1998, 2001c).

Stream	Reach	River Mile	Interstices	% Pools	Channel Roughness	Overall Habitat Rating
TROUT CREEK	1	0-2.2	2	2	3	**2**
TROUT CREEK	2	2.2-8.1	2	2	3	**2**
TROUT CREEK	3	8.1-11.3	2	3	2	**2**
TROUT CREEK	4	11.3-12.8	2	2	2	**2**
TROUT CREEK	5	12.8-14.9	2	2	2	**2**
TROUT CREEK	6	14.9-18.5	2	2	2	**2**
TROUT CREEK	*UNS 7	18.5-23.9	x	x	x	**x**
TROUT CREEK	8	23.9-25.2	2	1	3	**2**
TROUT CREEK	9	25.2-26.6	2	3	2	**2**
TROUT CREEK	*UNS 10	26.6-28.2	x	x	x	**x**
TROUT CREEK	11	28.2-30.7	2	3	2	**2**
TROUT CREEK	*UNS 12	30.7-44.4	x	x	x	**x**
TROUT CREEK	13	44.4-44.7	3	1	3	**2**
TROUT CREEK	14	44.7-45.0	2	1	3	**2**
TROUT CREEK	15	45.0-45.9	3	1	3	**2**
ANTELOPE CREEK	1	0-1.7	2	1	3	**2**
ANTELOPE CREEK	2	1.7-2.3	2	2	3	**2**
WARD CREEK	1	0-5.2	2	3	3	**3**
TENMILE CREEK	1	0-1.4	3	1	3	**2**
TENMILE CREEK	2	1.4-2.3	3	1	3	**2**
POTLID CREEK	1	0-0.5	3	1	3	**2**
POTLID CREEK	2	0.5-0.7	3	1	3	**2**
CARTWRIGHT CREEK	1	0-0.2	3	1	3	**2**
CARTWRIGHT CREEK	2	0.2-1.0	3	1	3	**2**
CARTWRIGHT CREEK	3	1.0-1.4	3	1	3	**2**
DUTCHMAN CREEK	1	0-0.1	2	1	3	**2**
DUTCHMAN CREEK	2	0.1-0.7	2	1	3	**2**
DUTCHMAN CREEK	3	0.7-1.6	3	1	3	**2**
BIG LOG CREEK	1	0-0.6	2	2	2	**2**
BIG LOG CREEK	2	0.6-2.0	3	1	3	**2**
BIG LOG CREEK	3	2.0-2.1	2	1	2	**2**
FOLEY CREEK	1	0-0.4	2	1	3	**2**
FOLEY CREEK	2	0.4-1.3	3	2	3	**3**
FOLEY CREEK	3	1.3-2.4	3	2	3	**3**
FOLEY CREEK	4	2.4-3.1	3	1	3	**2**
FOLEY CREEK	5	3.1-3.9	2	3	3	**3**
FOLEY CREEK	6	3.9-4.3	1	1	2	**1**
FOLEY CREEK	7	4.3-5.1	2	1	2	**2**
FOLEY CREEK	8	5.1-7.5	2	2	2	**2**
FOLEY CREEK	9	7.5-7.6	2	2	2	**2**
LITTLE TROUT CREEK	1	0-0.9	2	2	2	**2**

*** Unsurveyed Reach** **1=Poor, 2=Fair, 3=Good**

8.8 DATA GAPS

Fisheries

- Antelope Creek upper limit of steelhead spawning and rearing.
- Better knowledge of steelhead pre-smolt rearing areas and migration patterns within the Trout Creek watershed.
- Quantify limiting factors for egg to fry and fry to smolt life stage survival rates.
- Redband trout migration from Deschutes River to spawning areas within Trout Creek.
- Status of resident redband populations and if there are isolated population within the basin.
- Year round water temperature data throughout the basin.
- Better understanding of Wild and Hatchery summer steelhead adult interaction in the basin.
- Hatchery genetic introgression into wild summer steelhead population.

Habitat

- Hay Creek, Mud Springs, and Wilson Creek upstream barriers and habitat quality above lowest known barrier.
- Continuous physical habitat survey of fish bearing stream reaches.
- Field verification of all Road/Stream Crossings of all fish bearing streams.

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10.0 APPENDICES TO THE HYDROLOGY REPORT

10.1 ANALYSIS OF PEAK FLOW GENERATING PROCESSES

The annual peak flow records for gages #14093600 (Trout Creek below Amity Creek near Ashwood, Table 4-1), 14093700 (Woods Hollow at Ashwood), 14094300 (Cow Canyon Creek near Antelope), and 14095200 (Sagebrush Creek Trib. near Gateway) were examined to determine the peak flow generating process responsible for each peak flow event. Peak flow type was estimated for each event as either rain-on-snow (ROS), clear-sky snowmelt (CSS), or rain only (RAIN) following the methodology of MacDonald and Hoffman (1995). Local precipitation, temperature, and snowfall records prior to and on the date of the event, local snow pack data, and wind speed data, were examined to estimate the peak flow type.

The Antelope 1 NW climate station (see Table 1-7 and Figure 1-12 for climate station location and summary of available data) had information on daily maximum and minimum air temperatures, total daily precipitation, and total daily snowfall. Snowfall information available from this and other stations is in inches of snow regardless of the snow density. Snowpack data available from other stations described below is available in inches of snow-water equivalent (or SWE), which is a measure of the water content of the snowpack that is present. Consequently the two data are not directly comparable, but can be used to arrive at a qualitative estimate of snow available for melt during a storm.

The Ashwood 2 NE climate station (Table 1-7, Figure 1-12) had information on total daily precipitation and total daily snowfall. The Grizzly climate station (Table 1-7, Figure 1-12) had information on daily maximum and minimum air temperatures, total daily precipitation, and total daily snowfall. The Lower Hay Creek climate station (Table 1-7, Figure 1-12) had information on total daily precipitation and total daily snowfall. The Madras climate station (Table 1-7, Figure 1-12) had information on daily maximum and minimum air temperatures, total daily precipitation, and total daily snowfall.

The closet climate station to the Trout Creek watershed that has long-term wind speed data is located at the Redmond Airport (Roberts Field). In addition to mean daily wind speed data the station also has descriptions of daily weather conditions (such as the occurrence of thunderstorms). The Redmond airport station (NCDC station ID# 357062) is located approximately 35 miles south-southeast from the center of the Trout Creek watershed at an elevation of 3,042 feet.

No long-term records of snow pack conditions are available from within the Trout Creek watershed. The closest available long-term record is from the Marks Creek Snow course (Table 1-7, Figure 1-12) located southeast of the watershed near highway 26. Records from the Marks Creek site consist of first-of-the-month measurements of snowpack (expressed as SWE). More recent data on snowpack, collected on a daily basis is, available from the Ochoco Meadows SNOTEL site, located approximately 5 miles southeast of the Marks Creek site (Table 1-7, Figure 1-12). The Ochoco Meadows SNOTEL site also has precipitation and air temperature data available for certain years. The following is a narrative describing each event analyzed:

WY: 1957 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14095200 (Sagebrush Ck trib. near Gateway): 5/7/1957 (1 of 13) 5,200 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed based on records from the Marks Creek Snowcourse. Precipitation on 5/7/1957 was quite variable. Among the four climate stations within or near the watershed precipitation varied from 0 inches at Madras, Antelope 1 NW, and Lower Hay Creek to 1.7 inches at Grizzly. Thunderstorms and light rain showers reported at Redmond on 5/7/1957. Peak was probably due to local convective cell.

Peak flow type: Rain

WY: 1958 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14095200 (Sagebrush Ck trib. near Gateway): 6/7/1958 (3 of 13) 347 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed based on records from the Marks Creek Snowcourse. The only station reporting any precipitation on 6/7/1958 was the Grizzly station, which reported only 0.03 inches. However, Precipitation was heavy and variable on the previous day, ranging from 0.4" at the Ashwood 2 NE station to 1.7 inches at Grizzly. Thunderstorms and light rain showers reported at Redmond for the previous day, and light rain showers reported on the day of the peak. Peak was probably due to local convective cell.

Peak flow type: Rain

WY: 1959 none of the gages had records for this year

WY: 1960 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093700 (Woods Hollow at Ashwood): 3/9/1960 (11 of 15) 2.2 cfs

Climate conditions associated with peak flow: Snowpack was at 3.7" SWE on 2/25/60, and at 1.1" on 3/28/60 at the Marks Creek snowcourse. Records from the four climate stations indicate that a large snowfall occurred on 3/3/60. Air temperatures were generally below freezing for the week prior to 3/4/60, and rose above freezing beginning on 3/4/60. Mean daily wind speeds began increasing on 3/6/60, and were 9.5 and 5.9 knots on 3/8 and 3/9/60 (10% and 50% exceedance values). Precipitation was reported at all stations except Lower Hay Creek; ranging from 0.1" (at Madras) to 0.21" (at Grizzly). Rising air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1961 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093700 (Woods Hollow at Ashwood): 2/10/1961 (3 of 15) 25 cfs
Gage #14094300 (Cow Canyon Creek near Antelope): 2/10/1961 (2 of 10) 80 cfs
Gage #14095200 (Sagebrush Ck trib. near Gateway): 2/10/1961 (10 of 13) 54 cfs

Climate conditions associated with peak flow: Snowpack was at 0.2" SWE on 1/27/61, and at 0" on 2/24/61 at the Marks Creek snowcourse. Records from the four climate stations indicate that no snowfall from 1/27 to 2/10/61. Minimum air temperatures were at or above freezing, and maximum air temperatures were in the high 50's, for ten days prior to and on the day of the peak. Mean daily wind speeds began increasing on 2/7/61, and were 11 and 10 knots on 2/9 and 2/10/61 (5% and 8% exceedance values). Precipitation was reported as heavy at four of the stations (1.01" at Ashwood 2NE; 1.13" at Madras; 1" at Antelope 1 NW and Lower Hay Creek), but was 0" at the Grizzly station. The lack of snowpack suggests that this was not a rain-on-snow event.

Peak flow type: Rain

WY: 1962 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093700 (Woods Hollow at Ashwood):	12/20/1961	(10 of 15)	2.3 cfs

Climate conditions associated with peak flow: Snowpack was at 6" SWE on 12/27/61 at the Marks Creek snowcourse. Approximately 2" of snow (snow depth not SWE) was reported to have fallen at all climate stations from the day of the peak until 12/27, suggesting that a snowpack was present on the day of the peak. Min and max air temperatures were at below freezing on 12/12 at all stations, and rose gradually until the day of the peak when both min and max temperatures were above freezing. Mean daily wind speeds began increasing on 12/14/61, and were 11.4 and 11.2 knots on 12/19 and 12/20/61 (4% and 5% exceedance values). Precipitation was reported at all stations except Lower Hay Creek; ranging from 0.05" (at Ashwood 2 NE) to 0.3" (at Antelope 1 NW). Rain (both "heavy" and "light") reported at the Redmond airport on the day of the peak. Rising air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1963 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage #14093700 (Woods Hollow at Ashwood):	2/2/1963	(7 of 15)	6 cfs
Gage #14094300 (Cow Canyon Creek near Antelope):	2/3/1963	(6 of 10)	15 cfs
Gage #14095200 (Sagebrush Ck trib. near Gateway):	2/2/1963	(8 of 13)	90 cfs

Climate conditions associated with peak flow: No snowpack was reported at the Marks Creek snowcourse on 1/28/63, 5 days before the storm. However, 9.5", 4", and 9.7" of snow (snow depth not SWE) were reported to have fallen from 1/28 to 2/2/63 at the Madras, Antelope 1 NW, and Grizzly stations (the Ashwood 2 NE appeared to not have been operating). Min and max air temperatures were below freezing on 1/30/63 at all stations, and rose shapely above freezing on 2/2/63. Mean daily wind speeds began increasing from 4 knot on 1/31/63, and were 10.5 and 11.1 knots on 2/2 and 2/3/63 (6% and 5% exceedance values). Precipitation was reported at all stations; ranging from accumulated storm values of 0.9" (at Ashwood 2 NE) to 1.76" (at Grizzly). Light rain reported at Redmond for both 2/2 and 2/3. Rising air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1964 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage #14094300 (Cow Canyon Creek near Antelope):	12/28/1963	(3 of 10)	73 cfs

Climate conditions associated with peak flow: Snowpack was at 2.2" SWE on 12/30/63 at the Marks Creek snowcourse, 2 days after the peak, and no snow is reported to have fallen from 12/28 to 12/30. Minimum daily temperatures rose from below freezing on 12/27 to above freezing on 12/28 at all stations. Mean daily wind speed was low (2.8 knots; 94% exceedance value) at the Redmond airport on the day of the storm. Precipitation on the day of the storm was 0.27" at Madras, 0.22" at Grizzly, and 0" at Antelope 1 NW and Lower Hay Creek (data was missing from Ashwood 2 NE). Light rain reported at Redmond on both 12/27 and 12/28. Rising air temperatures, available snowpack, and rain suggest peak was a rain-on-snow event. Wind was light on the day of the peak in Redmond, but may have been higher within the watershed.

Peak flow type: ROS

WY: 1965 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093700 (Woods Hollow at Ashwood):	12/21/1964	(2 of 15)	44 cfs
Gage # 14094300 (Cow Canyon Creek near Antelope):	12/21/1964	(1 of 10)	142 cfs

Climate conditions associated with peak flow: Snowpack was at 1.8" SWE on 12/28/64 at the Marks Creek snowcourse, 7 days after the peak, and no more than 2" of snow (snow depth not SWE) are reported to have fallen at any of the stations from 12/21 to 12/28. Very cold temperatures preceded the storm (6 F was the maximum daily temperature reported at any of the stations on 12/17), rising to above freezing conditions the day of the storm. Mean daily wind speeds were 12.2 knots on the day of the peak (3% exceedance value). Heavy precipitation was reported at all five stations; three-day accumulations ranging from 1.59" at Ashwood 2NE to 4.03" at Antelope 1NW. The combination of air temperatures rising from below to above freezing conditions, the very windy conditions, the availability of a snowpack, and heavy rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1965 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage # 14095200 (Sagebrush Ck trib. near Gateway): 8/21/1965 (2 of 13) 347 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed. Precipitation on 8/21 was reported as low at all climate stations; below 0.05" at all stations. Thunderstorms and light rain showers reported at Redmond on 8/21. Peak was probably due to local convective cell.

Peak flow type: Rain

WY: 1966 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage # 14093700 (Woods Hollow at Ashwood): 1/3/1966 (6 of 15) 6.4 cfs
Gage # 14094300 (Cow Canyon Creek near Antelope): 1/3/1966 (4 of 10) 25 cfs

Climate conditions associated with peak flow: Snowpack was at 1" SWE on 12/29/65 at the Marks Creek snowcourse, 5 days before the peak, and approximately 8" of snow (snow depth not SWE) are reported to have fallen at the Grizzly and Antelope 1NW stations from 12/29/65 to 1/3/66. A warming trend existed at all air temperature stations, rising from below freezing conditions prior to the storm to above freezing conditions on the day of the peak. Mean daily wind speeds were high during the storm period; 13.5 and 11.1 knots on 1/2 and 1/3/66 (2% and 5% exceedance values). Precipitation volumes were moderate during the storm period. Two-day accumulated precipitation volumes ranged from 0.38" at Lower Hay Ck to 0.88" at Antelope 1NW for ½ and 1/3/66. Rising air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1966 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage # 14093600 (Trout Creek below Amity Ck): 3/13/1966 (20 of 22) 143 cfs

Climate conditions associated with peak flow: Snowpack was at 6.8" SWE on 2/28/66 at the Marks Creek snowcourse, 13 days before the peak, and almost no snow was reported to have fallen at any of the stations from 2/28 to 3/13. A slight warming trend existed at all air temperature stations from 2/28 to 3/13, however, maximum daily temperatures were above freezing for most of this period. Mean daily wind speeds were not particularly high during the storm period; 3.4 and 5.4 knots on 3/12 and 3/13 (90% and 60% exceedance values). Precipitation volumes were low during the storm period. Two-day accumulated precipitation volumes ranged from 0.03" at Grizzly to 0.12" at Antelope 1NW for 3/12 and 3/13. The climatic indicators give a weak suggestion that the peak was a rain-on-snow event. This may be reflected in the relatively small size of the peak (it ranked 20 out of 22 peaks).

Peak flow type: ROS

WY: 1966 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14095200 (Sagebrush Ck trib. near Gateway): 7/14/1966 (6 of 13) 145 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed. Precipitation was reported on 7/14 at all climate stations except Ashwood 2NE; ranging from 0.26" at Antelope 1NW to 0.66" at Madras. Thunderstorms and light rain showers reported at Redmond on 7/14. Peak was probably due to local convective cell.

Peak flow type: Rain

WY: 1967 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 1/28/1967 (14 of 22) 546 cfs

Climate conditions associated with peak flow: Snowpack was at 5.1" SWE on 1/27/67 at the Marks Creek snowcourse, the day before the peak. A warming trend existed at all air temperature stations, rising from below freezing conditions prior to the storm to above freezing conditions on the day of and the day preceding the peak. Mean daily wind speeds were moderately high during the storm period; 10.0 and 8.5 knots on 1/27 and 1/28 (8% and 16% exceedance values). Precipitation volumes were moderate during the storm period. Four-day accumulated precipitation volumes ranged from 0.45" at madras to 0.86" at Grizzly for the period 1/25-1/28. Rising air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1967 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14095200 (Sagebrush Ck trib. near Gateway): 8/14/1967 (7 of 13) 110 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed. No precipitation was reported on at any climate station on the day of, or for several days preceding, the peak. No thunderstorms were reported at Redmond on 8/14. Peak was probably due to local convective cell.

Peak flow type: Rain

WY: 1968 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage #14093600 (Trout Creek below Amity Ck): 2/21/1968 (18 of 22) 149 cfs

Gage #14093700 (Woods Hollow at Ashwood): 2/23/1968 (13 of 15) 1.5 cfs

Climate conditions associated with peak flow: Snowpack at the Marks Creek snowcourse was 0.8" SWE on 1/27, and 0" on 2/29, a week after the storm. Air temperatures were generally below freezing at all stations prior to 2/17, and rose to above freezing conditions by 2/19, where they remained for the duration of the storm period. Mean daily wind speeds were high at the beginning of the storm period (10.6 knots on 2/18 and 10.9 on 2/19), but were only moderate on the days of the peaks (4.9 knots on 2/21 and 7.3 on 2/23). Precipitation volumes were moderate at all climate stations during the storm period. Six-day accumulations ranged from 0.72" at Madras to 1.08" at Ashwood 2NE. Rising air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1969 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093700 (Woods Hollow at Ashwood): 3/20/1969 (9 of 15) 2.4 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 7.6" SWE on 2/25 and 6.4" on 3/25. Maximum air temperatures were in the 50's, and minimum temperatures around freezing at all stations on the day of the peak. The wide diurnal fluctuation suggests clear sky conditions. Mean daily wind speeds were low (2.8 knots) on the day of the peak. No precipitation was reported at any climate station on the day of the peak. The probable presence of a snowpack, combined with high temperatures, the suggestion of clear sky conditions, low wind speeds, and no precipitation suggest that the peak was due to clear-sky snowmelt.

Peak flow type: CSS

WY: 1969 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage #14093600 (Trout Creek below Amity Ck): 3/30/1969 (16 of 22) 251 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 6.4" on 3/25. Maximum air temperatures were in the high 60's to low 70's, and minimum temperatures around freezing at all stations on the day of the peak. The wide diurnal fluctuation suggests clear sky conditions. Mean daily wind speeds were low (4 knots) on the day of the peak. No precipitation was reported at any climate station on the day of the peak. The probable presence of a snowpack, combined with high temperatures, the suggestion of clear sky conditions, low wind speeds, and no precipitation suggest that the peak was due to clear-sky snowmelt.

Peak flow type: CSS

WY: 1969 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14095200 (Sagebrush Ck trib. near Gateway): 5/10/1969 (9 of 13) 60 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 0" on 4/25, and no snowfall was reported at any of the climate stations from 4/25 to the day of the peak. Air temperatures were above freezing for over a week prior to the peak. Mean daily wind speeds were low (less than 4 knots) on and preceding the day of the peak. No precipitation was reported at any climate station on the day of the peak or for at least a week prior to the peak. No thunderstorms were reported at Redmond on or preceding the day of the peak. Peak was probably due to local convective cell.

Peak flow type: Rain

WY: 1970 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage #14094300 (Cow Canyon Creek near Antelope): 1/23/1970 (8 of 10) 8.8 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 0.7" SWE on 12/24/69, and 1.2" SWE on 1/27/70. Minimum air temperatures had been below freezing several days prior to the peak, and were above freezing the day of the peak. Mean daily wind speeds were moderate (6.1 knots) the day prior to the peak and low (2.0 knots) the day of the peak. Precipitation was moderate for the duration of the storm period at all stations. Four-day accumulated volumes ranged from 0.97" at Lower Hay Ck to 1.57" at Antelope 1NW. Rising air temperatures, the probability of available snowpack, and rain, despite the low to moderate wind conditions, suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1970 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093600 (Trout Creek below Amity Ck): 1/30/1970 (10 of 22) 654 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 1.2" SWE on 1/27/70. Minimum air temperatures were below freezing, and maximum temperatures above freezing around the time of the peak. Mean daily wind speeds were low (1.6 knots) the day of the peak. No precipitation was reported at any of the stations on the day of, or for the day preceding, the peak. The probable presence of a snowpack, combined with high temperatures, low wind speeds, and no precipitation suggest that the peak was due to clear-sky snowmelt.

Peak flow type: CSS

WY: 1970 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093700 (Woods Hollow at Ashwood): 3/3/1970 (14 of 15) 1 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 0" SWE on 2/24/70, however, all stations reported snowfall for the five day period prior to and including the day of the peak. Values ranged from 6" (snow depth not SWE) at Madras and Antelope 1 NW to 8" at Ashwood 2 NE. Minimum air temperatures were below freezing, and maximum temperatures above freezing on the day of the peak, and had been rising for two days prior. Mean daily wind speeds were low (1.1 knots) the day of the peak. All stations reported precipitation for the five day period prior to and including the day of the peak. Values ranged from 0.16" at Madras to 0.43" at Ashwood 2 NE. Rising air temperatures, the probability of available snowpack, and rain, despite the low to moderate wind conditions, suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1970 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14095200 (Sagebrush Ck trib. near Gateway): 7/9/1970 (12 of 13) 17 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed. No precipitation was reported on at any climate station on the day of, or for several days preceding, the peak. Thunderstorms were reported at Redmond the day prior to the peak. Peak was probably due to local convective cell.

Peak flow type: Rain

WY: 1971 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage #14093600 (Trout Creek below Amity Ck): 1/17/1971 (4 of 22) 1,730 cfs

Gage #14093700 (Woods Hollow at Ashwood): 1/17/1971 (8 of 15) 2.5 cfs

Gage #14094300 (Cow Canyon Creek near Antelope): 1/17/1971 (9 of 10) 2.6 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 3.3" SWE on 12/28/70 and 2.7" SWE on 1/25/71. Max and Min air temperatures were generally below freezing on 1/13 and rose steadily to above freezing on the day of the peak. Mean daily wind speeds were high (15.5 knots) two days prior to the peak, and moderate (5.1 knots) the day of the peak. Moderate precipitation was reported at all climate stations for the storm period. Four-day accumulated volumes ranged from 0.66" at Ashwood 2 NE to 1.33" at Grizzly. Rising air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1972 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14094300 (Cow Canyon Creek near Antelope):	1/17/1972	(10 of 10)	< 0.5 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 6.1" SWE on 1/3 and 6.9" SWE on 1/31/72. Minimum temperatures were below freezing 2 days prior to the peak and rose steadily to above freezing on the day of the peak. Mean daily wind speeds were moderate (8.5 knots) the day of the peak. No precipitation was reported at any climate station for the four days prior to and including the peak. The probable presence of a snowpack, combined with high temperatures, moderate wind speeds, and no precipitation suggest that the peak was due to clear-sky snowmelt.

Peak flow type: CSS

WY: 1972 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093600 (Trout Creek below Amity Ck):	1/20/1972	(9 of 22)	707 cfs
Gage # 14093700 (Woods Hollow at Ashwood):	1/21/1972	(15 of 15)	0.9 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 6.1" SWE on 1/3 and 6.9" SWE on 1/31/72. Max and min temperatures were above freezing for the storm period. Mean daily wind speeds were high on the days of the peaks (15.3 knots on 1/20; 9.4 knots on 1/21). Precipitation was high for the storm period. Two-day accumulated volumes ranged from 0.8" at Grizzly to 1.74" at Ashwood 2 NE. High air temperatures, windy conditions, available snowpack, and rain suggest peaks were rain-on-snow events.

Peak flow type: ROS

WY: 1973 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093600 (Trout Creek below Amity Ck):	3/1/1973	(22 of 22)	33 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 0" SWE on 2/27, and no snowfall was reported at any station from 2/27 to the day of the peak. Max and min air temperatures were generally above freezing for the week prior to and including the day of the peak. Mean daily wind speed was 8.1 knots the day of the peak. Precipitation was reported at all stations the day of the peak, and ranged from 0.07" at Madras to 0.34" at Ashwood 2 NE. No thunderstorms were reported at the Redmond airport. Given the probable lack of snowpack it is unlikely that the peak was either a rain-on-snow or clear sky snowmelt event. Precipitation was not particularly heavy, however, given the relatively small magnitude of the peak (it ranked 22 out of 22) it is most likely that the peak was a rain driven event.

Peak flow type: Rain

WY: 1974 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093700 (Woods Hollow at Ashwood):	1/16/1974	(5 of 15)	11 cfs
Gage #14093600 (Trout Creek below Amity Ck):	1/18/1974	(1 of 22)	3,000 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 2.4" SWE on 12/26/73 and 0.1" SWE on 1/30/74. All stations reported snowfall for the period 12/26/73 – 1/18/74; ranging from 0.8" (snow depth not SWE) at Lower hay Ck to 8.5" at Antelope 1 NW. No snowfall was reported at any station for the period 1/18-1/30. Max and min temperatures were generally below freezing prior to 1/13, and rose sharply to the period of the peak flows, during which max and min temperatures were above freezing. Mean daily wind speeds were high during the storm period (11.1 knots on 1/16; 11.5 knots on 1/18). Precipitation was moderate for the storm period. Six-day accumulated volumes ranged from 0.31" at Lower Hay Ck to 0.96" at Grizzly. High air temperatures, windy conditions, available snowpack, and rain suggest peaks were rain-on-snow events.

Peak flow type: ROS

WY: 1975 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093700 (Woods Hollow at Ashwood): 4/24/1975 (12 of 15) 1.8 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 6.4" SWE on 3/25 and 1" SWE on 4/30. Max temperatures were above freezing (high 50's-low 60's) and min temperatures were at or above freezing for at least two weeks prior to the peak. Mean daily wind speeds were 9.6 knots the day of the peak. No precipitation was reported at any station for the six days prior to the peak. No precipitation was reported on the day of the peak at the Ashwood 2 NE station. Precipitation at the remaining stations on the day of the peak ranged from 0.03" at Grizzly to 0.27" at Antelope 1 NW. High air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1976 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14095200 (Sagebrush Ck trib. near Gateway): 8/4/1976 (11 of 13) 27 cfs

Gage #14093600 (Trout Creek below Amity Ck): 8/6/1976 (21 of 22) 86 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed. Cumulative precipitation for the period 8/1-8/4 ranged from 0.31" at Lower Hay Creek to 0.71" at Grizzly. Cumulative precipitation for the period 8/1-8/6 ranged from 0.31" at Lower Hay Creek to 1.73" at Grizzly. No thunderstorms were reported at Redmond on the days of the peak flows. Peak was probably a rain driven event

Peak flow type: Rain

WY: 1977 None of the gages had records for this year.

WY: 1978 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage #14093600 (Trout Creek below Amity Ck): 4/26/1978 (2 of 22) 2,160 cfs

Gage #14094300 (Cow Canyon Creek near Antelope): 4/26/1978 (7 of 10) 11 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 0" SWE on both 3/31 and 5/01, and only minor amounts of snowfall were reported to have fallen at any station between these dates. Max temperatures were well above freezing for at least ten days prior to the peak, and minimum temperatures were at or above freezing for the same time period. Mean daily wind speeds were high (11.1 knots) on the day of the peak. All stations reported high precipitation volumes on the day of the peak. Volumes ranged from 1.12" at Madras to 1.83" at Ashwood 2 NE. Given the probable absence of a snowpack, and the high precipitation volumes, the peak was probably a rain only event.

Peak flow type: Rain

WY: 1978 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage # 14093700 (Woods Hollow at Ashwood): 7/1/1978 (4 of 15) 14 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed. Cumulative precipitation for the three-day period prior to and including the day of the event ranged from 0.34" at Madras to 1.04" at Ashwood 2 NE. No thunderstorms were reported at Redmond on the day of the peak flow. Peak was probably a rain driven event

Peak flow type: Rain

WY: 1979 **Date, rank and magnitude (cfs) of annual peak flow at:**

Gage #14093700 (Woods Hollow at Ashwood): 2/7/1979 (1 of 15) 140 cfs

Gage #14094300 (Cow Canyon Creek near Antelope): 2/7/1979 (5 of 10) 23 cfs

Gage #14095200 (Sagebrush Ck trib. near Gateway): 2/7/1979 (4 of 13) 230 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 4" SWE on 1/29. Max and min temperatures were generally below freezing prior to 2/2, and were above freezing on, and several days prior to, the day of the peak. Mean daily wind speeds were 8.1 knots the day of the peak. Precipitation on the day of the peak ranged from 0" at Grizzly to 0.6" at Ashwood 2NE. High air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1980 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage # 14095200 (Sagebrush Ck trib. near Gateway): 6/25/1980 (5 of 13) 147 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed. Precipitation on the day of the event ranged from 0.34" at Antelope 1 NW to 0.77" at Ashwood 2 NE. Thunderstorms were reported at Redmond on the day prior to the peak flow. Peak was probably a rain driven event

Peak flow type: Rain

WY: 1981 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage # 14093600 (Trout Creek below Amity Ck): 2/16/1981 (7 of 22) 722 cfs

Climate conditions associated with peak flow: Snowpack at Marks Creek snowcourse was 1.6" SWE on 1/30 and 0.1" on 2/26. Max and min temperatures were above freezing on the day of the peak, and had been for the four days prior to the event. Mean daily wind speeds were 11.5 knots the day of the peak. Precipitation on the day of the peak ranged from 0" at Madras to 1.1" at the Ochoco Meadows SNOTEL site. High air temperatures, windy conditions, available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1981 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage # 14095200 (Sagebrush Ck trib. near Gateway): 9/26/1981 (13 of 13) 3 cfs

Climate conditions associated with peak flow: No substantial snowpack is likely to have existed in the watershed. Precipitation on the day of the event ranged from 0" at the Ochoco Meadows SNOTEL site and the Grizzly station to 0.86" at Madras. No thunderstorms were reported at Redmond on the day of the peak flow. Peak was probably a rain driven event. The variability in precipitation values from local stations suggests that it may have been due to a convective cell.

Peak flow type: Rain

WY: 1982 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 12/19/1981 (5 of 22) 1,690 cfs

Climate conditions associated with peak flow: Snowfall was reported at all climate stations approximately a week prior to the event. Snowfall values ranged from 1.5" at Lower Hay Ck to 4.5" at Madras. Snowpack at Marks Creek snowcourse was 6" SWE on 1/7/82, however, substantial snow was reported to have fallen at all climate stations in the period from 12/19/81 to 1/7/82. Max temperatures were above freezing on the day of the event and had been for 3 out of the 4 prior days. Min temperatures were generally at or below freezing for the same period. Mean daily wind speeds were 10.1 knots the day of the peak. Precipitation was reported at all stations during the storm period. Two-day cumulative precipitation volumes ranged from 0.67" at Ashwood 2 NE to 0.9" at the Ochoco Meadows SNOTEL site. High air temperatures, windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1983 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 2/18/1983 (8 of 22) 715 cfs

Climate conditions associated with peak flow: Snowpack at the Ochoco Meadows SNOTEL site was 14.3" SWE on the day of the peak. Max and min temperatures were above freezing at all climate stations on the day of the peak, and had been for approximately a week prior. Mean daily wind speeds were 7.3 knots on the day of the peak, and had been 11.5 knots on the prior day. Precipitation was reported at all stations for the storm period. Two-day cumulative volumes ranged from 0.22" at Lower Hay Ck to 1.09" at Antelope 1 NW. High air temperatures, windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1984 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 12/14/1983 (12 of 22) 618 cfs

Climate conditions associated with peak flow: Snowfall was reported at all climate stations approximately 7-14 days prior to the event. Cumulative snowfall values for this period ranged from 7" at Grizzly to 9.5" at Lower Hay Ck. Snowpack at Marks Creek snowcourse was 6.8" SWE on 1/2/84, however, substantial snow was reported to have fallen at all climate stations in the period from 12/14/83 to 1/2/84. Max and min temperatures were above freezing at all climate stations on the day of the peak, and for the day prior. Mean daily wind speeds were 3.5 knots on the day of the peak, and 3.9knots on the prior day. Precipitation was reported at all stations for the storm period. Two-day cumulative volumes ranged from 0.34" at Lower Hay Ck to 0.9" at the Ochoco Meadows SNOTEL site. High air temperatures, somewhat windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1985 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 11/13/1984 (13 of 22) 558 cfs

Climate conditions associated with peak flow: Snowpack at the Ochoco Meadows SNOTEL site was 2.5" SWE on the day of the peak. Max and min temperatures were above freezing at all climate stations on the day of the peak, and for three days prior. Mean daily wind speeds were 5.6 knots on the day of the peak, and had been 12.5 knots three days prior. Precipitation was reported at all stations for the storm period. Four-day cumulative volumes ranged from 0.77" at Ashwood 2 NE to 1.7" at the Grizzly and Ochoco Meadows SNOTEL sites. High air temperatures, windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1986 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 2/22/1986 (3 of 22) 1,840 cfs

Climate conditions associated with peak flow: Snowpack at the Ochoco Meadows SNOTEL site was 13" SWE on the day of the peak. Max and min temperatures were above freezing at all climate stations on the day of the peak, and had been rising for the past two days. Mean daily wind speeds were 10.5 knots on the day of the peak. Precipitation was reported at all stations on the day of the peak. Volumes ranged from 0.42" at Lower hay Ck to 0.95" at Antelope 1 NW. High air temperatures, windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1987 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 3/12/1987 (6 of 22) 730 cfs

Climate conditions associated with peak flow: Snowpack at the Ochoco Meadows SNOTEL site was 11.9" SWE on the day of the peak. Max and min temperatures were above freezing at all climate stations on the day of the peak. Mean daily wind speeds were 6.9 knots on the day of the peak. Precipitation was reported at all stations except Ashwood 2 NE during the storm period. Two-day cumulative volumes were up to 1.0" at the Ochoco Meadows SNOTEL site. High air temperatures, windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1988 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 12/10/1987 (17 of 22) 172 cfs

Climate conditions associated with peak flow: Snowpack at the Ochoco Meadows SNOTEL site was 2" SWE on the day of the peak. Max and min temperatures were generally above freezing at all climate stations on the day of the peak and had risen since the prior day. Mean daily wind speeds were 10.0 knots on the day of the peak, and had been 18.5 knots the prior day. Precipitation was reported at all stations during the storm period. Two-day cumulative volumes ranged from 0.65" at Grizzly to 1.3" at Ashwood 2 NE. High air temperatures, windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1989 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 3/9/1989 (11 of 22) 619 cfs

Climate conditions associated with peak flow: Snowpack at the Ochoco Meadows SNOTEL site was 12.7" SWE on the day of the peak. Max and min temperatures were generally above freezing at all climate stations on the day of the peak and had been for the three days prior. Mean daily wind speeds were 7.5 knots on the day of the peak. Precipitation was reported at all stations on the day of the peak except at Grizzly and Ashwood 2 NE. Maximum precipitation occurred at Madras which received 0.22". High air temperatures, windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1990 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 1/8/1990 (19 of 22) 145 cfs

Climate conditions associated with peak flow: Snowpack at the Ochoco Meadows SNOTEL site was 1.9" SWE on the day of the peak. Max and min temperatures were generally above freezing at all climate stations on the day of the peak. Mean daily wind speeds were 10.0 knots on the day of the peak, and was 14.7 knots on the prior day. Precipitation was reported at all stations during the storm period. Two-day cumulative volumes ranged from 0.69" at Lower Hay Ck to 1.5" at the Ochoco Meadows SNOTEL site. High air temperatures, windy conditions, a probable available snowpack, and rain suggest peak was a rain-on-snow event.

Peak flow type: ROS

WY: 1991 **Date, rank and magnitude (cfs) of annual peak flow at:**
Gage #14093600 (Trout Creek below Amity Ck): 5/17/1991 (15 of 22) 304 cfs

Climate conditions associated with peak flow: No snowpack was present at the Ochoco Meadows SNOTEL site, and no snowpack is likely to have existed in the watershed. Precipitation was present during the storm period at all stations. Two-day cumulative volumes ranged from 0.42" at Lower Hay Ck to 1.1" at the Ochoco Meadows SNOTEL site. No thunderstorms were reported at Redmond on the day of the peak flow. Peak was probably a rain driven event

Peak flow type: Rain

10.2 WATER RIGHTS WITHIN TROUT CREEK

Water rights within the Trout Creek watershed were summarized using information available from the OWRD (OWRD, 2002). The information below includes all non-cancelled water rights in the watershed as of 2/21/2002. Water rights in the following table are listed by both the subbasins defined for this assessment (Figure 1-1) and stream. The following is a brief description of the headings that appear in the table:

Certificate Permit: The certificate number (if available; if not a "0" is given) and permit number for the water right. The one or two letter code signifies the following: confirming decreed right (CD), confirming surface water (CS), decree (D), enlargement (E), groundwater (G), reservoir (R), surface (S), or underground (U).

DLC/LOT Location: The DLC/lot number (if available) and the legal description of the location (quarter-quarter, section, township, range) if available.

Use: Use that is made of the water. Includes the following:

IRRIGATION	**LIVESTOCK**	**MUNICIPAL**	**FISH**
I* - Irr.,domestic & stock	LV – Livestock	MU - Municipal	FI - Fish
ID -Irrigation&domestic	LW - /Wildlife	QM - Quasi-municipal	FW - /Wildlife
IL - Irrigation & stock			
IR - Irrigation	**DOMESTIC**	**RECREATION**	**MISCELLANEOUS**
IS - Supplemental	DO – Domestic	RC - Recreation	ST - Storage
IC - Primary&Supplemental	DS - /Stock		PM - Pond Maintenance

Priority: Priority date of the water right.

Source: Source that the water is taken from.

Quantity: Quantity of water allowed under the water right

Un.: Units that the quantity is expressed in: AFT = acre-feet, CFS = cubic feet per second, GPM = gallons per minute.

P/S: Indicates a primary (P) or supplemental (S) diversion.

S/G/R: Indicates if diversion is from surface (S), groundwater (G), or reservoir (R).

Certificate Permit	DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
Antelope Ck Subbasin: Antelope Cr > Trout Cr								
0 S 54003	NENW 26 8S 15E	IR	1/ 5/1995	SPR 1	0.007	CFS	P	S
0 S 54003	NWNE 26 8S 15E	IR	1/ 5/1995	SPR 2	0.011	CFS	P	S
1913 S 3190	SENW 34 8S 15E	IR	11/18/1916	ANTELOPE CR	0.04	CFS	P	S
2244 D 2244	SENE 19 8S 16E	I*	12/31/1873	2 SPRS	9	AFT	P	S
2245 D 2245	0 0 0	I*	12/31/1897	ANTELOPE CR	120	AFT	P	S
2251 D 2251	0 0 0	I*	12/31/1903	ANTELOPE CR	42	AFT	P	S
2251 D 2251	0 0 0	I*	12/31/1904	ANTELOPE CR	25.5	AFT	P	S
2251 D 2251	0 0 0	I*	12/31/1908	ANTELOPE CR	6	AFT	P	S
2258 D 2258	0 0 0	I*	2/28/1889	ANTELOPE CR	24	AFT	P	S
2401 D 2237	0 0 0	I*	12/31/1892	ANTELOPE CR	0		P	S
2426 S 3257	NESE 17 8S 16E	IR	1/26/1917	A SPR	0.02	CFS	P	S
24266 U 560	NESE 28 7S 17E	IR	6/25/1953	THOMSEN WELL	0.32	CFS	P	G
31117 S 25957	SENE 20 8S 16E	IR	1/21/1959	ANTELOPE CR	0.38	CFS	P	S
31214 S 25958	NWSE 19 8S 16E	IR	1/21/1959	ANTELOPE CR	0.38	CFS	P	S
34934 G 2740	SWNE 20 8S 16E	IR	8/12/1964	SUMP WELL 1	0.11	CFS	P	G
36468 D 2261	NWSE 32 7S 17E	LV	12/31/1873	ANTELOPE CR	0		P	S
36468 D 2261	NWSE 32 7S 17E	DO	12/31/1895	ANTELOPE CR	0		P	S
36468 D 2261	NWSE 32 7S 17E	IR	12/31/1901	ANTELOPE CR	1	AFT	P	S
38393 G 4093	SESE 1 8S 16E	IR	4/ 4/1968	WELL 1	0.64	CFS	P	G
38393 G 4093	NENE 12 8S 16E	IR	12/18/1968	WELL 2	1.05	CFS	P	G
42564 G 4010	NWNW 22 8S 16E	IR	2/28/1968	A WELL	0.41	CFS	P	G
42565 G 4822	SENW 21 8S 16E	IR	4/27/1970	A WELL	2.05	CFS	P	G
42566 G 5081	NWNW 22 8S 16E	IR	7/26/1971	A WELL	0.38	CFS	P	G
42863 G 5022	SENE 20 8S 16E	IR	9/14/1971	A WELL	0.38	CFS	P	G
43866 G 4254	SENE 20 8S 16E	IR	7/25/1968	A WELL	0.67	CFS	P	G
47112 G 5504	SENW 21 8S 16E	IR	12/27/1971	WELL 4	0.75	CFS	P	G
47541 D 2228	NWSE 19 8S 16E	I*	12/31/1870	ANTELOPE CR	0		P	S
48909 G 6274	SESE 20 8S 16E	IR	12/ 9/1974	WELL 3	0.66	CFS	P	G
48909 G 6274	SESE 20 8S 16E	IS	12/ 9/1974	WELL 3	0.17	CFS	S	G
61135 S 40422	NWNE 20 8S 16E	LV	3/22/1976	SPR 1	0.002	CFS	P	S
61135 S 40422	NWNE 20 8S 16E	LV	3/22/1976	SPR 2	0.002	CFS	P	S
66454 G 6889	SESW 6 8S 17E	IR	4/ 1/1976	A WELL	1.56	CFS	P	G
66572 S 42530	NENE 25 8S 15E	IR	6/26/1970	A SPR	0.24	CFS	P	S
66616 G 7148	NENE 29 8S 16E	IR	1/14/1977	A WELL	1.11	CFS	P	G
Antelope Ck Subbasin: Cold Camp Cr > Antelope Cr								
2249 D 2249	SWNE 23 8S 16E	I*	12/31/1890	COLD CAMP CR	27	AFT	P	S
Antelope Ck Subbasin: Cow Can > Antelope Cr								
2144 S 2418	NESE 28 8S 15E	DO	3/11/1915	COW CAN	0.1	CFS	P	S
6329 S 5624	SESE 28 8S 15E	DS	9/11/1922	COW CAN	0.05	CFS	P	S
65304 S 44566	NESE 28 8S 15E	DO	11/13/1979	COW CANYON SPR	0.005	CFS	P	S
Antelope Ck Subbasin: Deadman Can > Ward Cr								
42562 R 5694	NENE 19 8S 16E	FI	10/18/1971	DEADMAN CAN	1.5	AFT	P	R
Antelope Ck Subbasin: Grub Hol Cr > Antelope Cr								
2262 D 2262	NENW 4 8S 17E	I*	12/31/1888	GRUB HOL CR	15.75	AFT	P	S

Certificate	Permit		DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
36468	D	2261	SESE 32 7S 17E	I*	12/31/1873	GRUB HOL CR	0		P	S
Antelope Ck Subbasin: Indian Cr > Antelope Cr										
0	G	9591	NENW 30 8S 16E	IS	3/18/1982	A WELL	0.89	CFS	S	G
2254	D	2254	0 0 0	I*	12/31/1893	INDIAN CR	24	AFT	P	S
2446	S	2333	SWSE 35 7S 16E	IR	11/ 4/1914	INDIAN CR	0.1	CFS	P	S
Antelope Ck Subbasin: Johns Can > Antelope Cr										
2259	D	2259	NWSE 28 7S 17E	I*	12/31/1902	JOHNS CAN	96	AFT	P	S
Antelope Ck Subbasin: King Cr > Cold Camp Cr										
2473	S	4027	NWNE 30 7S 17E	MU	6/24/1918	THREE SPRS	0.225	CFS	P	S
Antelope Ck Subbasin: Pole Cr > Ward Cr										
48911	G	5653	NWNE 9 8S 15E	DO	12/13/1972	COW CAN REST A	0.02	CFS	P	G
Antelope Ck Subbasin: Unn Str > Antelope Cr										
47540	R	6309	NENE 10 8S 17E	LV	9/25/1974	UNN STR	1	AFT	P	R
47540	R	6309	SESW 22 8S 17E	LV	9/25/1974	UNN STR	0.5	AFT	P	R
64032	G	9763	NWSE 30 7S 17E	QM	3/17/1982	WELL 1	30	GPM	P	G
64032	G	9763	SESE 30 7S 17E	QM	3/17/1982	WELL 2	7	GPM	P	G
Antelope Ck Subbasin: Unn Str > Cold Camp Cr										
66658	S	47446	NESE 11 8S 17E	LV	1/ 4/1983	A SPR	0.005	CFS	P	S
Antelope Ck Subbasin: Unn Str > Grub Hol Cr										
66658	S	47446	NESE 11 8S 17E	LV	1/ 4/1983	UNN STR	0.005	CFS	P	S
Antelope Ck Subbasin: Unn Str > Ward Cr										
7337	S	6519	SWSW 15 8S 15E	DO	9/ 8/1924	SMALL SPR	0.05	CFS	P	S
Antelope Ck Subbasin: Ward Cr > Antelope Cr										
66556	G	9006	NESW 19 8S 16E	IR	3/13/1978	A WELL	0.26	CFS	P	G
Hay Creek Subbasin: Awbrey Cr > Calivan Cr										
2225	D	2225	35 11S 15E	I*	12/31/1885	AWBREY CR	34.5	AFT	P	S
2225	D	2225	35 11S 15E	I*	12/31/1885	AWBREY CR	16.5	AFT	P	S
2225	D	2225	35 11S 15E	I*	12/31/1885	AWBREY CR	519.75	AFT	P	S
2225	D	2225	35 11S 15E	I*	12/31/1886	AWBREY CR	563.25	AFT	P	S
2225	D	2225	35 11S 15E	LV	12/31/1886	AWBREY CR	0.25	CFS	P	S
2233	D	2233	35 11S 15E	I*	12/31/1885	AWBREY CR	45.75	AFT	P	S
7304	R	390	22 11S 15E	ST	1/23/1917	AWBREY CR	700	AFT	P	R
Hay Creek Subbasin: Calivan Cr > Hay Cr										
6794	S	3216	NWSE 25 11S 15E	IR	12/23/1916	CALIVAN CR	0.08	CFS	P	S
Hay Creek Subbasin: Hay Cr > Trout Cr										
0	G	9178	SESW 20 9S 15E	IS	10/ 4/1978	A WELL	2.83	CFS	S	G
0	G	11048	SWNW 29 9S 15E	IS	2/28/1990	A WELL	0.28	CFS	S	G
0	G	12762	NESE 7 10S 15E	IS	4/ 5/1991	WELL 8	0.5	CFS	S	G
0	G	12807	SWNE 27 11S 15E	IC	4/ 5/1991	WELL 1	1.34	CFS	P	G
0	G	12807	SWNE 27 11S 15E	IC	4/ 5/1991	WELL 2	2.67	CFS	P	G
0	G	12807	SESW 11 11S 15E	IC	4/ 5/1991	WELL 4	1.56	CFS	P	G
0	G	12807	SWSW 11 11S 15E	IC	4/ 5/1991	WELL 5	2.9	CFS	P	G
0	G	12807	NWSW 10 11S 15E	IC	4/ 5/1991	WELL 6	0.5	CFS	P	G
0	G	12807	NWSE 9 11S 15E	IC	4/ 5/1991	WELL 7	0.9	CFS	P	G

Certificate Permit	DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
1191 S 2031	SWNW 29 10S 15E	IR	5/25/1914	HAY CR	0.07	CFS	P	S
19455 S 17530	NESE 12 11S 15E	IR	12/12/1946	LITTLE WILLOW	0.93	CFS	P	S
19455 S 17530	NESE 12 11S 15E	IS	12/12/1946	LITTLE WILLOW	6.09	CFS	S	S
2225 D 2225	0 11S 15E	I*	12/31/1879	DRAINAGE	300	AFT	P	S
2225 D 2225	0 0 0	I*	12/31/1885	HAY CR	79.5	AFT	P	S
2238 D 2238	0 0 0	I*	12/31/1885	HAY CR	433.2	AFT	P	S
2248 D 2248	NESW 5 11S 15E	I*	12/31/1885	HAY CR	45	AFT	P	S
2248 D 2248	NESW 5 11S 15E	I*	12/31/1898	HAY CR	86.25	AFT	P	S
2263 D 2263	0 0 0	I*	12/31/1885	HAY CR	660	AFT	P	S
2263 D 2263	0 0 0	I*	12/31/1907	HAY CR	7.5	AFT	P	S
27528 S 22849	NWNE 31 9S 15E	IR	3/ 8/1954	HAY CR	5.72	CFS	P	S
30963 G 1297	SWSW 20 9S 15E	IS	3/ 5/1959	A WELL	0.62	CFS	S	G
30964 G 1486	SWNW 29 9S 15E	IS	11/18/1959	HORIGAN POND	0.81	CFS	S	G
3331 S 3425	NESE 18 10S 15E	IR	6/ 4/1917	HAY CR	0.1	CFS	P	S
36064 S 21403	SENE 10 11S 15E	IR	7/20/1951	LITTLE WILLOW	8.601	CFS	P	S
36065 R 1376	NWSW 22 11S 15E	ST	7/20/1951	HAY CR	760	AFT	P	R
36065 R 1376	NWSW 22 11S 15E	ST	9/12/1951	HAY CR	120	AFT	P	R
36066 S 21496	NWSW 22 11S 15E	IS	7/20/1951	BREWER RES	599.4	AFT	S	S
60705 G 8322	NWSW 29 9S 15E	IR	8/16/1978	A WELL	0.13	CFS	P	G
64254 G 10253	SWNW 29 9S 15E	IS	9/14/1983	A WELL	0.56	CFS	S	G
64254 G 10253	SWNW 29 9S 15E	IS	11/14/1983	A WELL	0.14	CFS	S	G
65503 S 45501	NENE 19 9S 15E	IR	8/28/1980	HAY CR	0.22	CFS	P	S
7303 S 3243	NWSW 22 11S 15E	IS	1/23/1917	BREWER RES	6.36	CFS	S	S
9689 R 108	SESE 6 10S 15E	IS	5/ 6/1911	HAY CR	103	AFT	S	R
9690 E 100	NESW 5 10S 15E	IS	5/ 6/1911	LYLE DITCH/RES	2.5	CFS	S	S
Hay Creek Subbasin: Jims Cr > Little Willow Cr								
1972 S 1904	26 11S 15E	IR	2/11/1914	JIMS CR	0.1	CFS	P	S
2225 D 2225	26 11S 15E	I*	12/31/1885	JIMS CR	18.25	AFT	P	S
Hay Creek Subbasin: Little Willow Cr > Hay Cr								
19454 R 866	NESE 12 11S 15E	ST	12/10/1946	LITTLE WILLOW	361.84	AFT	P	R
2225 D 2225	0 0 0	I*	12/31/1885	LITTLE WILLOW	279.25	AFT	P	S
2225 D 2225	0 0 0	I*	12/31/1885	LITTLE WILLOW	984.75	AFT	P	S
2225 D 2225	18 11S 16E	I*	12/31/1885	LITTLE WILLOW	49.5	AFT	P	S
2225 D 2225	18 11S 16E	I*	12/31/1885	LITTLE WILLOW	51.25	AFT	P	S
2225 D 2225	0 0 0	LV	12/31/1908	LITTLE WILLOW	0.25	CFS	P	S
2243 D 2243	0 0 0	I*	12/31/1901	LITTLE WILLOW	12	AFT	P	S
36063 R 1333	NESE 12 11S 15E	ST	7/20/1951	LITTLE WILLOW	412	AFT	P	R
36063 R 1333	NESE 12 11S 15E	ST	9/12/1951	LITTLE WILLOW	187.8	AFT	P	R
36064 S 21403	SENE 12 11S 15E	IS	7/20/1951	LITTLE WILLOW	412	AFT	S	S
36064 S 21403	SENE 12 11S 15E	IS	9/12/1951	LITTLE WILLOW	187.8	AFT	S	S
73844 R 101998	NWSE 23 11S 16E	LW	1/ 1/1993	BARBER CK/RES	0.008	AFT	P	R
Hay Creek Subbasin: Unn Str > Hay Cr								
0 G 12807	SWSE 16 11S 15E	IC	4/ 5/1991	DOMESTIC WELL	0.05	CFS	P	G
1366 S 1665	SWNW 8 11S 15E	IR	6/14/1913	UNN SMALL SPR	0.02	CFS	P	S
Hay Creek Subbasin: Unn Str > Little Willow Cr								

Certificate Permit	DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
73844 R 101998	SENW 28 11S 16E	LW	1/ 1/1993	L WILLOW CR/RE	0.013	AFT	P	R
73844 R 101998	NWNE 28 11S 16E	LW	1/ 1/1993	A SPR/RES 2	0.01	AFT	P	R
73844 R 101998	NWSE 28 11S 16E	LW	1/ 1/1993	L WILLOW CR/RE	0.011	AFT	P	R
Hay Creek Subbasin: Wilson Cr > Hay Cr								
2238 D 2238	0 0 0	I*	12/31/1877	WILSON CR	122.7	AFT	P	S
2263 D 2263	0 0 0	I*	12/31/1886	WILSON CR	410.55	AFT	P	S
3895 S 1926	NENW 10 10S 15E	IR	3/12/1914	WILSON CR	0.94	CFS	P	S
50363 D 2230	NWSW 29 9S 15E	I*	12/31/1886	WILSON CR	0		P	S
7208 S 5866	SENW 5 10S 15E	DO	1/30/1922	WILSON CR	0.1	CFS	P	S
Lower Trout Subbasin: Dry Cr > Trout Cr								
73939 R 102975	SWNW 25 9S 16E	LW	1/ 1/1993	A SPR/RES 5	0.28	AFT	P	R
73939 R 102975	SWNW 25 9S 16E	LW	1/ 1/1993	RUNOFF/RES 6	0.07	AFT	P	R
Lower Trout Subbasin: Little Trout Cr > Trout Cr								
2226 D 2226	SENW 16 9S 17E	I*	12/31/1897	LITTLE TROUT C	60	AFT	P	S
Lower Trout Subbasin: Long Hol > Trout Cr								
73939 R 102975	SWSW 24 9S 16E	LW	1/ 1/1993	RUNOFF/RES 8	0.44	AFT	P	R
73940 R 102976	NESW 31 9S 17E	LW	1/ 1/1993	RUNOFF/RES 7	0.22	AFT	P	R
Lower Trout Subbasin: Pony Cr > Trout Cr								
0 G 8467	NWNW 27 9S 14E	IR	1/ 9/1979	A SUMP	0.63	CFS	P	G
0 G 13875	SENW 10 9S 15E	IR	3/16/2000	A WELL	0.232	CFS	P	G
0 G 13875	SENW 10 9S 15E	PM	3/16/2000	A WELL	0.668	CFS	P	G
0 G 13875	SENW 10 9S 15E	IS	3/16/2000	A WELL	0.448	CFS	S	G
0 R 13100	SENE 29 9S 16E	FW	1/ 4/2001	A SPR/AGATE PT	8	AFT	P	R
1072 S 2489	SENW 11 9S 15E	ID	4/13/1915	BOSTICK SPR	0.15	CFS	P	S
45510 D 2256	SWNE 11 9S 15E	I*	12/31/1879	PONY CR	0		P	S
65238 G 8422	NESW 9 17S 22E	IC	12/22/1978	A WELL	1.19	CFS	P	G
77026 D 2256	NWNE 17 9S 15E	I*	12/31/1879	TROUT CR	1.5	AFT	P	S
Lower Trout Subbasin: Post Hol > Little Trout Cr								
73940 R 102976	NENW 19 9S 17E	LW	1/ 1/1993	A SPR/RES 1	0.5	AFT	P	R
73940 R 102976	NWSW 20 9S 17E	LW	1/ 1/1993	RUNOFF/RES 2	0.2	AFT	P	R
73940 R 102976	SESW 20 9S 17E	LW	1/ 1/1993	A SPR/RES 3	0.15	AFT	P	R
Lower Trout Subbasin: Sheep Hol > Trout Cr								
73939 R 102975	SESE 23 9S 16E	LW	1/ 1/1993	RUNOFF/RES 7	0.44	AFT	P	R
73939 R 102975	NENW 23 9S 16E	LW	1/ 1/1993	A SPR/RES 9	0.38	AFT	P	R
73939 R 102975	NESW 23 9S 16E	LW	1/ 1/1993	RUNOFF/RES 10	0.26	AFT	P	R
Lower Trout Subbasin: Timber Culture G > Trout Cr								
73939 R 102975	NWSW 26 9S 16E	LW	1/ 1/1993	RUNOFF/RES 1	0.39	AFT	P	R
73939 R 102975	NESW 26 9S 16E	LW	1/ 1/1993	RUNOFF/RES 2	0.22	AFT	P	R
73939 R 102975	NWSE 26 9S 16E	LW	1/ 1/1993	RUNOFF/RES 3	0.25	AFT	P	R
73939 R 102975	NESE 26 9S 16E	LW	1/ 1/1993	RUNOFF/RES 4	0.44	AFT	P	R
Lower Trout Subbasin: Trout Cr > Deschutes R								
0 CD 2227	NENW 3 9S 15E	IR	12/31/1880	TROUT CR	96.9	AFT	P	S
0 CD 2227	NENW 3 9S 15E	IR	12/31/1880	TROUT CR	35.22	AFT	P	S
0 CD 2231	NENW 3 9S 15E	IR	12/31/1885	TROUT CR	236.46	AFT	P	S

Certificate Permit	DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
0 CD 2231	NENW 3 9S 15E	IR	12/31/1886	TROUT CR	299.1	AFT	P	S
0 CD 2234	NWNE 25 9S 16E	I*	12/31/1891	TROUT CR			P	S
0 CD 2234	SWSE 25 9S 16E	I*	12/31/1891	TROUT CR			P	S
0 CD 2234	NESW 24 9S 16E	I*	3/31/1898	TROUT CR			P	S
0 CD 2240	2 NWNE 5 9S 14E	I*	12/31/1897	TROUT CR	117	AFT	P	S
0 CD 2247	2 NWNE 5 9S 14E	I*	12/31/1897	TROUT CR	94.5	AFT	P	S
0 CD 2257	NENW 3 9S 15E	IR	12/31/1880	TROUT CR	127.74	AFT	P	S
0 CD 2257	NENW 3 9S 15E	IR	12/31/1880	TROUT CR	22.74	AFT	P	S
0 CS 2716	NENW 3 9S 15E	IR	11/12/1915	TROUT CR	0.42	CFS	P	S
0 CS 7320	SWNE 36 9S 16E	IR	5/25/1925	TROUT CR	0.34	CFS	P	S
1007 S 487	NESW 18 9S 15E	IR	12/ 7/1910	TROUT CR	0.08	CFS	P	S
1209 S 2156	4 9S 15E	DO	6/22/1914	SPRS	0.1	CFS	P	S
1436 S 3166	NENE 11 9S 14E	DO	11/ 4/1916	A SPR	0.1	CFS	P	S
2036 S 2045	NENE 5 9S 15E	DO	4/18/1914	A SPR	0.03	CFS	P	S
2229 D 2229	SWNW 3 9S 15E	I*	12/31/1879	TROUT CR	300	AFT	P	S
2229 D 2229	SWNW 3 9S 15E	I*	12/31/1884	TROUT CR	210	AFT	P	S
2229 D 2229	SWNW 3 9S 15E	I*	12/31/1884	TROUT CR	225	AFT	P	S
2232 D 2232	0 0 0	I*	12/31/1888	TROUT CR	84	AFT	P	S
2232 D 2232	0 0 0	I*	12/31/1901	TROUT CR	90	AFT	P	S
2234 D 2234	0 0 0	I*	12/31/1891	TROUT CR	95.4	AFT	P	S
2234 D 2234	0 0 0	I*	3/31/1898	TROUT CR	87.6	AFT	P	S
2242 D 2242	0 0 0	I*	12/31/1887	TROUT CR	511.5	AFT	P	S
2242 D 2242	0 0 0	I*	12/31/1899	TROUT CR	141	AFT	P	S
2242 D 2242	0 0 0	I*	12/31/1903	TROUT CR	90	AFT	P	S
2242 D 2242	0 0 0	I*	12/31/1904	TROUT CR	12	AFT	P	S
2242 D 2242	0 0 0	I*	12/31/1907	TROUT CR	9	AFT	P	S
2252 D 2252	0 0 0	I*	12/31/1904	TROUT CR	18	AFT	P	S
2253 D 2253	NESW 18 9S 15E	I*	5/31/1898	TROUT CR	201.4	AFT	P	S
2255 D 2255	0 0 0	I*	5/31/1878	TROUT CR	270	AFT	P	S
2255 D 2255	0 0 0	I*	12/31/1893	TROUT CR	198	AFT	P	S
2255 D 2255	0 0 0	I*	12/31/1897	TROUT CR	108	AFT	P	S
2255 D 2255	0 9S 15E	I*	12/31/1908	A SPR	7.5	AFT	S	S
2258 D 2258	0 0 0	I*	2/28/1889	TROUT CR	169.5	AFT	P	S
2260 D 2260	0 0 0	I*	12/31/1902	TROUT CR	78	AFT	P	S
49780 D 2239	NWSW 9 9S 14E	IL	12/31/1904	TROUT CR	2.5	CFS	P	S
49781 G 1456	NESW 9 9S 15E	IR	9/22/1959	EXCAVATED PIT	0.45	CFS	P	G
50363 D 2230	NWSW 29 9S 15E	I*	12/31/1879	TROUT CR	0		P	S
50363 D 2230	NESE 8 9S 15E	I*	12/31/1885	HAY CR	0		P	S
61063 G 6487	SENW 1 9S 16E	IR	6/ 6/1975	WELL 1	0.44	CFS	P	G
61134 S 40701	NWSW 9 9S 14E	IR	10/31/1974	TROUT CR	0.28	CFS	P	S
72479 S 40187	NESW 24 9S 16E	IR	1/13/1976	TROUT CR	2.87	CFS	P	S
72480 S 7320	SWNE 36 9S 16E	IR	5/25/1925	TROUT CR	0.34	CFS	P	S
72481 D 2234	SWSE 25 9S 16E	IR	12/31/1891	TROUT CR	6	AFT	P	S
75966 D 2227		I*	12/31/1880	TROUT CR	91.98	AFT	P	S
75966 D 2227		I*	12/31/1880	TROUT CR	125.4	AFT	P	S
75966 D 2227		I*	12/31/1896	TROUT CR	487.5	AFT	P	S

Certificate Permit	DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
75967 D 2231		IR	12/31/1885	TROUT CR	9.54	AFT	P	S
75967 D 2231		IR	12/31/1886	TROUT CR	8.4	AFT	P	S
75968 D 2257	NENW 3 9S 15E	I*	12/31/1880	TROUT CR	59.52	AFT	P	S
75969 S 2716		IR	11/12/1915	TROUT CR	8.61	CFS	P	S
76962 S 42196	SWSE 25 9S 16E	IR	5/31/1977	TROUT CR	1.5	CFS	P	S
76962 S 42196	NWSE 25 9S 16E	IR	5/31/1977	TROUT CR	1.2	CFS	P	S
Lower Trout Subbasin: Tub Sprs Can > Trout Cr								
48825 G 6367	NWNE 6 9S 17E	IR	4/ 4/1975	WELL 1	1.5	CFS	P	G
48825 G 6367	NENE 1 9S 16E	IR	4/ 4/1975	WELL 2	0.2	CFS	P	G
48826 G 6368	NWNE 6 9S 17E	IR	6/ 5/1975	WELL NO 1	1.5	CFS	P	G
49956 G 6394	SESE 36 8S 16E	IR	3/18/1975	A WELL	0.53	CFS	P	G
Lower Trout Subbasin: Unn Str > Long Hol								
73940 R 102976	NWNE 30 9S 17E	LW	1/ 1/1993	A SPR/RES 4	0.3	AFT	P	R
73940 R 102976	SESE 30 9S 17E	LW	1/ 1/1993	A SPR/RES 5	0.51	AFT	P	R
73940 R 102976	NENE 30 9S 17E	LW	1/ 1/1993	RUNOFF/RES 6	0.33	AFT	P	R
Lower Trout Subbasin: Unn Str > Trout Cr								
73479 R 103394	SESW 8 9S 14E	DO	1/ 1/1993	SPRS/RES 9	0.021	AFT	P	R
73479 R 103394	SWSE 8 9S 14E	DO	1/ 1/1993	SPRS/RES 10	0.027	AFT	P	R
73479 R 103394	NESE 8 9S 14E	DO	1/ 1/1993	SPRS/RES 11	0.021	AFT	P	R
77027 D 2230	NWSE 18 9S 15E	I*	12/31/1882	UNN STR	1.5	AFT	P	S
Lower Trout Subbasin: Woods Hol > Trout Cr								
73940 R 102976	SENW 36 9S 16E	LW	1/ 1/1993	RUNOFF/RES 8	0.3	AFT	P	R
73940 R 102976	NENE 36 9S 16E	LW	1/ 1/1993	RUNOFF/RES 9	0.51	AFT	P	R
Mud Springs Ck Subbasin: Dewies Can > Red Shed Can								
0 S 52362	SWNE 2 11S 14E	LW	9/19/1983	MONNER SPR	0.004	CFS	P	S
Mud Springs Ck Subbasin: Mud Sprs Cr > Trout Cr								
0 G 8179	NESE 33 9S 14E	IR	4/26/1978	A WELL	0.83	CFS	P	G
0 S 40461	SENW 20 9S 14E	IR	2/11/1976	MUD SPRS CR	3.92	CFS	P	S
0 S 40461	SENW 20 9S 14E	IR	2/11/1976	MUD SPRINGS CR	3.8	CFS	P	S
0 S 52356	NWSE 16 11S 14E	LW	9/19/1983	MUD SPRS PUMP	0.01	CFS	P	S
0 S 52357	SENE 21 11S 14E	LW	9/19/1983	MUD SPR	0.01	CFS	P	S
0 S 52375	SESW 31 9S 14E	LW	9/19/1983	KENNEDY SPR	0	CFS	P	S
48824 S 39650	SESE 17 9S 14E	IR	10/31/1974	MUD SPRS CR	4.5	CFS	P	S
48827 S 40460	NWNE 20 9S 14E	IR	2/11/1976	MUD SPRS CR	1.7	CFS	P	S
61075 G 7384	SWNW 29 9S 14E	IC	3/ 3/1977	DON KNECHTGES	0.23	CFS	P	G
61373 G 5898	SWNE 20 9S 14E	IR	8/ 6/1973	A WELL	0.27	CFS	P	G
61379 G 8112	NESW 20 9S 14E	IR	7/ 5/1977	A WELL	0.18	CFS	P	G
63581 G 8660	4 NWNW 4 11S 14E	IR	4/30/1979	A WELL	0.09	CFS	P	G
64358 S 47373	NWSE 16 11S 14E	LW	7/30/1981	MUD SPRS CR	0.005	CFS	P	S
65367 S 43003	NESW 20 9S 14E	IS	6/16/1977	MUD SPRS CR	0.2	CFS	S	S
66514 G 9337	NWSE 32 10S 14E	IR	4/21/1980	A WELL	0.02	CFS	P	G
73479 R 103394	SWSE 17 9S 14E	DO	1/ 1/1993	SPRS/RES 1	0.03	AFT	P	R
73479 R 103394	SWSE 17 9S 14E	DO	1/ 1/1993	SPRS/RES 2	0.014	AFT	P	R
73479 R 103394	SWSE 17 9S 14E	DO	1/ 1/1993	SPRS/RES 3	0.06	AFT	P	R
73479 R 103394	SESE 17 9S 14E	DO	1/ 1/1993	SPRS/RES 4	0.04	AFT	P	R

Certificate Permit	DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
73479 R 103394	NESE 17 9S 14E	DO	1/ 1/1993	SPRS/RES 5	0.004	AFT	P	R
73479 R 103394	NESE 17 9S 14E	DO	1/ 1/1993	SPRS/RES 6	0.004	AFT	P	R
73479 R 103394	SENE 17 9S 14E	DO	1/ 1/1993	SPRS/RES 7	0.004	AFT	P	R
73479 R 103394	NENW 17 9S 14E	DO	1/ 1/1993	SPRS/RES 8	0.004	AFT	P	R
73479 R 103394	SWNW 9 9S 14E	DO	1/ 1/1993	SPRS/RES 12	0.014	AFT	P	R
Mud Springs Ck Subbasin: Old Maids Can > Sagebrush Cr								
65354 G 9399	NENE 27 9S 14E	IR	7/22/1981	A WELL	0.04	CFS	P	G
Mud Springs Ck Subbasin: Red Shed Can > Mud Sprs Cr								
0 G 12495	SWNE 28 10S 14E	IS	6/10/1992	A WELL	2.25	CFS	S	G
Mud Springs Ck Subbasin: Sagebrush Cr > Mud Sprs Cr								
0 S 43932	NWNW 27 9S 14E	IS	1/ 9/1979	UNNAMED DRAINA	1.28	CFS	S	S
2252 D 2252	SWSW 15 9S 14E	I*	12/31/1897	SAGEBRUSH CR	82.5	AFT	P	S
2252 D 2252	SWSW 15 9S 14E	I*	12/31/1897	SAGEBRUSH CR	73.5	AFT	P	S
48018 S 39926	SESE 21 9S 14E	IR	3/ 1/1976	SAGEBRUSH CR	0.71	CFS	P	S
64158 S 44271	NESE 9 9S 14E	IR	5/24/1979	SAGEBRUSH CR	0.22	CFS	P	S
64424 S 36704	SESE 21 9S 14E	IR	6/20/1972	SAGEBRUSH CR	3.59	CFS	P	S
Mud Springs Ck Subbasin: Trout Cr > Deschutes R								
0 G 11766	SWNW 34 9S 14E	IC	8/ 2/1991	A WELL	0.88	CFS	P	G
Mud Springs Ck Subbasin: Unn Str > Mud Sprs Cr								
0 G 13339	NWNE 7 11S 14E	IR	2/18/1997	WELL 1	2	CFS	P	G
0 S 52360	SESE 10 11S 14E	LW	9/19/1983	PARKEY SPRS	0.005	CFS	P	S
0 S 52361	SESW 2 11S 14E	LW	9/19/1983	SCHMOKER SPR	0.002	CFS	P	S
Mud Springs Ck Subbasin: Unn Str > Sagebrush Cr								
0 G 7957	NESE 33 9S 14E	IR	11/18/1977	A WELL	0.68	CFS	P	G
0 G 12509	NWNW 27 9S 14E	IS	10/ 2/1992	A WELL	0.891	CFS	S	G
0 G 12715	NENE 33 9S 14E	IR	8/14/1995	A WELL	0.206	CFS	P	G
0 G 13138	NWNE 33 9S 14E	IC	1/23/1995	A WELL	0.25	CFS	P	G
61076 G 7960	SWNW 29 9S 14E	IS	3/ 3/1978	A WELL	0.23	CFS	S	G
67060 G 6989	NWSE 33 9S 14E	IR	9/10/1976	FESSLERS WELL	0.08	CFS	P	G
76340 S 36704	SESE 21 9S 14E	IR	6/20/1972	SAGEBRUSH CR	1.07	CFS	P	S
Mud Springs Ck Subbasin: Wagonblast Can > Mud Sprs Cr								
0 S 52363	SWSE 23 11S 14E	LW	9/19/1983	COTTONWOOD SPR	0.001	CFS	P	S
Upper Trout Subbasin: Auger Cr > Opal Cr								
65465 S 48969	SESW 12 12S 18E	LV	11/ 8/1984	INGRAM SPR	0.004	CFS	P	S
65465 S 48969	SESW 12 12S 18E	DO	11/ 8/1984	INGRAM SPR	0.001	CFS	P	S
77822 S 51328	NENW 12 12S 18E	LV	10/14/1983	INGRAM MEADOW	0.001	CFS	P	S
Upper Trout Subbasin: Barber Cr > Foley Cr								
70788 R 101999	SESE 34 11S 16E	LW	1/ 1/1993	FOLEY CR/RES	0.005	AFT	P	R
73844 R 101998	NENE 26 11S 16E	LW	1/ 1/1993	A SPR/RES 5	0.007	AFT	P	R
73844 R 101998	SWSE 26 11S 16E	LW	1/ 1/1993	BARBER CK/RES	0.008	AFT	P	R
73844 R 101998	NWSE 29 11S 17E	LW	1/ 1/1993	FOLEY CK/RES 9	0.006	AFT	P	R
Upper Trout Subbasin: Beaver Cr > Trout Cr								
2225 D 2225	0 0 0	I*	12/31/1879	BEAVER CR	67.5	AFT	P	S
70401 R 101612	NWSE 12 11S 16E	LV	1/ 1/1993	RUNOFF/RES 2	0.5	AFT	P	R

Certificate Permit	DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
70401 R 101612	NENW 5 11S 17E	LV	1/ 1/1993	RUNOFF/RES 7	0.5	AFT	P	R
70401 R 101612	SENE 5 11S 17E	LV	1/ 1/1993	RUNOFF/RES 8	0.5	AFT	P	R
70401 R 101612	NESE 5 11S 17E	LV	1/ 1/1993	RUNOFF/RES 9	0.5	AFT	P	R
70401 R 101612	SESW 5 11S 17E	LV	1/ 1/1993	SPRS/RES 10	0.5	AFT	P	R
Upper Trout Subbasin: Board Hol > Trout Cr								
2225 D 2225	15 11S 17E	I*	12/31/1885	BOARD HOL	108.6	AFT	P	S
2225 D 2225	15 11S 17E	I*	12/31/1885	BOARD HOL	163.5	AFT	P	S
70401 R 101612	SWSW 13 11S 16E	LV	1/ 1/1993	RUNOFF/RES 1	0.5	AFT	P	R
Upper Trout Subbasin: Cartwright Cr > Trout Cr								
77824 S 51330	NESW 1 12S 17E	LV	10/14/1983	POND SPR	0.001	CFS	P	S
Upper Trout Subbasin: Clover Cr > Trout Cr								
0 R 11858	SWSW 32 10S 17E	LV	3/12/1990	CLOVER CR/RES	4.23	CFS	P	R
70401 R 101612	NWSE 31 10S 17E	LV	1/ 1/1993	RUNOFF/RES 3	0.5	AFT	P	R
70401 R 101612	SWSW 32 10S 17E	LV	1/ 1/1993	RUNOFF/RES 4	4.8	AFT	P	R
70401 R 101612	SWNW 33 10S 17E	LV	1/ 1/1993	RUNOFF/RES 5	0.5	AFT	P	R
70401 R 101612	NWSW 33 10S 17E	LV	1/ 1/1993	RUNOFF/RES 6	0.5	AFT	P	R
Upper Trout Subbasin: Dick Cr > Trout Cr								
68188 S 49539	NESW 4 12S 18E	LV	9/19/1983	DOE SPR	0.005	CFS	P	S
Upper Trout Subbasin: Dutchman Cr > Big Log Cr								
76544 S 48645	SWNE 15 12S 17E	LV	9/11/1981	DUTCHMAN SPR	0	CFS	P	S
76544 S 48645	SWNE 15 12S 17E	DO	9/11/1981	DUTCHMAN SPR	0	CFS	P	S
Upper Trout Subbasin: Foley Cr > Trout Cr								
2225 D 2225	0 0 0	I*	12/31/1879	FOLEY CR	150	AFT	P	S
Upper Trout Subbasin: Gooseberry Cr > Trout Cr								
2225 D 2225	0 0 0	I*	12/31/1884	GOOSEBERRY CR	30	AFT	P	S
Upper Trout Subbasin: Opal Cr > Trout Cr								
73969 R 103321	NESW 23 11S 18E	RC	1/ 1/1993	UNN STR/RES 8	0.3	AFT	P	R
Upper Trout Subbasin: Potlid Cr > Trout Cr								
63984 S 49540	NWNE 13 12S 17E	LV	9/19/1983	ANGUS SPR	0.001	CFS	P	S
63985 S 49541	NESE 6 12S 18E	LV	9/19/1983	BOX SPR	0.005	CFS	P	S
Upper Trout Subbasin: S Amity Cr > Amity Cr								
2225 D 2225	0 11S 18E	I*	12/31/1879	S AMITY CR	120	AFT	P	S
2225 D 2225	0 11S 18E	I*	12/31/1891	S AMITY CR	99	AFT	P	S
2225 D 2225	0 11S 18E	I*	12/31/1895	S AMITY CR	315	AFT	P	S
Upper Trout Subbasin: Trout Cr > Deschutes R								
0 CD 2250	NESE 1 10S 16E	I*	12/31/1904	TROUT CR	21	AFT	P	S
2225 D 2225	0 0 0	I*	12/31/1879	TROUT CR	346.5	AFT	P	S
2225 D 2225	0 0 0	I*	12/31/1880	TROUT CR	109.5	AFT	P	S
2225 D 2225	0 0 0	I*	12/31/1884	TROUT CR	141	AFT	P	S
2235 D 2235	0 0 0	I*	12/31/1889	TROUT CR	98	AFT	P	S
2235 D 2235	0 0 0	I*	8/30/1893	TROUT CR	72	AFT	P	S
2236 D 2236	0 0 0	I*	12/31/1878	TROUT CR	178.8	AFT	P	S
2236 D 2236	0 0 0	I*	12/31/1885	TROUT CR	335.4	AFT	P	S
2236 D 2236	0 0 0	I*	12/31/1897	TROUT CR	153	AFT	P	S

Certificate Permit	DLC/LOT Location	Use	Priority	Source	Quantity	Un.	P/S	S/G/R
2236 D 2236	0 0 0	I*	12/31/1906	TROUT CR	57.6	AFT	P	S
2236 D 2236	0 0 0	I*	12/31/1908	TROUT CR	30	AFT	P	S
2241 D 2241	NENE 15 11S 17E	I*	12/31/1894	TROUT CR	27	AFT	P	S
2264 D 2264	0 0 0	I*	12/31/1883	TROUT CR	234	AFT	P	S
2265 D 2265	0 0 0	I*	12/31/1883	TROUT CR	3	AFT	P	S
63877 S 48668	SENW 16 12S 18E	LV	9/11/1981	COUGAR SPR	0.002	CFS	P	S
63980 S 49534	SWSE 15 12S 18E	LV	9/19/1983	STOVE SPR	0.005	CFS	P	S
76963 D 2234	NWSE 25 9S 16E	I*	12/31/1891	TROUT CR	1.5	AFT	P	S
Upper Trout Subbasin: Unn Str > Board Hol								
73844 R 101998	SWSE 24 11S 16E	LW	1/ 1/1993	BARBER CK/RES	0.006	AFT	P	R
73844 R 101998	NWSW 24 11S 16E	LW	1/ 1/1993	BARBER CK/RES	0.009	AFT	P	R
Upper Trout Subbasin: Unn Str > Foley Cr								
73844 R 101998	SWSW 34 11S 16E	LW	1/ 1/1993	A SPR/RES 4	0.005	AFT	P	R
Upper Trout Subbasin: Unn Str > Opal Cr								
73969 R 103321	SESE 21 11S 18E	RC	1/ 1/1993	UNN STR/RES 8	0.3	AFT	P	R

11.0 APPENDICES TO THE RIPARIAN / WETLANDS REPORT

11.1 RIPARIAN ZONE PLANT ASSOCIATION INFORMATION

The following information was summarized from *Riparian Zone Associations – Deschutes, Ochoco, Fremont, and Winema National Forests* (Kovalchik, 1987). Other resources (e.g., NRCS ecoregion site guides) may be more appropriate for some of the lower-elevation areas of the watershed.

A plant association is a group of plants found together with enough frequency to identify it as a distinct unit, such as a pine forest, a prairie, or a marsh. Plant associations tend to repeat across the landscape and over time. This list includes the plant associations described by Kovalchik. There may be additional plant associations not described here.

Ponderosa Pine/Common snowberry-Floodplain (*Pinus ponderosa/Symphoricarpos alba*)

Site Summary: Abundant on the Ochoco, and in the grassland areas of central OR. Occurs at low to moderate elevations (2700-4700 feet) within moderately broad, moderate gradient floodplain landforms.

Soils: Coarse sandy loam to sandy clay loam.

Wildlife/fisheries: Fish habitat is degraded. Important habitat for deer and elk.

Fire: Moderately resistant to fire.

Restoration pathways: 2-3 years rest from grazing will significantly increase Kentucky bluegrass cover on deteriorated sites. Rehabilitation can be accelerated with rest. Livestock can be reintroduced when alder is established on the streambanks and their stems are tall enough to withstand browsing (about 5 years).

Lodgepole pine/Kentucky bluegrass (*Pinus contorta/Poa pratensis*)

Site Summary: Common in Ochoco mountains Various ecological potentials where potential has been altered by grazing or where water table has been lowered.

Soils: Soil texture and parent material variable. Parent material includes pumice, rhyolite, basalt, andesite, and tuff. High water holding capacity.

Wildlife/fisheries: Pocket gophers, mice, and Columbian ground squirrels can have significant periodic impact by increasing the prevalence of perennial and annual forbs. It can take several years to reestablish Kentucky bluegrass after ground squirrel activity. Deer and elk use for cover and shade. Important habitat for raptors.

Fire: Cool burns should have little impact on rhizomatous Kentucky bluegrass or perennial forbs. Fire could reduce excessive little buildup on rested pastures with care given to fire sensitive lodgepole pine.

Restoration pathways: Renovation with native graminoids seems impractical given depleted water tables and morphological flexibility of Kentucky bluegrass. Unless water table is restored these sites will remain with a ground cover dominated by Kentucky bluegrass. 2-3 yrs of rest will restore the vigor of Kentucky bluegrass on fair or better condition pastures. Introduction of domestic species is not recommended.

Lodgepole pine/aquatic sedge (*Pinus contorta/Carex aquatilis*)

Site Summary: Locally common at higher elevations in the Ochoco mountains. Occurs between 4,600-6,800 ft. Forested floodplains, shores of lakes and ponds, and forested basins.

Soils: Sandy loam to loam.

Wildlife/fisheries: Important raptor habitat where it occurs next to water and meadow. Deer and elk appear to spend considerable time here and in adjacent meadows in spring, summer, & fall. Provides important calving& fawning habitat for elk & deer.

Fire: Wildfire was probably infrequent. Aquatic sedge will regenerate from rhizomes.

Restoration pathways: Site in mid seral or better ecological condition status will increase rapidly in status with rest and late season grazing. Site converted to LLP Kentucky bluegrass may need stream rehab to raise the water table to regain the sedge. Increasing woody debris in streams and stabilizing banks with sedges and willows is recommended.

Sagebrush/Cusick bluegrass (*Artemesia tridentate-A. cana/Poa cusickii*)

Site Summary: Common in the Ochoco mountains from 4400 to 5600 feet in elevation. Prominent on broad, low gradient floodplains where it occurs on dry terraces and inactive floodplains.

Soils: Deep, easily eroded alluvium with surface textures of fine sandy to silty clay loams.

Wildlife/fisheries: Streams passing through floodplains supporting this association are potentially good fisheries but are largely degraded.

Fire: Big sagebrush is sensitive to all but the coolest fire. Silver sage resprouts at all levels of fire intensity. Repeated burning will decrease big sagebrush cover and increase the competitive ability of Cusick bluegrass. Silver sage will decrease in cover in response to increased vigor of Cusick bluegrass.

Restoration pathways: In floodplains, raise water tables to reestablish willow/sedge habitats. A combination of rest from grazing and structures such as loose rock checkdams will give the fastest recovery. Willows may be planted but it is better to wait until the site shows lack of natural regeneration. In meadows, delay livestock grazing until after tufted hairgrass sites are dry enough to graze. This insures that the sagebrush/Cusick bluegrass sites are mature enough to withstand grazing. Livestock should then be removed at 40% utilization.

Mountain alder (*Alnus incana*)

Site Summary: Found throughout central OR in all physiographic regions with elevations 2,400-5,600 ft. Sites are young seral, active channel shelves that lie between active and flood stage streambank.

Soils: Shallow, skeletal alluvium over water worked cobbles and gravels.

Wildlife/fisheries: Most streams passing through landforms containing alder association are degraded although capable of producing valuable fisheries. Banks anchored by alder are stable and can withstand relatively severe spring runoff. Moderately narrow, moderately deep stream profiles can provide cover, food, and shade for salmonids. Birds find habitat, and deer and elk browse on alder.

Fire: Fire is infrequent. Alder will only survive the coolest ground fires. Most fires will destroy the alder, leaving the active fluvial surfaces protected from erosion only by weak rooted graminoids and forbs.

Restoration pathways: Critical factors for channel shelf formation are season long moisture and rest from grazing. The dish profile stream is often bank full at peak runoff but is dry or nearly so by summer. This condition will not support the development of riparian vegetation and with continued overuse by livestock there can't be any positive change in the condition of the site. In 2-5 yrs with rest a relatively permanent channel with banks and channel shelves stay moist season long and begin to support the growth of riparian vegetation. Once the vegetation is tall enough to trap sediments it will take at least 5 yrs for the alder to grow stems heights and diameters resistant to grazing. 40% utilization of the herbaceous vegetation or less insures that livestock use will not cause degradation.

Mountain alder-Common Snowberry (*Alnus incana-Symphoricarpos alba*)

Site Summary: Abundant between 2,200-5,500 ft in Ochoco mountains.

Soils: Sediment deposit has built soil depth to change site potential from Mt alder to Mt alder-common snowberry association.

Wildlife/fisheries: Alder provides good bank stability and protection from floods. Diversity provided by the alder provides browse for deer and elk and habitat for birds.

Fire: Fire is infrequent. Alder will only survive the coolest ground fires. Most fires will destroy the alder, leaving the active fluvial surfaces protected from erosion only by weak rooted graminoids and forbs.

Restoration pathways: Mt alder is a prolific seeder and will usually reestablish after fire. It will not root from cutting.

Mountain alder-Douglas spiraea (*Alnus incana-Spiraea douglasii*)

Site Summary: Common in Ochoco mountains from 2200 feet. Occurs on active fluvial surfaces on the banks of large streams in deep V-shaped canyons.

Soils: Accumulation of sediment has increased soil depth so that the vegetation composition reflects a drier moisture regime than the mountain alder association. Well-aerated alluvium.

Wildlife/fisheries: The diversity canopy provides habitat for birds, and browse for deer and elk.

Fire: Fire is infrequent. Alder will only survive the coolest ground fires. Most fires will destroy the alder, leaving the active fluvial surfaces protected from erosion largely by weak rooted graminoids and forbs. Mt alder is a prolific seeder and will usually reestablish after fire. It will not root from cutting. Weakly rooted spiraea, grasses and forbs provide protection from erosion. Widefruit sedge will provide good bank stability if abundant.

Restoration pathways: Mt alder will reestablish after fire, but requires protection from overuse by livestock and perhaps deer and elk. Alder seedlings can be planted in well-aerated soils that are moist throughout the summer. When livestock are removed at 40% forage use a return to late seral ecological status can be attained in 10-20 yrs. The rehab process can be accelerated if the pastures are rested for at least 5 yrs.

Willow/Kentucky bluegrass (*Salix/Poa pratensis*)

Site Summary: Occurs on sites that have been highly altered by grazing, lowering water table or both. It is common on the Ochoco NF and may occur in the watershed.

Soils: Deep fine textured alluvium over subsurface soils of various textures.

Wildlife/fisheries: Rodents such as pocket gophers, mice and Columbian ground squirrel can be a significant impact. Willows provide browse for deer and elk and diversity for birds.

Fire: Cool burns should have little impact on rhizomatous species such as Kentucky bluegrass and willows will resprout following fire.

Restoration pathways: 2-3 yrs of rest will restore the vigor of Kentucky bluegrass. 5-6 yrs can provide 5-8 ft willows. Unless water table can be restored, these sites will for all practical purposes remain with a ground cover dominate by bluegrass and should be managed as a naturalized community. Renovation of highly degraded site with native grasses and sedge is largely impractical given depleted water table and the flexibility of Kentucky bluegrass

Willow/Wooly sedge (*Salix/Carex lanuginosa*)

Site Summary: Found in Ochoco mountains, on low-gradient floodplains at 4400-5500 feet.

Soils: This is the driest natural willow association, on deep moderately fine-textured alluvium.

Wildlife/fisheries: Excellent habitat for deer, may support trout when in good condition.

Fire: Fire will decrease litter and temporarily increases herbage production. Willows are fire sensitive but resprout.

Restoration pathways: Rest and mid to late season grazing will increase cover of sedge and willow. Livestock should be kept off the site during high water and wet soils. Use streambank rehabilitation to elevate water table on sites that have degraded to sagebrush/Cusick bluegrass association. Willow cuttings will succeed where water tables are normal and are protected from livestock, deer, elk, and beaver.

Kentucky bluegrass (Poa Pratensis)

Site Summary: Abundant from 3000-5000 feet on the Ochoco NF. Occurs on sites once occupied by native grass communities.

Soils: Variable.

Wildlife/fisheries: Provides important habitat for raptors. Rodents such as pocket gophers, mice and Columbian ground squirrel can have a significant impact. Kentucky bluegrass associations are not resistant to bank erosion or overland flow of water. Bank erosion and downcutting are often severe and limit fisheries.

Fire: Fire is an effective tool in reducing the effects of excessive litter buildup on rested pastures. Cool burns have little impact on Kentucky bluegrass.

Restoration pathways: Avoid early season use to prevent soil compaction and breaking of sod. Restore natural sedge and willow associations on active fluvial surfaces to help prevent further streambank erosion and streambed downcutting.

Tufted Hairgrass (*Deschampsia cespitosa*)

Site Summary: One of the most abundant and diverse associations in central OR. Occurs from 4000-7500 feet. . Meadow sites in flat to slightly concave drainages and basins and lakeshores.

Soils: Variable.

Wildlife/fisheries: Deer, elk, rodents, and raptors area common.

Fire: Repeated burning may favor rhizomatous species such as Kentucky bluegrass, beardless wheatgrass, and western needlegrass. Frequent fire is unlikely to provide a noticeable affect on tufted hairgrass.

Restoration pathways: Time the season of use to both drying of the soil surface and to maturation of the seedheads. Remove livestock at 40% utilization of herbaceous forage. Meadows in mid seral or better ecological condition will respond rapidly to improved grazing strategies. Domestic species such as Kentucky bluegrass, Timothy, & meadow foxtail can be seeded but tufted hairgrass is preferred.

Cusick Bluegrass (*Poa cusickii*)

Site Summary: Flat micro relief of dry basins and drainages and inactive floodplains and terraces within the Cold Wet Pumice Plateau Basins Ecoregion.

Soils: Pumice alluvium.

Wildlife/fisheries: Important habitat for raptors. Rodents such as mice, pocket gophers, and Columbian ground squirrel can have a large periodic impact. Feeding ground for deer and elk.

Fire: Little is known about the effects of fire. Cusick bluegrass is more sensitive to burning than the rhizomatous species such as Kentucky bluegrass or widefruit sedge. Fire frequency is probably less than 15 yr interval.

Restoration pathways: Excellent response of this meadow to rest is expected in areas where meadows have reached mid seral or better ecological status. Most sites are highly degraded with a low density of Cusick bluegrass that responds slowly to improved livestock management systems. Floodplains seeded with good results although it would be preferable to plant Cusick bluegrass. Drier sites are more common and may not be suitable for introduction of domestic grass seeds because of fluctuating water tables, soils and extreme summer drought.

Nebraska sedge (*Carex nebraskensis*)

Site Summary: Found in most Ecoregions east of the Cascades at elevations between 4,000-5,000 ft.

Soils: Smooth organic loams derived from alluvium.

Wildlife/fisheries: If willows are supported birds and some mammals will use the area.

Fire: It is difficult to burn this wet type except for late summer. Only the top growth would burn which would reduce the water holding capacity and reduce the sediment capture in spring runoff.

Restoration pathways: Nebraska sedge forms thick, dense, rhizome mats that provide stream bank erosion. It would be desirable to manage these areas to return to willow communities, however Nebraska sedge is very competitive. Grazing should be managed to remove livestock at 40% utilization standard. Excess grazing will result in pedestalling and breaking the sod.

Wooly sedge (*Carex lanuginosa*)

Site Summary: Abundant on the Ochoco NF. Most common on active fluvial surfaces within low gradient, low to moderate elevation (4400-5600 feet).

Soils: Variable.

Wildlife/fisheries: Good fisheries potential. Habitat provided for deer, elk, raptors and other wildlife.

Fire: It can be burned in late summer or early fall. Fire can reduce litter and competitors. Wooly sedge is very resistant to damage by ground fire.

Restoration pathways: Streams can be stabilized and pool riffles increased by building structures such as loose rock checkdams. Streambanks should be revegetated with wooly sedge and willows. Livestock should be kept off these sites until the surface soils are dry.

Short-beaked sedge (*Carex simulata*)

Site Summary: Scattered throughout central OR.

Soils: Organic loam and sedge peat.

Wildlife/fisheries: Deer use this when hiding cover is in close proximity. Early spring forage may be provided.

Fire: Prescribed fire is not a useful tool. Soil surface becomes dry and the organic soils may become flammable destroying the sedge rhizomes.

Restoration pathways: Rehabilitation is not needed as the association is in late seral or climax ecological condition.

Small-fruit bulrush Bigleaf sedge (*Scirpus microcarpus Carex amplifolia*)

Site Summary: Found in grasslands and Ochoco mountains in areas 2,400-5,700 ft.

Soils: Water worked alluvium.

Wildlife/fisheries: Overgrazing, trampling, and erosion disrupt the normal successional pattern and prevent development of other sedges and mountain alder, which would provide better wildlife habitat.

Fire: Both of these graminoids are resistant to fire. In late summer fire could be used to reduce litter. Fire should not be used on active fluvial surfaces because it would remove above ground plant parts critical to sediment entrapment slowing soil building.

Restoration pathways: Revegetation is not generally needed as small fruit bulrush and bigleaf sedge have dense, thick rhizomes that respond to rapidly to rest. Both are prolific seeders. Where bank erosion is severe, grasses such as reed canarygrass, Timothy, reedgrass, bentgrass, and meadow foxtail may be used to temporarily stabilize active fluvial surfaces. Areas with soil development may response to willow or mountain alder planting.

Inflated Sedge (*Carex vesicaria*)

Site Summary: Wide geographic and elevational (4,000-6,000 ft) distribution in a variety of low gradient landforms supporting shallow flooding or semipermanently saturated soils

Soils: Deep sedge and sedimentary peats or organic loam except seral sites such as active channels shelves.

Wildlife/fisheries: Inflated sedge provides excellent barrier to streambank erosion, helping to form narrow, deep profiles. Ponded sites provide important nesting and feeding habitat for a wide variety of waterfowl. Inflated sedge provides important forage for elk in mid to late summer.

Fire: Fire is likely on in late summer or fall. Fire reduces litter and increases productivity for several years but will not change species composition. Peat soils are flammable destroying sedge rhizomes.

Restoration pathways: Dense rhizomes are very resistant to trampling. Disturbed sites in mid seral or better ecological status will rapidly recolonized by inflated sedge with rest and late season grazing. Revegetation can be accomplished using grasses such as reed canarygrass, tall mannagrass, Timothy, and reedgrass, however these are not as resistant to erosion as inflated sedge. The site is too wet for willow planting.

Beaked sedge (*Carex rostrata*)

Site Summary: One of the wettest riparian associations in wide geographic and elevational distribution (4,000-6,000 ft) in every association in central OR. Low gradient landforms from permanently flooded basins to floodplains and wet meadows. Occurs on wet fluvial surfaces such as streambank, active channel shelves, overflow channels, marshes, and fens.

Soils: Deep sedge or sedimentary peats, organic loam, or muck except for recently deposited alluvium.

Wildlife/fisheries: Semi-permanently flooded sites provide habitat for many species of waterfowl.

Fire: Burns will be possible in dry summers when water table is below soil surfaces. Fire will reduce litter accumulation and increase productivity for several yrs but will not change species composition. Peat soils are flammable.

Restoration pathways: Dense sod is very resistant to trampling and beaked sedge will rapidly recolonize disturbed sites with rest. Banks can be temporarily revegetated with grasses such as reed canarygrass, tall mannagrass, Timothy, and reedgrass, however these are not as resistant to erosion as beaked sedge. The site is too wet for willow planting.

Creeping spikerush (*Eleocharis palustris*)

Site Summary: Found throughout central OR in a range of physiographic regions with elevations 3,000-6,800 ft., riparian landforms, and Ecoregions. Low valley gradient and standing bodies of water in natural or manmade settings, such as stockponds and reservoirs. It frequently forms community in ponded sites between stream rehabilitation structures.

Soils: Margins or lakes and older reservoirs are organic loam and sedimentary peat.

Wildlife/fisheries: Broad zones of creeping spikerush along major lakes, larger stock ponds, and reservoirs offer valuable habitat for waterfowl. Seeds of rushes and sedges provide fair to good forage for duck and geese. Pondweeds, smartweeds, and water lentils are excellent forage for ducks and geese.

Fire: Prescribed fire is not a useful tool. Soil surface becomes dry and the organic soils may become flammable destroying the sedge rhizomes and will not change species composition unless fire penetrates organic soil.

Restoration pathways: Generally not needed. Stock ponds will revegetate rapidly if protected from trampling. The area should be fenced and water gravity fed to stock tanks protecting vegetation and water quality.