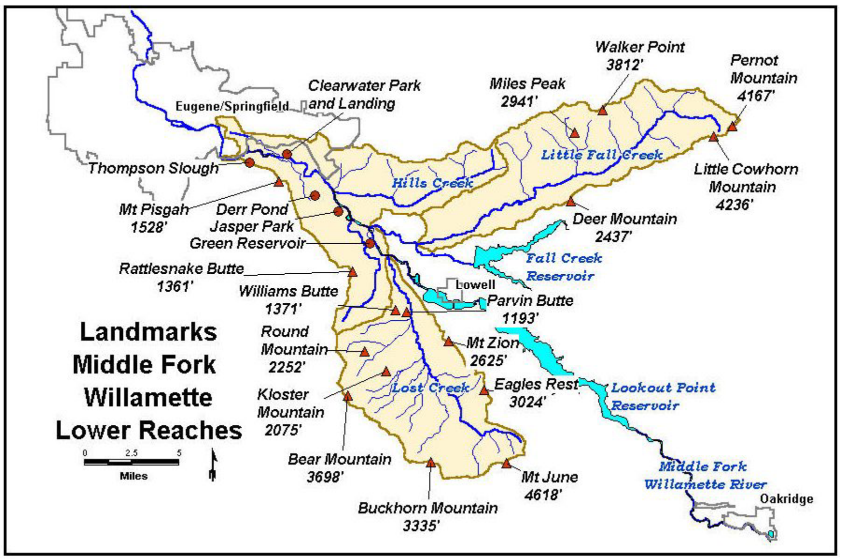
Lower Middle Fork Willamette River

Watershed Assessment



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Prepared for:

The Middle Fork Willamette

Watershed Council

Watershed Assessment Team

- **John Runyon, BioSystems:**

  Project Management and Introduction

- **Tim Grubert, BioSystems:**

  Sediment Sources

- **Jenny Allen, BioSystems:**

  Document Preparation

- **Jim Reed, Consultant:**

  GIS and map production

- **Val Rogers, Council Contractor:**

  Hydrology, Riparian Habitat Conditions, and Water Quality

- **Kim Mattson*, Ecosystems Northwest:***

  Aquatic Habitat and Fish Populations, and Wetlands

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1.0 INTRODUCTION

The purpose of this assessment is to characterize current watershed conditions in the Lower Middle Fork of the Willamette River and surrounding watersheds (Assessment Area). Information from the assessment is used to evaluate opportunities for improvements in watershed conditions, particularly the fish habitat and water quality. The assessment will aid the Middle Fork Willamette Watershed Council in identifying opportunites and priorities for watershed restoration projects.

1.1 THE WATERSHED ASSESSMENT AREA

The watershed assessment focuses on the Lower Middle Fork Willamette River below Dexter Dam and the associated tributary watersheds of Hills, Little Fall, and Lost Creeks (Figure 1-1). The total assessment area encompasses 108,026 acres, a little over 12% of the entire 865,920 acre Middle Fork Willamette River Basin (Figure 1-2). For the the Assessment Area is divided into three watersheds:

- **The Lower Middle Fork Willamette Watershed**. The watershed encompasses the river from the mouth of Lost Creek to the confluence with the Coast Fork, including Hills Creek, all other tributary streams and surrounding upland areas. For the riparian and fisheries portions of this report, the assessment area is extended at the base of Dexter Dam to include the channel and floodplain area along the river.

- **Little Fall Creek Watershed.** The watershed includes the creek to its confluence with Fall Creek and all tributary streams and surrounding upland areas.

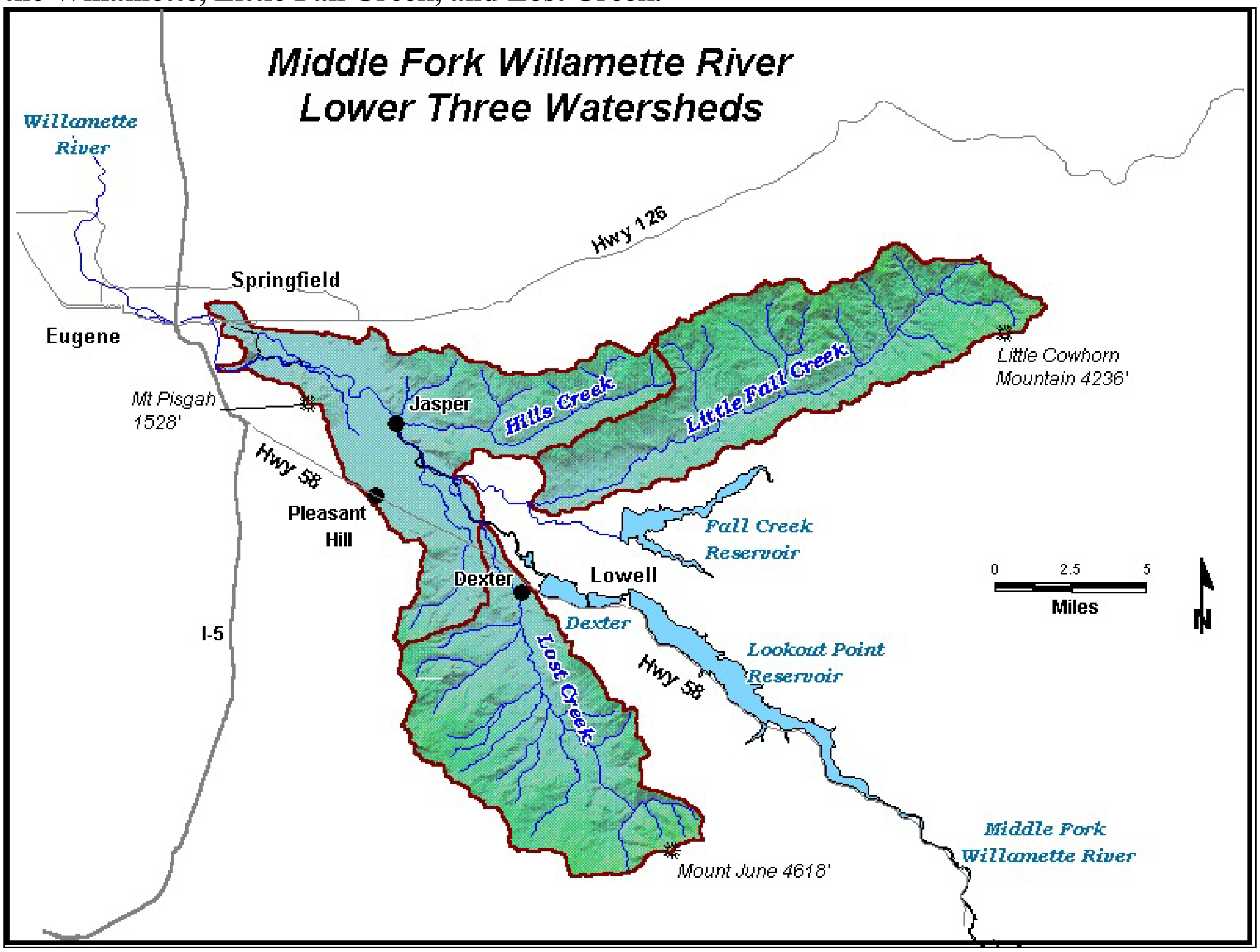
- **Lost Creek Watershed**. The watershed includes the creek to its confluence with the Middle Fork of the Willamette River and all tributary streams and surrounding upland areas.

The three watersheds in the Assessment Area are very similar in size, but they differ significantly in average elevation and precipitation (Table 1-1). The Lower Middle Fork Willamette watershed has both the lowest mean elevation and mean precipitation of the three, while the Little Fall Creek watershed has the highest values. Lost Creek and Little Fall Creek are similar to each other in terms of minimum and maximum elevations, but their mean values for elevation and precipitation are rather different.

Table 1-1. General watershed characteristics of the three watersheds in the Assessment Area.

Watershed	Area (Acres)	Mean Elevation (ft)	Minimum Elevation (ft)	Maximum Elevation (ft)	Mean Annual Precipitation (in)
Lower MFW	36,006	800	446	2710	49
Little Fall Creek	37,402	1989	616	4227	66
Lost Creek	34,618	1673	600	4243	55
Total	108,026				

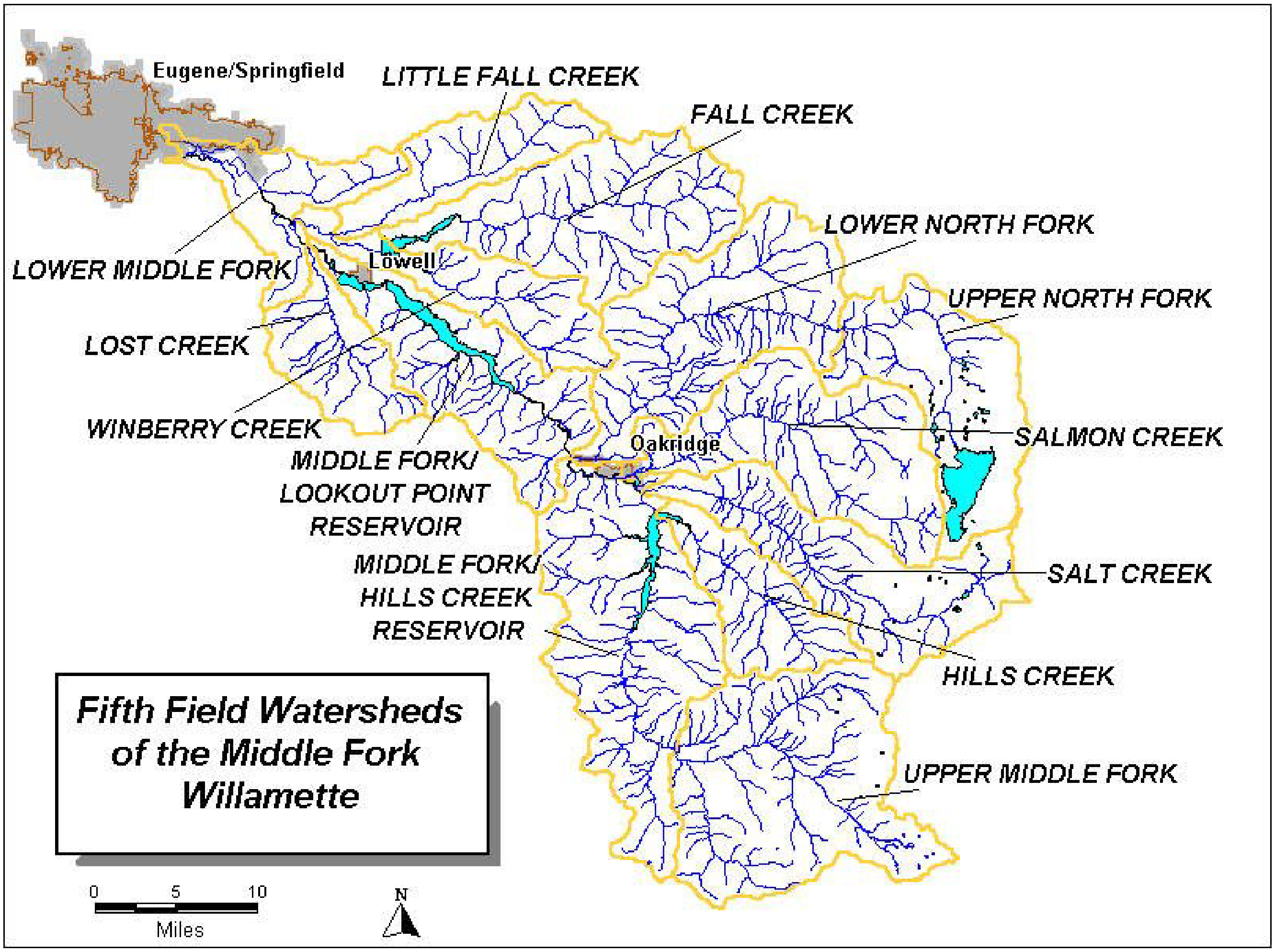
Figure 1-1. Watershed assessment area with the three watersheds: Lower Middle Fork of the Willamette, Little Fall Creek, and Lost Creek.



1.2 LANDFORMS AND GEOLOGY

The Assessment Area is located primarily in the older, more deeply eroded Western Cascades portion of the Cascade Mountain physiographic province. This V-shaped region is bounded on the east by the younger, snow covered peaks of the High Cascades region of the province and on the west by the Willamette Valley.

Figure 1-2. This map depicts all of the 5th-field watersheds comprising the Middle Fork Willamette River Basin (865,920 acres). The Assessment Area covers the lower three 5th-field waterheds -- Lower Middle Fork, Little Fall Creek, and Lost Creek – for a total of 108,026 acres, a little over 12% of the entire Basin.



Geomorphic characteristics throughout much of the Assessment Area include the steep ridges, narrow valleys, and volcanic soils which typify the western slope of the Cascades. Figure 1-3 is a geologic map of the Assessment Area. Refer to table 1-2 for a description of the geologic map units. Past episodes of glaciation and active stream erosion have created a highly dissected landscape characterized by steep, high gradient stream reaches in the upper portions of the Assessment Area and low gradient stream reaches in the lower portions (Orr et al, 1992).

Figure 1-3. Geology of the Assessment Area.

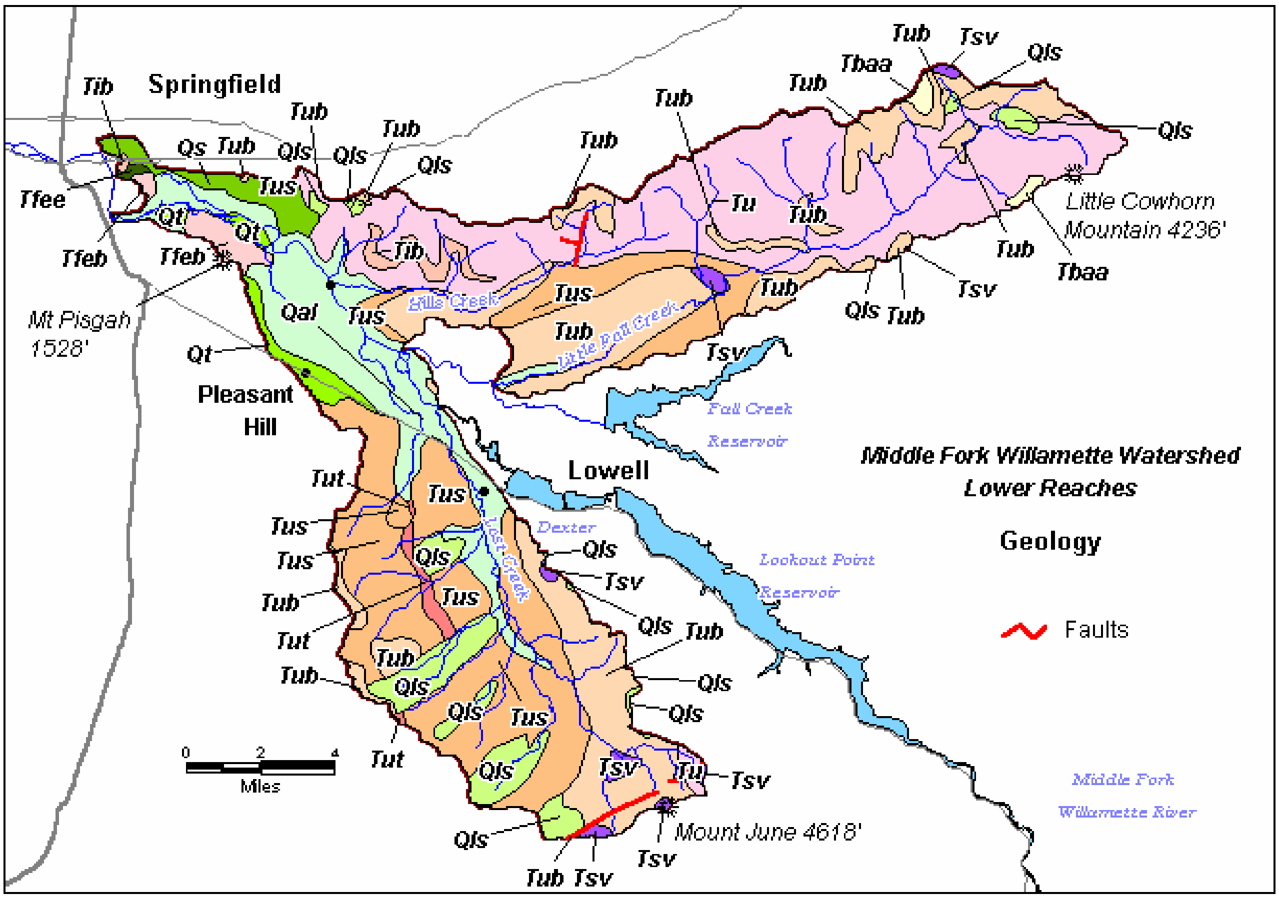


Table 1-2. Description of Geologic Map Units (Walker and MacCleod, 1991).

Map Symbol	Geologic Unit	Description of Rocks in Assessment Area
Quaternary Period		
Qal	Alluvium	Moderately sorted cobble gravel along rivers to poorly sorted gravely sand on small tributary fans. Includes post-glacial terrace gravels that are perched above modern floodplain surfaces.
Qls	Landslide deposits	Distinct ancient landslide, including headscarp (where present) and downslope deposit of poorly sorted clay-rich mud and angular clasts of bedrock and surficial deposits.
Qs	Lacustrine and fluvial sedimentary rocks	Unconsolidated to semi-consolidated lacustrine clay, silt, sand, and gravel; in places include mudflow and fluvial deposits and sidcontinuous layer of peat. Includes older alluvium and related deposits of alluvial silt, sand and gravel that form terrace deposits.
Qt	Terrace, pediment, and lag gravels	Unconsolidated deposits of gravels, cobbles, and boulders intermixed and locally interlayed with clay, silt, and sand. Mostly on terraces and pediments above present floodplains.
Tertiary Period		
Tbaa	Andesitic and basaltic rocks	Flows and flow breccias of andesite, basaltic andesite and some basalt. Includes interbedded volcaniclastic rocks mostly of andesite composition. Flows commonly exhibit platy flow jointing, in many places with red hematite stain on joints. Locally includes massive layers of red clinkers. Younger, upper part of unit, generally unaltered. Lower parts commonly altered. Unit generally caps main ridges, uncomformably capping Tu; in places present as slump blocks on canyon walls. Erupted mostly from widespread, northwest-trending dikes and dike swarms and related plugs and lava cones approximately 17 to 10 million years before present (MaBP).
Tfeb	Basaltic rocks	Basaltic lava flows overlain by a welded tuff.
Tfee	Marine Eugene Formation	Thin to moderately thick bedded, coarse to fine grained arkosic and micaaceous sandstone and siltstone, locally highly pumiceous; and coeval and older andesittic lapilli tuff, breccia, water laid and air fall silicic ash.
Tib	Intrusive basalt and andesite	Sills, plugs, and dikes of basaltic andesite, basalt, and andesite. May represent feeders, exposed by erosion, for flows and flow breccias of Tbaa.
Tu	Undifferentiated volcanics	Tuffaceous sediment rocks, basalt flows, and tuffs, undivided; a heterogeneous assemblage of continental, largely volcanogenic deposits of basalt and basaltic andesite, including flows and breccias, complexly interstratified with volcaniclastic deposits. Includes extensive ash-flow and air-fall ruffs, abundant lapilli tuff and tuff breccia, andesitic mudflow (lahar) deposits, massive to bedded fine- to coarse-grained tuffaceous sediment rocks and volcanic conglomerates. Deposited approzimately 32 to 17 MaBP, incorporating the time of deposition of both Tus and Tub.
Tus	Clastic sedimentary rocks	Pale green to gray lapilli tuffs, mudflow (lahar deposits), flow breccias, and volcanic conglomerates, mostly of andesitic compostion, iron-stained tuffs of basaltic and andesitic composition, and white, tan, light-gray, orange-gray, and grayish-red ash-flow, air-fall, and water-laid tuffs of rhyolitic compostion. Tuffs and breccias grade laterally into flows of basalt and basaltic andesite. Deposited late in the period of Tu deposition.
Tub	Basalt and basaltic andesite flows and flow breccias	Grades laterally into ruff and breccia and into clastic sedimentary rocks (Tus). May include some mafic sills and dikes intrusive into Tus. Deposited during the middle of Tu deposition.
Tut	Tuff	Welded to unwelded, mostly vitric crystal and vitric ash-flow tuff of several ages. Glass in tuff locally altered to clay, zeolites, and secondary silica minerals.

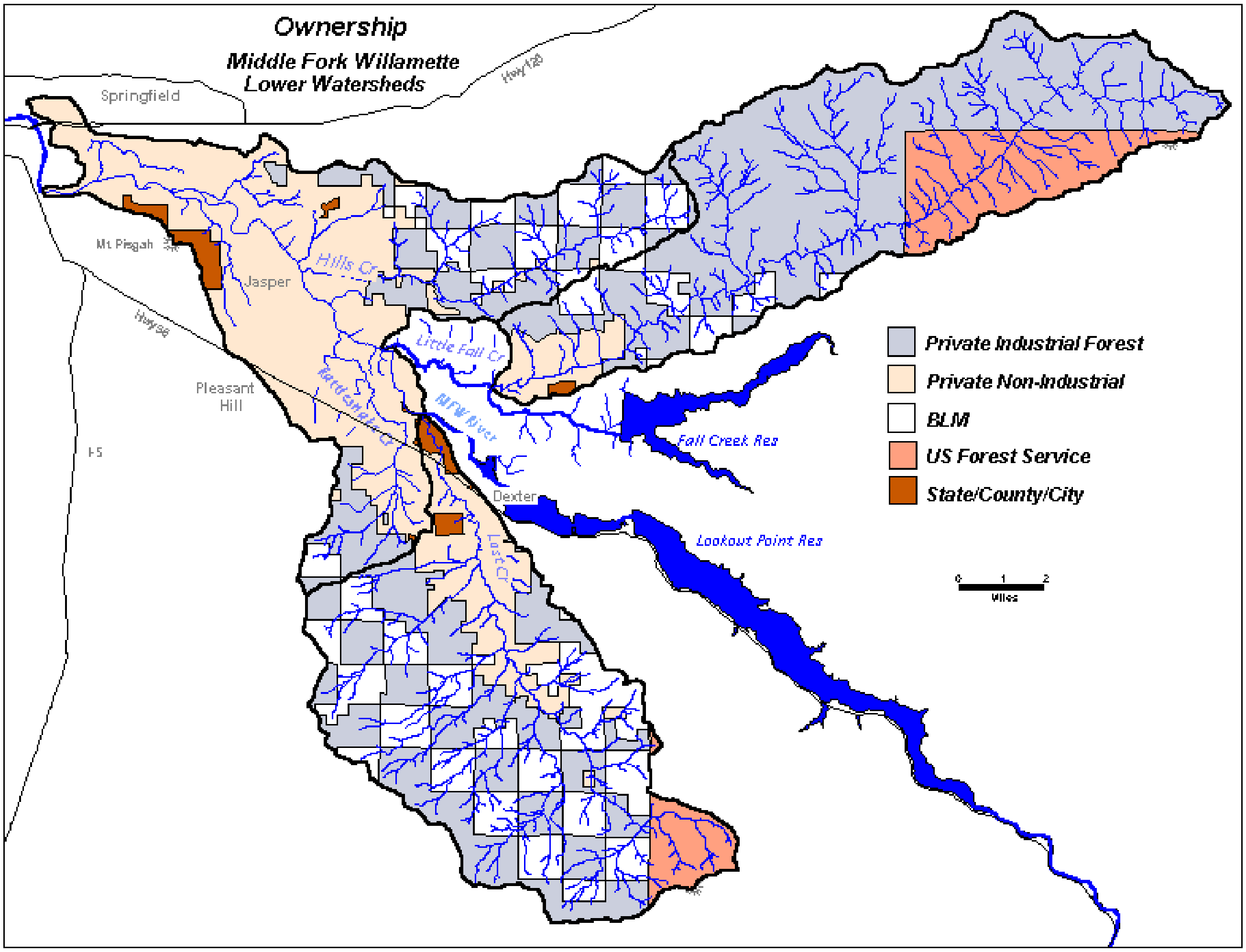
1.3 LAND OWNERSHIP AND USES

The Assessment Area has a mix of public and private lands (Figure 1-4). The ownership patterns vary by watershed (Table 1-3). Private industrial forestlands are the largest ownership category, covering 49,521 acres, or 46% of the Assessment Area. Most of the industrial forestlands are concentrated in the Little Fall (70% of this watershed's area) and Lost Creek (42% of this watershed's area) watersheds. Approximately 27% of the Assessment Area is in non-industrial forest ownership (which includes small woodlots, rural residential, and agricultural lands), with the largest concentration in the Lower Middle Fork Willamette watershed (60% of this watershed's area). Public lands occupy about 27% of the Assessment Area, with most under Bureau of Land Management (17%) or Forest Service management (8%). Lost Creek watershed has the largest concentration of public lands (40% of the watershed's area), primarily managed by the Bureau of Land Management.

Table 1-3. Land ownership within the three watersheds within the Assessment Area.

	Ownership Category (acres and percent)						
Watershed	**BLM**	**USFS**	**Other Public**	**State**	**Private Industrial Forest**	**Other Private Lands**	**Total**
Lower MFW	4,826 (13%)	---	78 (<1%)	787 (2%)	8,647 (24%)	21,668 (60%)	36,006
Little Fall Creek	2,377 (6%)	6,461 (17%)	110 (<1)	---	26,317 (70%)	2,137 (6%)	37,402
Lost Creek	11,432 (33%)	2,304 (7%)	204 (<1%)	380 (1%)	14,557 (42%)	5,741 (17%)	34,618
Total	18,635 (17%)	8,765 (8%)	392 (<1%)	1,167 (1%)	49,521 (46%)	29,546 (27%)	108,026

Figure 1-4. Land ownership patterns within the Assessment Area.



The distribution of land uses and land ownership within the Assessment Area follow similar patterns (Figures 1-4 and 1-5). All three watersheds are dominated by forestry land use (Table 1-4). The lower mean elevation and wide floodplain area of the Lower Middle Fork Willamette Watershed allow for a greater diversity of other land uses. Forestry accounts for over 90% of the land use in Lost and Little Fall Creek watersheds as compared to 65% in the Lower Middle Fork Willamette. Throughout the Assessment Area, agricultural land use is concentrated along the mainstem of the river and creeks, with forestry dominating the uplands. A small area of urban land use occurs near the mouth of the Middle Fork of the Willamette River.

Figure 1-5. Land use patterns within the Assessment Area.

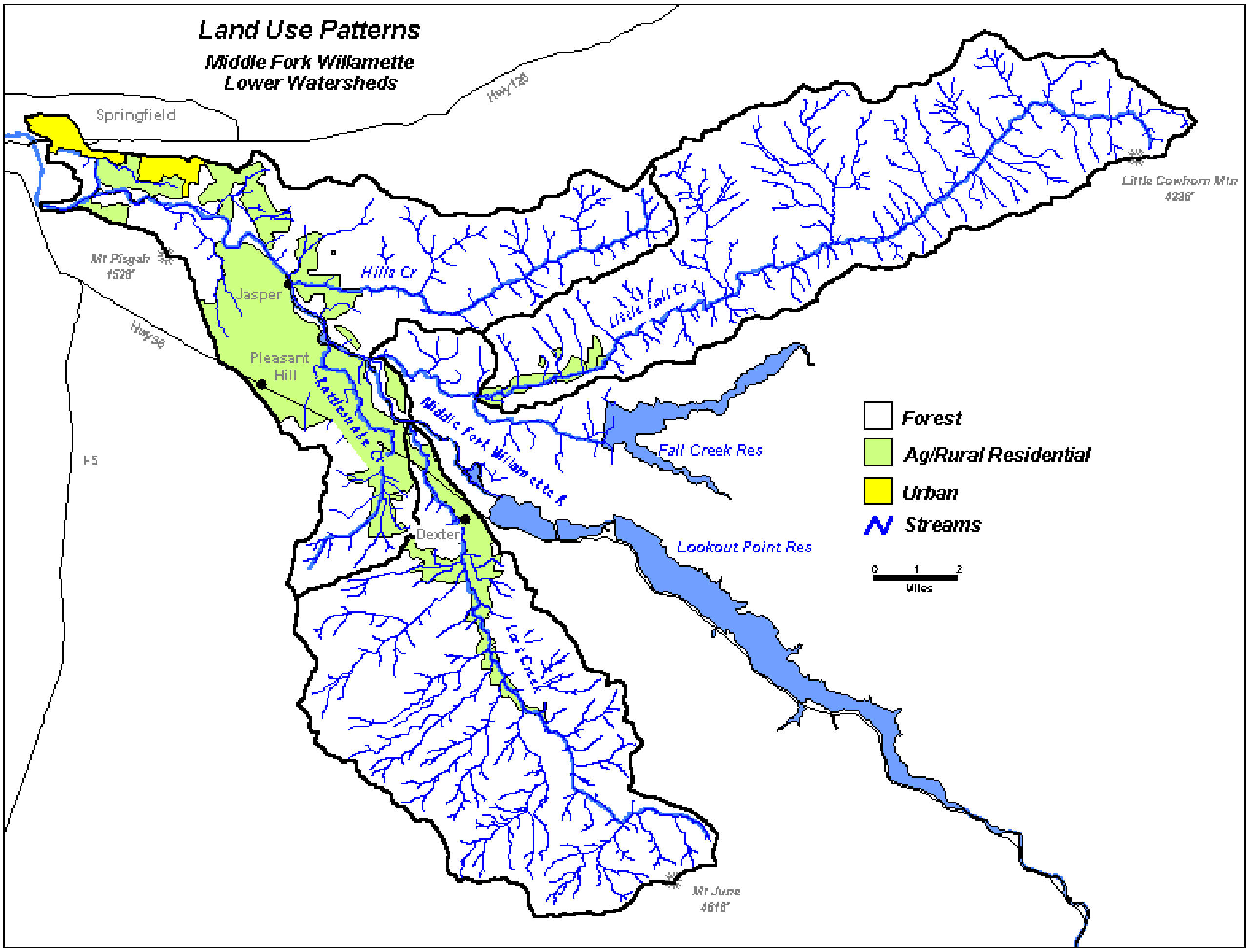


Table 1-4. Land uses in the Assessment Area.

Watershed	Forestry		Ag/Rural Residential		Urban		Other	
	Acres	%	Acres	%	Acres	%	Acres	%
Lower MFW	23,404	65	11,162	31	1,080	3	360	1
Little Fall Creek	36,654	98	748	2	0	0	0	0
Lost Creek	31,849	92	2,769	8	0	0	0	0

1.4 WATERSHED ASSESSMENT APPROACH

The assessment followed the general framework described in the Oregon Watershed Enhancement Board's Watershed Assessment Manual (WPN, 1999). The assessment primarily used existing information, relying on archived data, aerial photography, and previously published reports and other documents. This existing information was supplemented by a Council-sponsored stream habitat inventory of Lost and Little Fall Creeks (Ecosystems Northwest, 2001). Two completed watershed assessments provided valuable information in Little Fall and Hills Creek Watersheds (Weyerhaeuser Corporation, 1997) and Lost Creek Watershed (Bureau of Land Management, 1997). In addition, limited 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.

1.5 ORGANIZATION OF THE DOCUMENT

The following assessment sections organize the document:

- Hydrology and water use (Section 2.0);
- Riparian and habitat conditions (Section 3.0);
- Aquatic habitat and fish populations (Section 4.0);
- Wetland conditions (Section 5.0);
- Water quality (Section 6.0); and
- Sediment sources (Section 7.0).

2.0 HYDROLOGY

2.1 INTRODUCTION

The hydrologic component of this assessment identifies land uses and water uses that have the potential to impact the hydrologic processes of the Assessment Area. For this analysis, simplified techniques are used to screen for possible impacts. Identifying the specific cause or degree of impact would require more in-depth technical analysis and is beyond the scope of this assessment.

2.2 METHODS AND KEY QUESTIONS

The hydrology assessment was conducted using hydrologic data (e.g., stream flow records), existing reports, interviews with resource professionals, and other information. The following are key questions.

1. What land uses and processes generate peak flows?

2. What is the flood history of the area?

3. What are the effects of dam regulation on Middle Fork Willamette River flow patterns?

4. What are the ecological effects of altered flow patterns?

2.3 RESULTS

The results of this section are organized to address the critical questions.

2.3.1 What Land Uses and Processes Generate Peak Flows?

2.3.1.1 Peak Flow Processes

The purpose of this part of the assessment is to identify the main process which produces peak runoff in each of the three watersheds within the Assessment Area. Determining which process is most responsible for peak runoff is not an exact science. There are various "rules of thumb" which are used, as well as professional judgement and experience. Hydrologists generally agree that, in this region, rainstorms are the dominant cause of runoff in areas below 1500 ft elevation

(BLM, 1997; USFS, 1997). Above 1500 ft, significant amounts of snow can accumulate during the winter. When warm rainstorms rapidly melt the accumulated snow, a process known as rain-on-snow, additional runoff is created. Each of the 3 watersheds in the Assessment Area has some portion in the rain-on-snow zone above 1500 ft.[1] The percentage of rain-on-snow zones for the watersheds are shown in table 2-1.

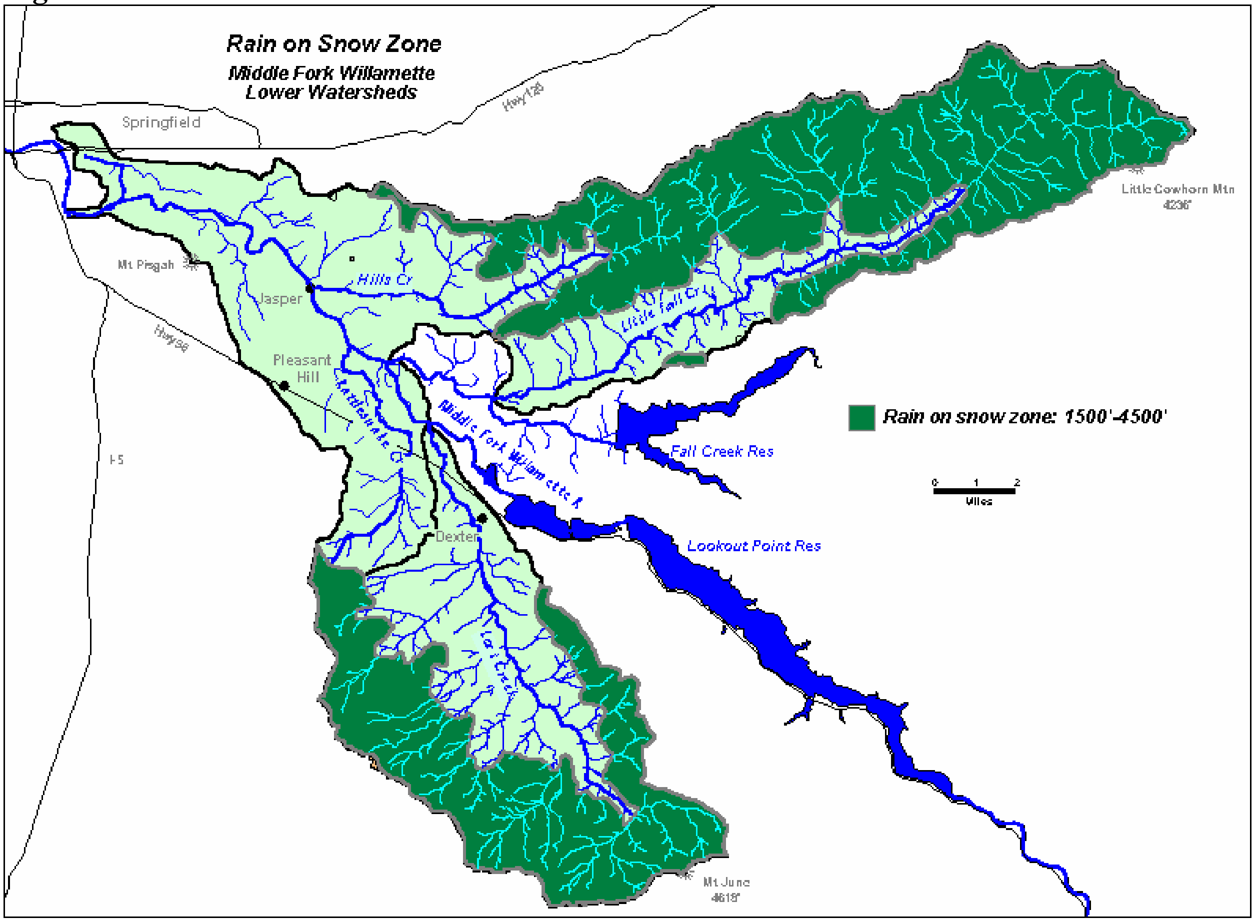
Table 2-1. Dominant peak flow processes in the Assessment Area.

Watershed Name	Watershed Area	Rain Dominant		Rain-On-Snow Dominant	
	mi^2	mi^2	%	mi^2	%
Lower MFW	56.2	46.6	83	9.6	17
Little Fall Creek	58.4	15.2	26	43.2	74
Lost Creek	54.1	23.3	43	30.8	57

The three watersheds together represent a spectrum of dominant runoff processes. Rain is the primary source of peak flow generating runoff in the Lower Middle Fork Willamette watershed, while rain-on-snow is the dominant process in the Little Fall Creek watershed. Both processes are roughly equally responsible for peak flows in the Lost Creek watershed. Another process, high spring runoff from seasonal melting of long-term snowpacks is not a significant factor in producing the peak flows of any of the watersheds due to their relatively modest elevations. Figure 2-1 displays the boundary between the rain and rain-on-snow zones in the Assessment Area.

[1] The Ecoregion Appedix of the OWEB Watershed Assessment Manual lists 2300 feet evevation as the lower limit for the rain-on-snow zone for the valley foothills and Western Cascades. Given the location of the Assessment Area in the southern end of the Ecoregion, an elevation of 1500 feet was chosen as the lower limit of the rain-on-snow zone in order to provide a conservative estimate of the potential degree of impact to the watershed. Usin this elevation may overestimate the potential impact, but probably does not underestimate it. For screening puposes, overestimating the potential impact is less risky than underestimating them.

Figure 2-1. Rain-on-snow zone within the Assessment Area.



2.3.1.2 Land Use

The differences in basic watershed characteristics noted in section 2.2 above are correlated with differences in land use among the three watersheds. Table 2-2 compares the area and percentage of different land uses for the 3 watersheds.

Table 2-2. Land uses in the Assessment Area.

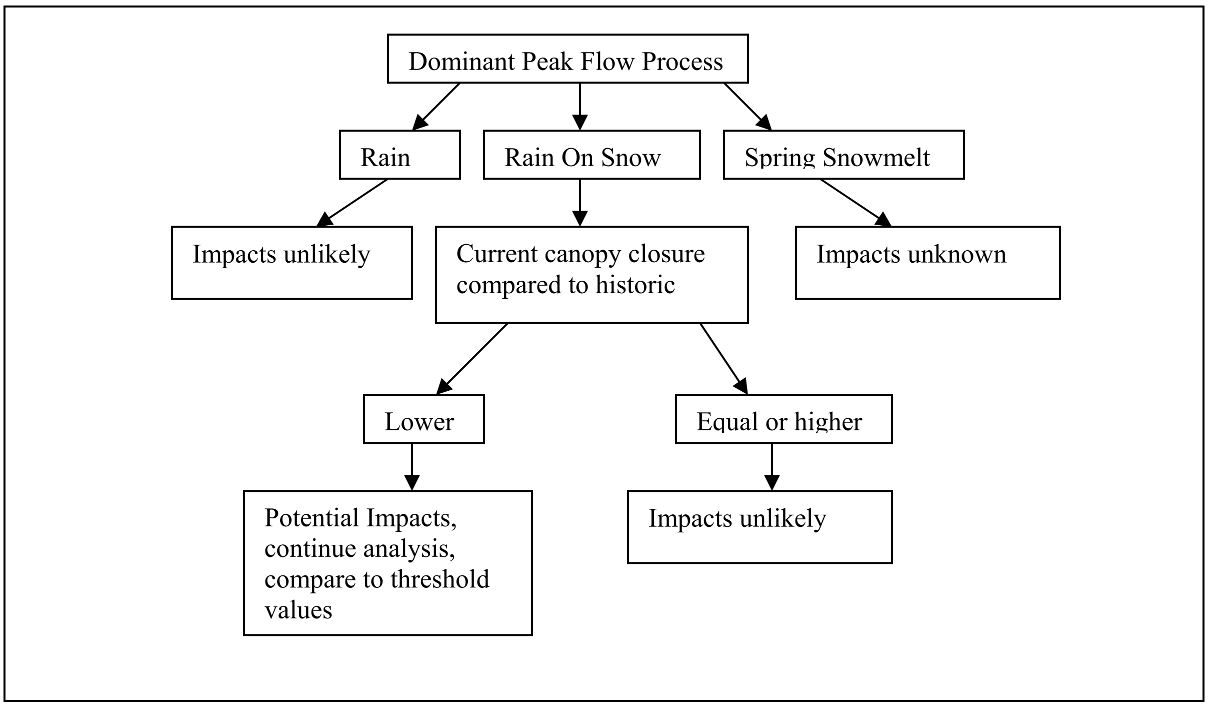
Watershed Name	Area (mi^2)	Forestry		Ag/Rural Residential		Urban		Other	
		mi^2	%	mi^2	%	mi^2	%	mi^2	%
Lower MFW	56.2	36.53	65	17.4	31	1.7	3	0.5	1
Little Fall Creek	58.4	57.2	98	1.2	2	0	0	0	0
Lost Creek	54.1	49.8	92	4.3	8	0	0	0	0

2.3.1.3 Land Use Effects on Peak Flows

2.3.1.3.1 Forest Land Use

The potential for forest land use to affect peak flows is related to the openings in the forest canopy caused by clearcut harvest. Research has shown that more snow can accumulate in these openings and the snow can also melt faster because it is more directly exposed to wind and rain than it would be if the forest canopy were intact (WPN, 1999). Several steps are prescribed in the OWEB manual to determine if forest land use has a high likelihood of increasing peak flows. The flow chart below summarizes these steps (Figure 2-2).

Figure 2-2. Peak flow assessment steps.



Because 83% of the Lower Middle Fork Willamette watershed is in the rain-dominated precipitation zone, it is unlikely that impacts from forest land use would significantly increase peak flows. The Lost Creek and Little Fall Creek watersheds do have 57% and 74% of the total watershed area respectively, in the rain-on-snow precipitation zone Since the area in this precipitation zone is entirely used for forestry, there is the potential for forest land use to impact peak flows in these watersheds.

To determine the likelihood of impacts, the current amount of forest canopy closure is compared to historical conditions. In the Western Cascades Lowlands (4a) and Highlands (4b) Ecoregions, (*refer to the riparian chapter for a description of the ecoregions*) forests historically had greater than 30% crown closure overall, including openings created by disturbances such as fire. Figure 2-3 below outlines the areas of forest in the rain-on-snow zone that currently have less than 30% crown closure. Areas with limited crown closure tipically are recent harvest units and sparse stands which were visible on digital orthophotos.

Figure 2-3. Forest crown closure less than 30% in rain-on-snow zone.

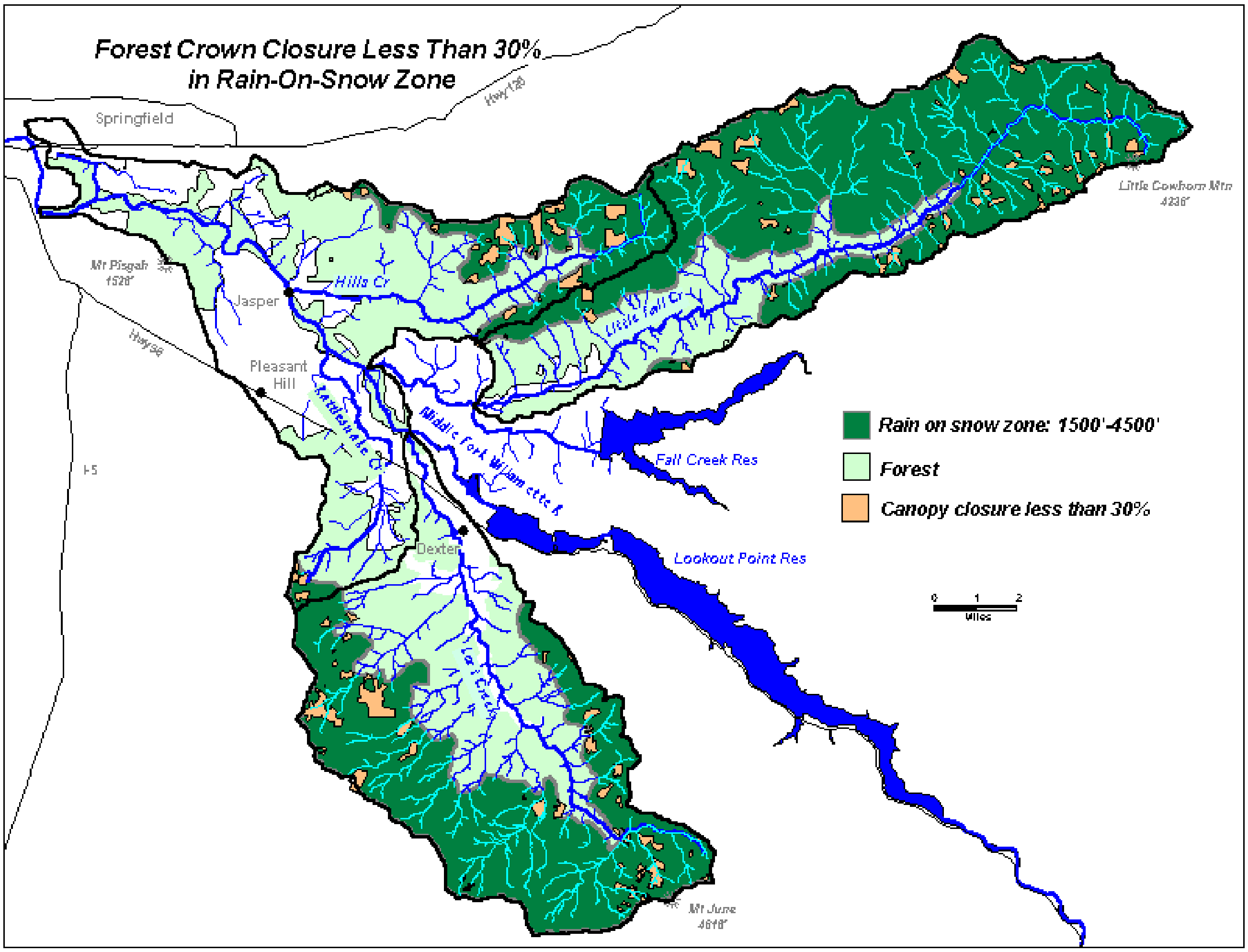


Table 2-3 shows that in the Lost Creek watershed a total of 7.4% of the forested landscape in the rain-on-snow zone currently has less than 30% crown closure. For Little Fall Creek, the figure is 5.2%. These percentages are well below the threshold which can cause measurable change in peak flows (OWEB, 1999). For example, in the Lost Creek watershed, roughly 60% of the forest in the rain-on-snow zone would need to be in an "open canopy" condition to cause a detectable increase in peak flows. In Little Fall Creek, because more of the watershed as a whole is in the rain-on-snow zone, effects on peak flows could occur with 40% of the area in an open canopy condition.

Table 2-3. Risk of forest land use effects on peak flows. ROS = rain-on-snow.

Watershed Name	% of watershed in ROS Zone	Historic Crown Closure in ROS	% of ROS with < 30% current crown closure	Threshold value where% ROS with < 30% crown closure may increase peak flow	Risk of Peak Flow Impacts from Forest Land Use
Lower MFW	17	NA	NA	NA	Low
Little Fall Cr.	74	> 30%	5.2%	40%	Low
Lost Cr.	57	> 30%	7.4 %	60%	Low

While it is unlikely that forest land use is increasing peak flows at the scale of the whole watershed, i.e. near the mouths of the mainstem creeks, at the subwatershed scale, there may be impacts to tributaries with smaller drainages such as Anthony Creek that currently have a higher proportion of open canopy areas.

2.3.1.3.2 Agriculture(Ag) / Rural Residential (RR) Land Use

The analysis of the effects of Ag/RR land use on runoff uses another screening procedure to detect the chance of significant change from natural conditions. Of the three watersheds, the Lower Middle Fork Willamette has by far the highest percentage of Ag/RR landuse, 31% compared to 8% for Lost Creek and 2% for Little Fall Creek. Therefore, this analysis was completed only for the Lower Middle Fork Willamette watershed. The results are assumed to represent conditions in the smaller Ag/RR portions of the other two watersheds.

To estimate the likelihood of increased runoff from Ag/RR land, the OWEB method involves calculating runoff for different combinations of hydrologic soil groups, cover types (row crop, for example), and treatments (such as contour planting). In addition to these variables, a hydrologic condition class (good, fair, poor) is assigned to each site. While the hydrologic soil group is based on intrinsic soil properties such as texture and depth, the hydrologic condition class is determined by other factors that influence infiltration and runoff such, as vegetative cover and surface roughness.

Since this analysis was done by Natural Resources Conservaion Services personnel from the Corvallis office, direct field observations of hydrologic condition class were not made. Instead, two separate calculations of runoff were completed: one in which the condition was assumed to be good, the other in which it was assumed to be poor. Thus the range of potential conditions was bracketed by the separate calculations.

The results are summarized in table 2-4. See the appendix for intermediate steps of the calculations.

Table 2-4. Effects of agriculture/rural residential land use on peak flow for the Lower Middle Fork Willamette watershed.

	% Ag/RR in main hydro soil group (LMFW)	Av. Increase in Runoff (inches) from Ag/RR practices		% Ag/RR in 2nd hydro soil group (LMFW)	Av. Increase in Runoff (inches) from Ag/RR practices		% Ag/RR in 3rd hydro soil group (LMFW)	Av. Increase in Runoff (inches) from Ag/RR practices		Weighted Average Increase for combined soil groups		Threshold Increase (inches) for Peak Flow Impacts	Potential for Increased Peak Flow
Hydro condition class		Poor	Good		Poor	Good		Poor	Good	Poor	Good	<0.5	Low
												0.5-1.5	Mod
Soil Group	(C) 45%	0.97	0.42	(D) 27.5%	0.85	0.39	(B) 25%	1.03	0.44	0.93	0.41	> 1.5	High

The results indicate that, under good hydrologic conditions on Ag/RR land in the Lower Middle Fork Willamette watershed, with an average increase of 0.41 inches of runoff depth, the potential for peak flow enhancement is low. Under poor conditions, a worst case scenario with an average increase of 0.93 inches of runoff depth, the potential to increase peak flows is moderate. Thus, there does not seem to be a significant risk of Ag/RR land use increasing peak flows in the Lower Middle Fork Willamette watershed, nor by extension, in the Lost Creek and Little Fall Creek watersheds.

2.3.1.3.3 Roads

Research has shown that dense road networks can contribute to increases in peak flows (OWEB, 1999). To screen for potential hydrologic impacts of roads, the percent of total area occupied by roads is calculated for forest and Ag/RR land use in each watershed. For the small area of urban land use in the Lower Middle Fork Willamette watershed, road density, (miles of road/mi^2), serves as an indicator metric of percent impervious area.

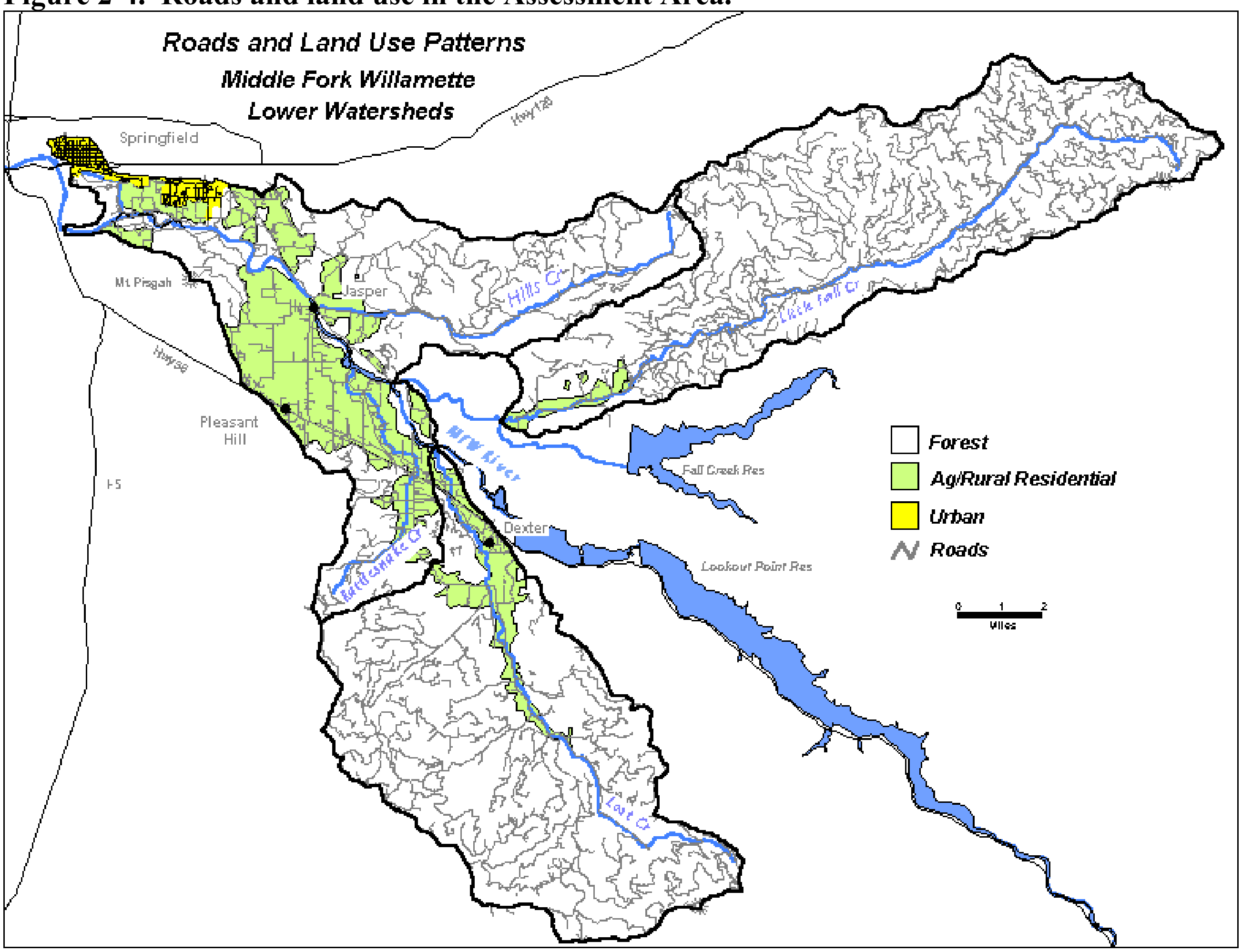
The results of these calculations are compared to threshold values to determine the likelihood of impacts. The different levels of roaded area are associated with different levels of potential impacts to peak flows as shown in table 2-5.

Table 2-5. Potential road effects on peak flows.

Percent Roaded Area in Forest or Ag/RR Land Use	Potential Risk of Peak Flow Enhancement		Road Density in Urban Land Use	Total Impervious Area Associated with that Road Density	Potential Risk of Peak Flow Enhancement
< 4%	Low		< 4.2 mi/mi2	<5%	Low
4 – 8%	Moderate		4.2 – 5.5mi/mi2	5 – 10%	Moderate
> 8%	High		>5.5 mi/mi2	> 10%	High

Table 2-6 summarizes the road assessment for all three watersheds. In all three watersheds, the risk of peak flow impacts from forest roads across the watershed overall is low. Since road density is not evenly distributed across the watershed, there are greater risks of road impacts in localized areas of higher road density (see Figure 2-4).

Figure 2-4. Roads and land use in the Assessment Area.



For example, the risk of impacts from Ag/RR roads in the Little Fall and Lost Creek watersheds is rated as moderate due to the higher road density associated with this land use. However, since the percentage of each watershed in this land use is quite small (2% in Little Fall Creek, 8% in

Lost Creek), the overall effect at the watershed scale is relatively slight, though localized effects could be significant. Similarly, because the road density in the small urbanized portion (3.2%) of the Lower Middle Fork Willamette watershed is three times higher than the threshold value for potential impacts, the risk rating for this land use is high. If urban land use expands significantly in the future, the risk of peak flow impacts to the watershed as a whole would also increase.

Table 2-6. Roaded area and risk of peak flow impacts.

Watershed	Percent Forest Area in Roads	Risk of Impacts from Forest Roads	Percent Ag/RR Area in Roads	Risk of Impacts from Ag/RR Roads	Urban Road Density	Risk of Impacts from Urban Roads
Lower MFW	1.8%	Low	3.9%	Low	18.1	High
Little Fall Cr.	2.9%	Low	7.2%	Mod	NA	NA
Lost Cr.	2.0%	Low	6.9%	Mod	NA	NA

2.3.1.4 Combined Land Use Effects on Peak Flow

The results of the screening procedures described in the previous sections indicate that the potential for impacts to peak flow runoff from land uses in the three watersheds is generally low to moderate (Table 2-7). Roads, particularly in rural and urban areas have a greater potential to impact runoff, especially in a localized area.

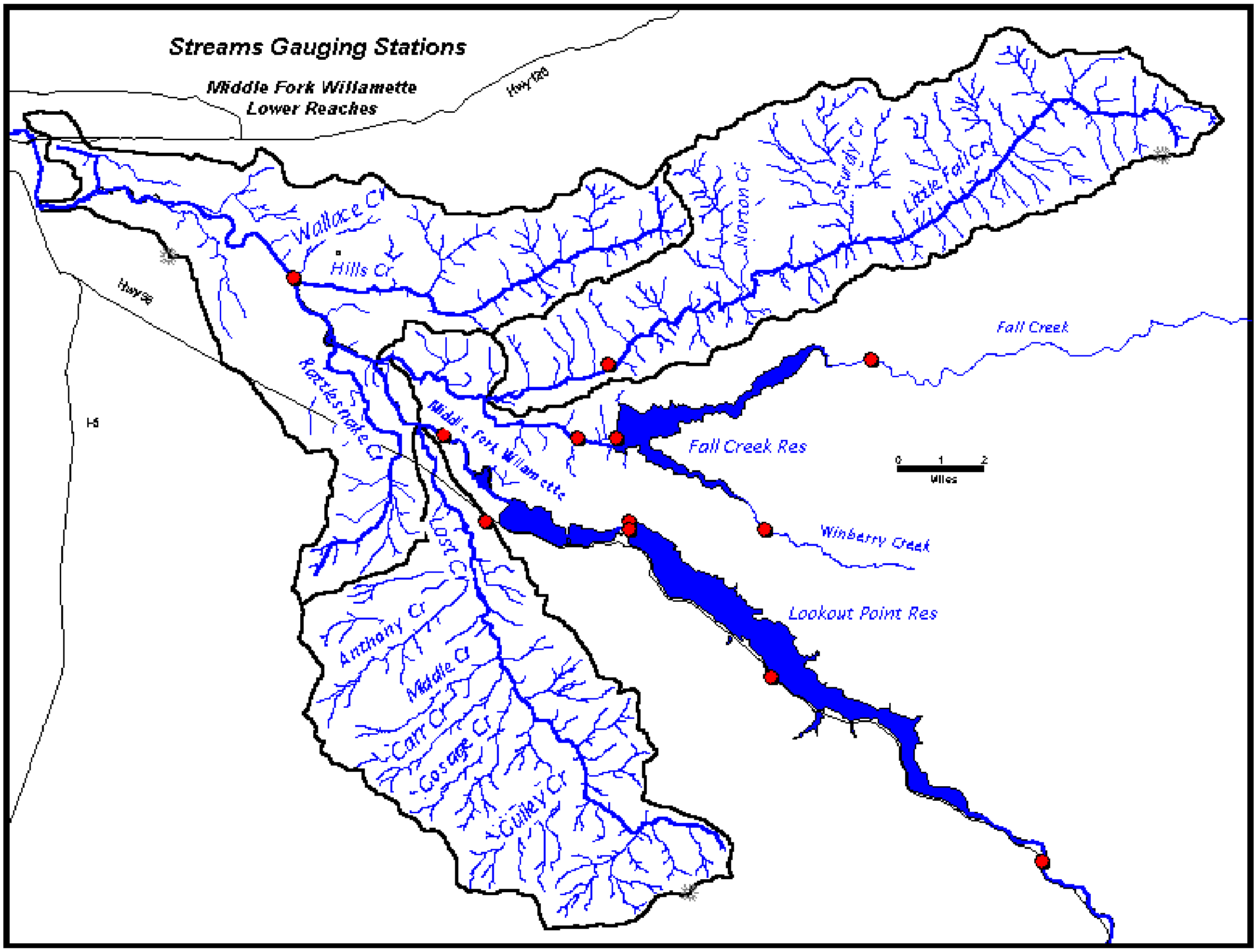
Table 2-7. Summary of potential land use impacts on peak flow runoff.

Watershed	Risk from Forest Land	Risk from Ag/RR land		Risk from Forest Roads	Risk From Ag/RR Roads	Risk from Urban Roads
		Poor Cond.	Good Cond.			
Lower MFW	Low	Mod	Low	Low	Low	High
Little Fall Cr.	Low	Mod	Low	Low	Mod	NA
Lost Cr.	Low	Mod	Low	Low	Mod	NA

2.3.2 What is the Flood History for the Assessment Area?

Stream gauge records provide a view of the annual peak flows that have occurred over time in each watershed. Refer to figure 2-5 for stream gauge locations for the Assessment Area. Understanding the flood history of a watershed is helpful in interpreting observations of channel form, riparian condition, and fish habitat. The hydrologic terminology of flood frequency (5yr, 10 yr, 25 yr. events, etc.) refers to specific flood discharges that are predicted to occur once in 5, 10, or 25 years on average, though their occurrence may not be evenly spaced over a given time period.

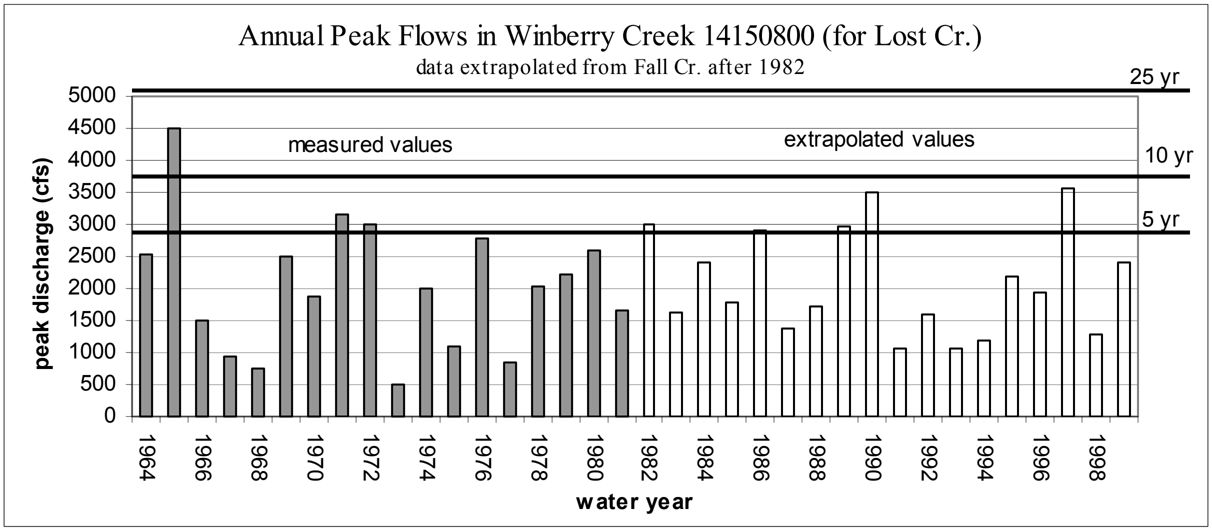
Figure 2-5. Stream discharge gauging stations near the Assessment Area.



2.3.2.1 Lost Creek Flood History

There are no available flow records for Lost Creek. The BLM watershed anaysis (BLM, 1997) used flow data from Winberry Creek, a nearby watershed of similar size, to estimate flows in Lost Creek. The data from Winberry Creek were found to be generally representative of Lost Creek when compared to the results obtained from regional flood frequency equations commonly used for streams in Oregon (Wellman, et.al., 1993). The flood history data for Winberry Creek is presented in figure 2-6. Actual discharge values for Lost Creek would be approximately 10% to 20% higher.

Figure 2-6. Flood history of Winberry Creek (represents Lost Cr.).



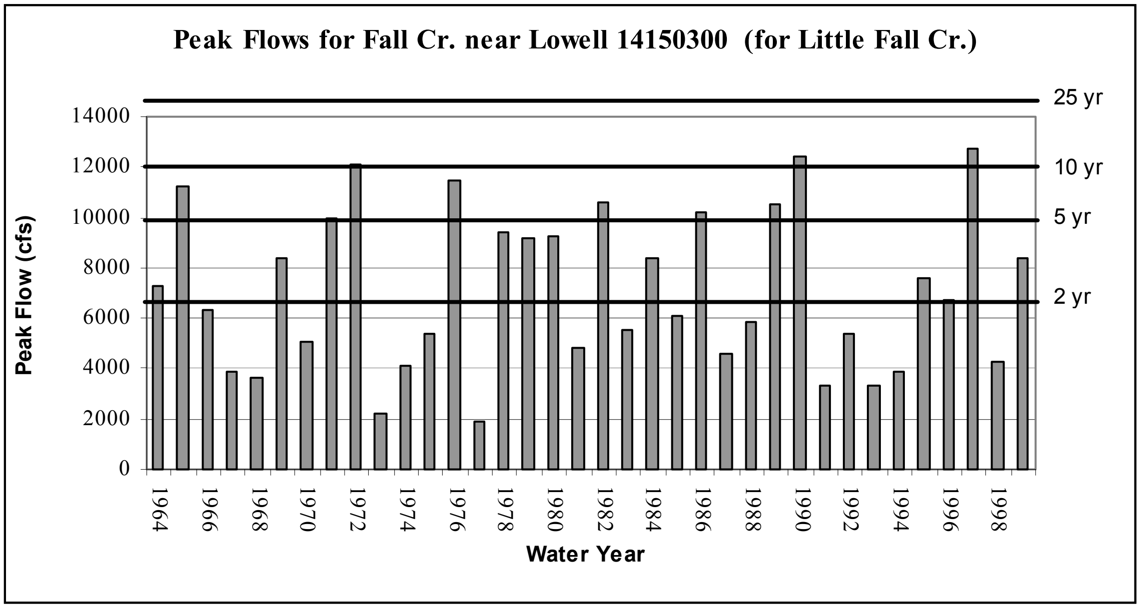
The period of record at this gauge is relatively limited and does not include floods that have occurred in the past 20 years. To get some idea of the recent flood history, the earlier data for Winberry Creek was compared to data for the same period (water years 1964-1981) from Fall Creek near Lowell (USGS 14150300). The relationship between the two stations (r^2=0.75) was used to extend the period of record for Winberry Creek.

Keeping in mind that the discharge values only approximately represent the actual flows in Lost Creek, it is likely that the flood of November 1996 (water year 1997) was one of the 2 or 3 highest flows in the past 35 years in Lost Creek and was probably similar to a flood in water year 1990. Both were likely between a “5 and 10 year event”, and both were probably somewhat smaller than the flood of December, 1964 (water year 1965). The size of that flood was apparently between a 10 and 25 year event.

2.3.2.2 Little Fall Creek Flood History

The only gauge records for Little Fall Creek are from 1936-1948, so the recent flood history must be inferred from nearby stations. In the Weyerhaeuser watershed analysis of Little Fall/Hills Creek (1997), a good correlation (r^2= 0.85) was made between this early data for Little Fall Creek (USGS 14151500) and records from the same period on Fall Creek below Winberry Creek (USGS 14151000). However, since flows at that station have been regulated since 1966, data from Fall Creek above the reservoir (USGS 14150300) must be used to get some picture of the recent peak flow pattern in Little Fall Creek. Since there is no direct overlap in the period of record between Little Fall Creek and Fall Creek above the reservoir, the precise relationship between the flows at the two sites cannot be determined. The data presented are useful primarily for revealing the pattern over time of relatively high and low annual peaks. The actual magnitude of the annual peak discharges in Little Fall Creek is not known.

Figure 2-7. Flood history of Fall Creek (represents Little Fall Creek).



Depending on how well these data represent conditions in Little Fall Creek, it appears the recent flood of water year 1997 was one of the 3 largest in the past 35 years and similar in size to a flood that occurred in water year 1990. Both floods were perhaps a bit larger, approximately 12 to 15 year events, in Little Fall Creek compared to 8 to 9 year events in Lost Creek. Both floods, plus another in water year 1972, may have been larger than the flood of water year 1965 in Little Fall Creek.

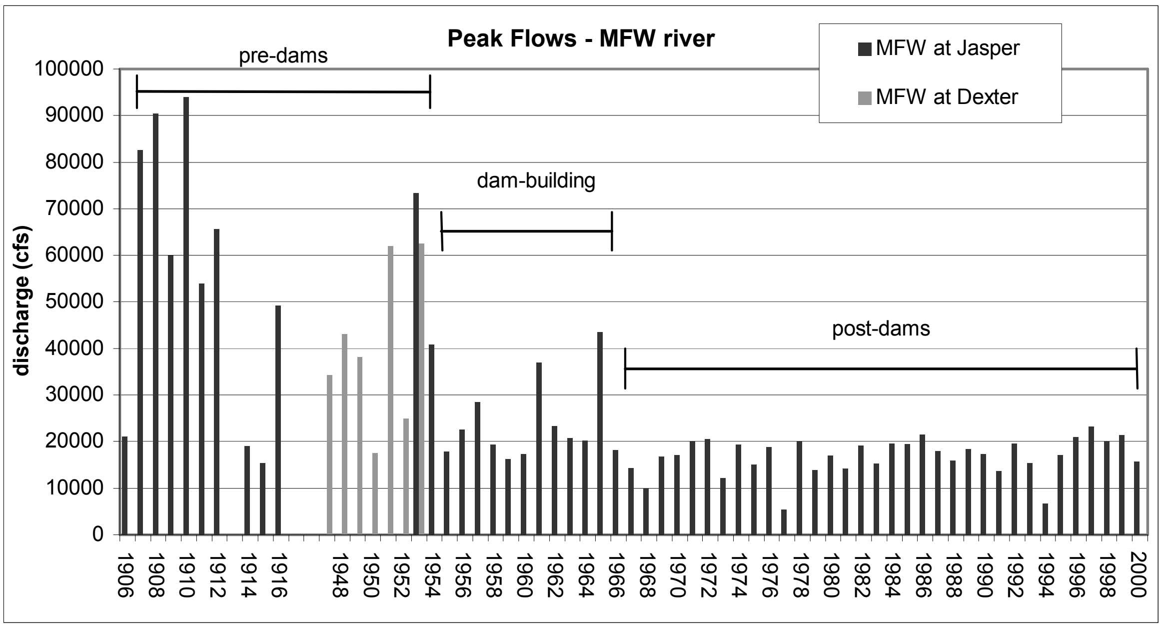
2.3.2.3 Middle Fork Willamette River Flood History

Two gauging stations provide discharge data for the lower Middle Fork Willamette River. The gauge at Jasper Bridge is at river mile 8, and measures flow from virtually the entire MFW subbasin, 1340 sq. mi. out of a total area of 1350 sq. mi. It also has the longest period of record including several years from the early 1900's. This gauge was discontinued for nearly four decades before becoming operational again in water year 1953.

To help fill in the picture of the natural flood pattern of the river, a few years of data from the Dexter gauge is also included on the graph below. The Dexter gauge is at river mile 16 and has a drainage area of only 1001 sq. mi. of the subbasin. Based on comparing data from the two gauges for water year 1953, the peak flows at the Jasper gauge for water years 1947 – 1952 would likely have been 15 to 20% higher than the flow measured at the Dexter gauge.

The annual peak flows of the Middle Fork Willamette at Jasper, with additional data from the Dexter gauge, are shown in figure 2-7.

Figure 2-8. Annual peak flows in the MFW River at Jasper Bridge with additional data from the Dexter gauge.



The records from the early 1900's plus 1953 represent natural flows before a series of upstream dams became operational. Lookout Point, which became operational in water year 1954, was the first dam to alter the flood pattern on the river. Dexter Dam, which re-regulates releases from Lookout Point, also became operational at that time. Later, Hills Creek dam in water year 1962 and Fall Creek dam in water year 1966 completed the flood control system on the Middle Fork Willamette River. Together this system of dams regulated 87% of the Middle Fork Willamette subbasin, the highest percentage of any subbasin of the Willamette River.

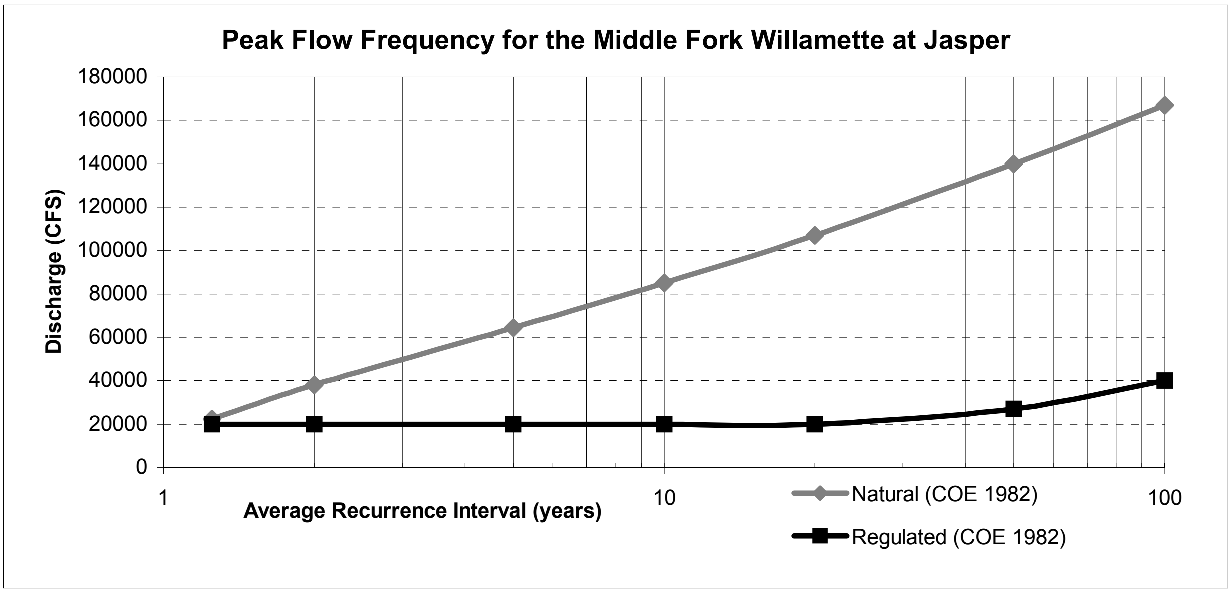
2.3.3 What are the Effects of Dam Regulation on Middle Fork of the Willamette River Peak Flows?

The primary purpose of the Army Corps of Engineers' system of dams and reservoirs is flood control. This system has been extremely effective in reducing peak flows in the Middle Fork

Willamette River to 25-30% of the previous peak flow volume. Also the yearly variability among peaks, which was formerly 100% or greater, has typically been less than 50% since the mid-1960's.

The recurrence interval of the full range of discharge values has also been altered significantly. The Army Corps of Engineers has computed the average recurrence interval for selected flows of the Middle Fork Willamette River at Jasper Bridge, both with and without regulation by the system of dams. These data are presented in figure 2-9.

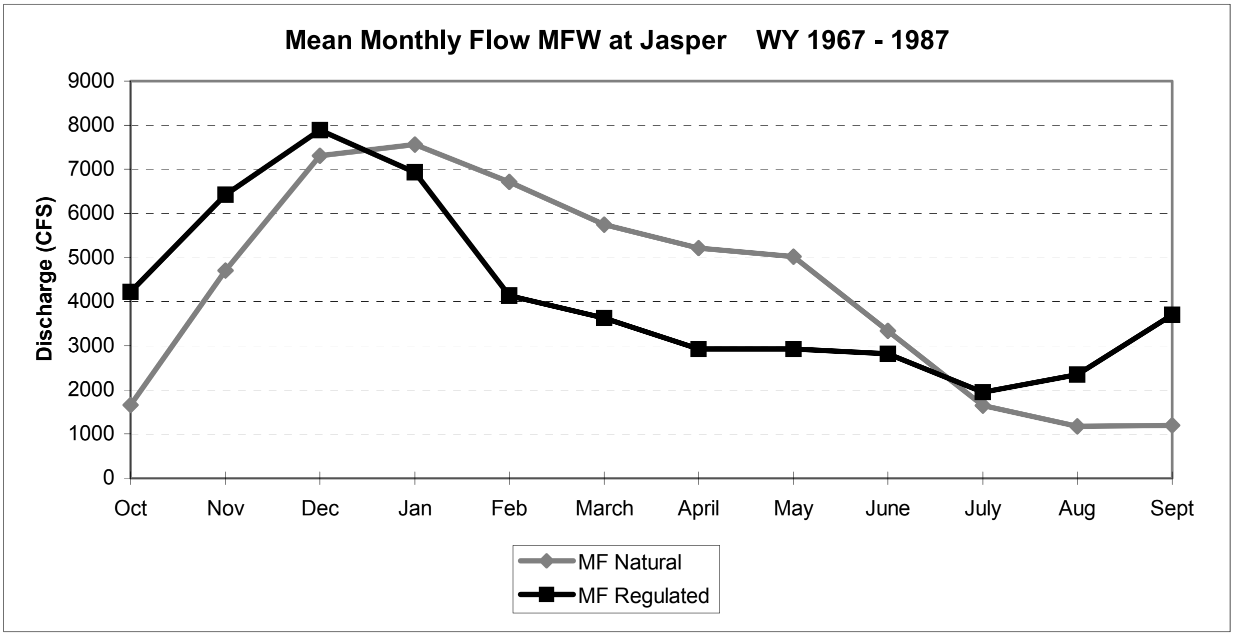
Figure 2-9. Effects of regulation on peak flow recurrance interval for Middle Fork Willamette River at Jasper.



Under natural conditions, the river's discharge at Jasper Bridge would have reached 40,000 cubic feet per second (cfs) about every 2 years on average. With regulation, this flow level is expected to occur only about once every 100 years. As an example, the highest peak flow of the 35 year post-dam period, in water year 1997, was 23,300 cfs, only just over half the flow which formerly occurred roughly every other year. Note also that under natural conditions, the flow which occurred once in 20 years would have been five times larger than the flow which occurred roughly annually (100,000+ cfs compared to 20,000+). With regulation, that variability has been eliminated. As the flat line on the graph indicates, even a 50 year flow is predicted to be regulated down to a discharge roughly equivalent to the natural 1.5 year, or "bankfull flow" event.

The regulation of peak flows for flood control is accomplished through short-term storage of excess storm runoff followed by releases of the stored water over a period of days. Other secondary purposes of the reservoir system – power generation, navigation, irrigation, and pollution dilution - require regulating flows on a longer-term seasonal basis. Figure 2-10 displays the change in the seasonal flow pattern of the Middle Fork Willamette River at Jasper.

Figure 2-10. Effects of regulation on mean monthly flow – Middle Fork Willamette River at Jasper.



With regulation, the average monthly flows from February through May, during the period of reservoir filling, are only about two thirds of what they were under natural conditions. In contrast, flows during the dry months of August through October are more than double what they were naturally, due to the gradual release of stored water. In the main flood control months of December and January, the average monthly flows are similar under natural and regulated conditions because flood storage is relatively brief. With regulation, average flow declines sharply from 7000 to 4000 cfs between January and February. Under natural conditions, this reduction in flow happened much more gradually over a period of 4 months.

Additional statistics comparing the natural and regulated flow regimes of the Middle Fork Willamette River at Jasper are shown in table 2-8. This data is from a recent report by the consulting firm Ecohydrology West. The report, A Hydrogeomorphic Index for River-Floodplain Habitat Assessment in the Willamette Basin, examines the altered flow regimes of major Willamette River tributaries and provides tools for evaluating the ecological restoration potential of floodplain sites that are subject to those altered flow regimes (Dykaar, 2000). The definitions of the statistics in the table are as follows:

Mean Annual Flow (cfs): The average of the individual daily flows for a water year.

Mean Annual Peak Flow (cfs): The average of the maximum daily flows of each water year for the designated period.

Mean Summer Flow (cfs): The average of the average daily August flow of each water year for the designated period.

Seasonal Flow Range (dimensionless): Ratio of the mean annual peak flow to the mean annual flow. Rivers with large seasonal flow range tend to form wider and shallower channels to accommodate the variation in flow (Xu, 1996).

Bankfull Flow (cfs): Flow sufficient to fill a channel up to the floodplain. Bankfull is considered a channel forming flow. It is a measure of those flows most effective in transporting coarse bedload sediment which creates the forms and features of the river channel. A recurrence interval of 1.5 years is used to define a bankfull flow.

Time Above Bankfull (days/year): Average number of days per water year that the daily flow equals or exceeds a specified bankfull flow value. From a geomorphic perspective, this parameter indicates the amount of channel and floodplain forming work the river can do (Andrews and Nankervis, 1995). Sustained bankfull flow is required to form new habitat. This parameter also indicates the degree of hydrologic connection between channel and floodplain.

Table 2-8. Summary flow statistics for the Middle Fork Willamette River at Jasper (gauge 14152000).

Period	Mean Annual Flow (cfs)	Mean Annual Peak Flow (cfs)	Mean Summer Flow (cfs)	Seasonal Flow Range (ratio)	Bankfull Flow (cfs)	Time Above Bankfull (days/year)
Pre-dam (1907-53)	3,673	45,660	961	12.4	29,010	3.1
Post-dam (1966-98)	4,086	15,830	2,475	3.9	(-)	0.0
Dimensionless Ratios of Post-dam to Pre-dam Period Statistics						
Change (Post/Pre)	1.11	0.35	2.6	0.31	(-)	0.0

As noted in Dykaar, the post-dam average annual flow is 11% greater than in the pre-dam period, reflecting wetter conditions overall during the post-dam decades. Differences in certain aspects of the flow regime, such as Mean Annual Peak Flow, would be even more pronounced between the two periods had precipitation remained consistent. These data indicates that peak flows have been reduced by 65%, low flows are 2.6 times higher, and seasonal variability is one-third that of the pre-dam period. Also, in the post-dam period, daily average flows have never attained what was a bankfull flow under natural conditions.

Bankfull flow is commonly understood by river professionals as having a particularly significant relationship to channel form. Without enough flow to regularly fill the channel up to the top of the banks, a reduction of overall channel capacity, especially width, is likely to occur as channel form adjusts to the reduced flow regime. Flows that are less than bankfull are also less effective in mobilizing and redistributing the riverbed sediment. This reduced sediment transport capacity combined with the reduced sediment supply from damming and bank revetments may also be reflected in decreased channel size (Knighton, 1984).

2.3.4 What are the Ecological Effects of Altered Flow Patterns?

Major alterations to a river's flow regime have important implications for the restoration potential of instream and floodplain habitat. The dynamic physical environment, including processes of flooding, erosion, and deposition create habitat and provide the foundation for complex biological interactions. Ecological relationships are adapted to and supported by that system of physical processes in which they have developed. Though a full enumeration of the potential effects of altered flow regimes is beyond the scope of this assessment, some key implications for consideration are excerpted from Dykaar (2000). Dykaar examined a number of sites along rivers in the upper Willamett Basin, with two sites along the Middle Fork Willamette River.

The sites included in the Dykaar report "were selected to be representative of floodplain habitat with the least on-site human distruptions such as logging, mining, or roads,…and which had intact floodplain vegetation and geomorphic development history captured by aerial photography" (p. 15). The two floodplain sites along the Middle Fork Willamette River were selected to be representative of conditions for this part of the river. The sites are twelve miles apart and are located at opposite ends of the river below Dexter Dam. The upper site is above all the major tributaries, while the lower site is below all tributaries in the reach.

The Dykaar report (2000) concluded that the Willamette floodplain appears to be composed of innumerable bars and islands which have been deposited and dissected by the river over thousands of years. Through the shifting and filling of channels and the establishment and growth of pioneering trees, river forms gradually merge with the surrounding floodplain. New forms are created through continual recycling of sediment. This process maintains a variety of aquatic and floodplain habitats through time. A diverse array of physical forms has been produced by the historically wide variation of flood forces. Without this variable "power source" of flooding, the process of floodplain habitat creation, modification, and renewal is greatly diminished. Many of those features, habitats, and organisms adapted to the previous pattern of river/floodplain interaction may decline over time, even with land use protection, if the land-forming process of flooding continues to be severely limited.

2.3.4.1 Habitat for Pioneer Riparian Vegetation

Perhaps the biggest change in the floodplain environment since regulation is the near elimination of new sites for the establishment of pioneer riparian vegetation species such as black cottonwood, red alder, and willow. These species are uniquely adapted to the rigorous conditions found on incipient floodplain landforms. They are shade intolerant, grow rapidly on infertile mineral substrates, and maintain direct access to the water table through vigorous root development. Mature stands of pioneer trees typically do not reseed in place because full sun is required for establishment and growth. Without large freshly formed bars and islands available for colonization, the total area occupied by pioneer riparian species will likely decrease over time, while the area occupied by mid-successional species such as Bigleaf Maple and Oregon Ash will likely increase.

In addition to being a physical force that creates landforms, the distribution of water on a floodplain is a key factor regulating ecosystem function and organizing habitat structure, and may be characterized in terms of its seasonal timing, frequency, amount, and duration.

2.3.4.2 Changes in Inundation Duration

Inundation duration, a measure of the length of time different levels of a floodplain site are submerged under water, is an example of the kind of physical condition that has been altered in ways which affect ecological function. Floodplain surfaces that are subject to frequent, but not too persistent submergence, have the potential to provide the greatest variety of habitat functions because they experience the greatest variation in physical conditions. Floodplain surfaces that are at high elevations relative to the main channel are less hydraulically connected to the river and provide less diverse habitat.

For example, at a reference site on the McKenzie River where pre-dam and post-dam flow regimes were relatively similar, 62% of the length of a transect line across the floodplain was found to be inundated between 1 week and 1 month per year, so the majority of the floodplain site was directly hydrologically connected to the river, at least briefly, every year. Only 2% of the transect length was above the elevation of the post-dam mean annual peak flow of the

McKenzie River. In contrast, for two sites on the Middle Fork Willamette, one near the Millrace inlet, and one just below Dexter dam, only 10% of the transect length was inundated 1 week to 1 month per year, while 60 to 70% was above the elevation of the post-dam mean annual peak flow of the Middle Fork of the Willamette. Thus, most of the area of these two Middle Fork Willamette floodplain sites does not have an annual direct surface water connection, of any duration, to the river. Under the pre-dam flow regime, 80 to 95% of the transect length of these sites would have been below the elevation of the mean annual peak flow.

2.3.4.3 Changes in Seasonal Timing

While inundation durations can provide some indication of the degree of annual connection between floodplain surfaces and river water, the seasonal timing of various flow levels is another factor which independently affects ecological functions. Even though a feature may be submerged for an equivalent amount of time during the year, if inundation occurs in the fall where it formerly occurred in the spring, ecological relationships can be disrupted.

The habitat requirements of the Northern Red-legged Frog are directly related to the seasonal timing of flows.

"*In the Willamette Valley, frogs breed in February, eggs hatch in March, and metamorphosis begins in June... Continuously flooded conditions are required for about 5 months through metamorphosis. Seasonal (ephemeral) wetlands without surface water in the summer preclude the establishment of exotic predatory fish, and larval bullfrogs which require 1-3 years of continuously flooded conditions to reach metamorphosis*." (Dykaar pp. 76-77)

As noted above, regulated spring flows during the period of frog development are only two thirds of the natural flow level. Some areas formerly flooded every spring may no longer be flooded at all or may be much smaller in extent. Conversely, since the regulated summer flow is triple what it was naturally in September and October; many areas that would have formerly dried up may remain wet on the surface and thus facilitate the survival of the frog's predators.

In addition to favoring the persistence of some exotic species, elevated summer water levels also reduce plant root depth by raising the water table. This can make trees more vulnerable to blowdown.

The ecological consequences of other aspects of changes to flow patterns have not been fully analyzed. However, one may speculate that the shift in timing of the rapid decrease in average flow may indeed have multiple ecological effects. Under natural conditions, average flow dropped rapidly in May as snowmelt and rainfall simultaneously declined. This corresponds to the peak month for returning Spring Chinook adult fish into the river. It is also a time of rapid vegetation growth along the land/water fringe area called the "littoral zone", as well as the time of seed dispersal for cottonwood and willow. Under the regulated flow regime, the river stage drops rapidly in the middle of winter, between January and February, months before any of these other ecological events, which were formerly coincident with the changing river stage, occur. The rapid mid-winter decline in flow may also disrupt the primary productivity of the river ecosystem as large areas of riverbed algae are desiccated by exposure to the air.

2.3.4.4 Middle Fork Willamette River Floodplain Restoration Potential

Many valuable floodplain features such as islands, bars, sloughs, braided channels, and substantial riparian woodlands still exist along the river below Dexter dam. Changing the pattern of flow regulation is perhaps the most difficult, but undoubtedly the most effective approach to restoration of this formerly dynamic system. Physical manipulation of the landscape for improved flood detention, such as reconnecting side channels, creating alcoves and backwaters, etc. has little chance of long- term success without an ongoing flow regime that is matched to these characteristics. The hydrogeomorphic index developed by Dykaar is a readily applicable tool which can be used to assess the potential value and function of floodplain sites given various alternative flow regimes.

The present system of regulating dams and reservoirs in the Willamette basin does provide at least one advantage over natural conditions which can be utilized for restoration purposes. Modest flood spikes can be created separately at different times in different rivers, thus creating a localized river response while avoiding the cumulative downstream flood effects that a large regional storm would produce.

In terms of mimicking the natural seasonal distribution of flow, it may also be beneficial to take a basin-wide view. Perhaps, to restore some year- to- year variability, a natural seasonal flow pattern could be allowed periodically on a rotating basis in each of the regulated watersheds of the Willamette basin.

2.4 RECOMMENDATIONS

- Urbanization within the Lower Middle Fork Willamette watershed, especially on the edge of the Eugene-Springfield metropolitan area, has increased the amount of impervious surfaces, which has increased peak stream discharges in local areas. Where possible, limit new impervious surfaces and impacts on peak flows through measures suchs as storm water detention basins.

- Dams regulate 87% of the land area within the Middle Fork of the Willamette Subbasin. Regulation of discharge by the dams has affected peak flows and the amount of time that floodplains are underwater. Changes in the timing and magnitute of floods has affected the establishment of pioneer plant species such as cottonwoods and impacted some forms of aquatic life. In cooperation with the Army Corps of Engineers, explore mechanisms for increasing the duration and magnitude of channel-forming peak flows to help maintain key ecological processes.

3.0 RIPARIAN HABITAT CONDITIONS

3.1 INTRODUCTION

The purpose of this portion of the assessment was to evaluate current riparian vegetation[2] conditions for their ability to provide recruitment[3] of large wood[4] (LW) and stream shading. Section 3.2 describes the assessment methods that were used and section 3.3 presents the results of the assessment for each of the three watersheds within the Assessment Area.

3.2 METHODS AND KEY QUESTIONS

The riparian conditions assessment generally follows the methodology as outlined in the Oregon Watershed Assessment Manual (OWEB, 1999). As in other chapters, the riparian assessment methodology is designed to answer critical questions.

The critical questions that were addressed in this assessment were:

1. What is the current condition of riparian vegetation in the watershed in terms of large woody debris recruitment potential and stream shading?

2. How do current riparian conditions compare to potential or typical riparian conditions for the ecoregion?

3. What conservation, restoration, or enhancement opportunities are appropriate for different riparian areas?

Information on potential or typical riparian conditions for the different ecoregions in the Assessment Area came from the OWEB Watershed Assessment Manual Ecoregion Appendix. Aerial photographs provided the primary data source to determine current riparian conditions. An existing assessment of riparian conditions done by Weyerhaeuser's watershed analysis team in 1997 for the Little Fall Creek and Hills Creek watersheds was incorporated directly into this report. The methods documented by Weyerhaeuser (1997) are also based on aerial photograph

[2] Riparian vegetation refers to the vegetation found on stream banks and adjoining floodplain
[3] 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
[4] Large wood, as it is used in this context, refers to pieces of wood (such as tree trunks, stumps, or large branches) important in the formation of channel shape, and consequently, in creating and enhancing fish habitat.

interpretation and are essentially the same as the OWEB methods. The photos used by Weyerhaeuser for the riparian assessment of Little Fall Creek and Hills Creek were taken in 1993 and were likely a typical color set of land resource photos at a scale of 1:12,000 to 1:20,000. For the remainder of the Assessment Area, (the Lower Middle Fork Willamette and Lost Creek watersheds) riparian stand types were interpreted from 1:12,000 scale color aerial photos taken during May & June 2000 by the Eugene District BLM. A limited amount of field-verification, consisting of visual observations of vegetation type, size, and density was completed during March 2002, primarily in the Lower Middle Fork Willamette watershed. Riparian transect data from stream surveys of Lost Creek was also cross-referenced with riparian stand types interpreted from the aerial photographs for additional verification.

3.2.1 Selection and Size of Riparian Areas

Due to the time and labor-intensive methods required, only a subset of the complete stream network was included in the riparian assessment. The Weyerhaeuser analysis limited the riparian assessment in the Little Fall and Hills Creek watersheds to the fish-bearing portion of the stream network. For Lost Creek and the remainder of the Lower Middle Fork Willamette watersheds, all second-order and larger streams (based on the BLM digital stream database) were included in the riparian assessment.

In order to remain consistent with the method employed in the earlier riparian assessment by Weyerhaeuser, the width of the riparian area was defined as 100 feet horizontal distance from the edge of the stream. The majority of large wood contributed to a stream channel from the riparian area comes from within this distance (OWEB, 1999). An exception to the 100 ft limit was made for riparian stands along the mainstem Middle Fork Willamette River. These stands along the river were delineated according to their actual extent in the floodplain and were not limited to an arbitrary width.

3.2.2 Riparian Stand Types

Riparian Stand Types were assigned to portions of the riparian area in which the vegetation type, size, and density remained approximately the same. When riparian characteristics changed, a new Riparian Stand Type was delineated. Opposite sides of a stream may have the same or different Riparian Stand Types.

The Riparian Stand Type was represented by a three letter code describing vegetation type (first letter), vegetation size (second letter), and vegetation density (third letter). The choices are listed in Table 3-1. 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 3-1. Codes used to describe riparian vegetation (OWEB, 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)

For most of the Lower Middle Fork Willamette watershed and the Lost Creek watershed, the Riparian Stand Types were marked initially on the aerial photos, and then mapped directly into GIS, using USGS orthophotos as a backdrop to properly place the stand type boundaries. Information on how the mapping step was completed was not available for Little Fall Creek and Hills Creek. GIS coverage of stand types was obtained directly from Weyerhaeuser and transferred into the database for this assessment.

3.2.3 Large Wood (LW) Recruitment Potential

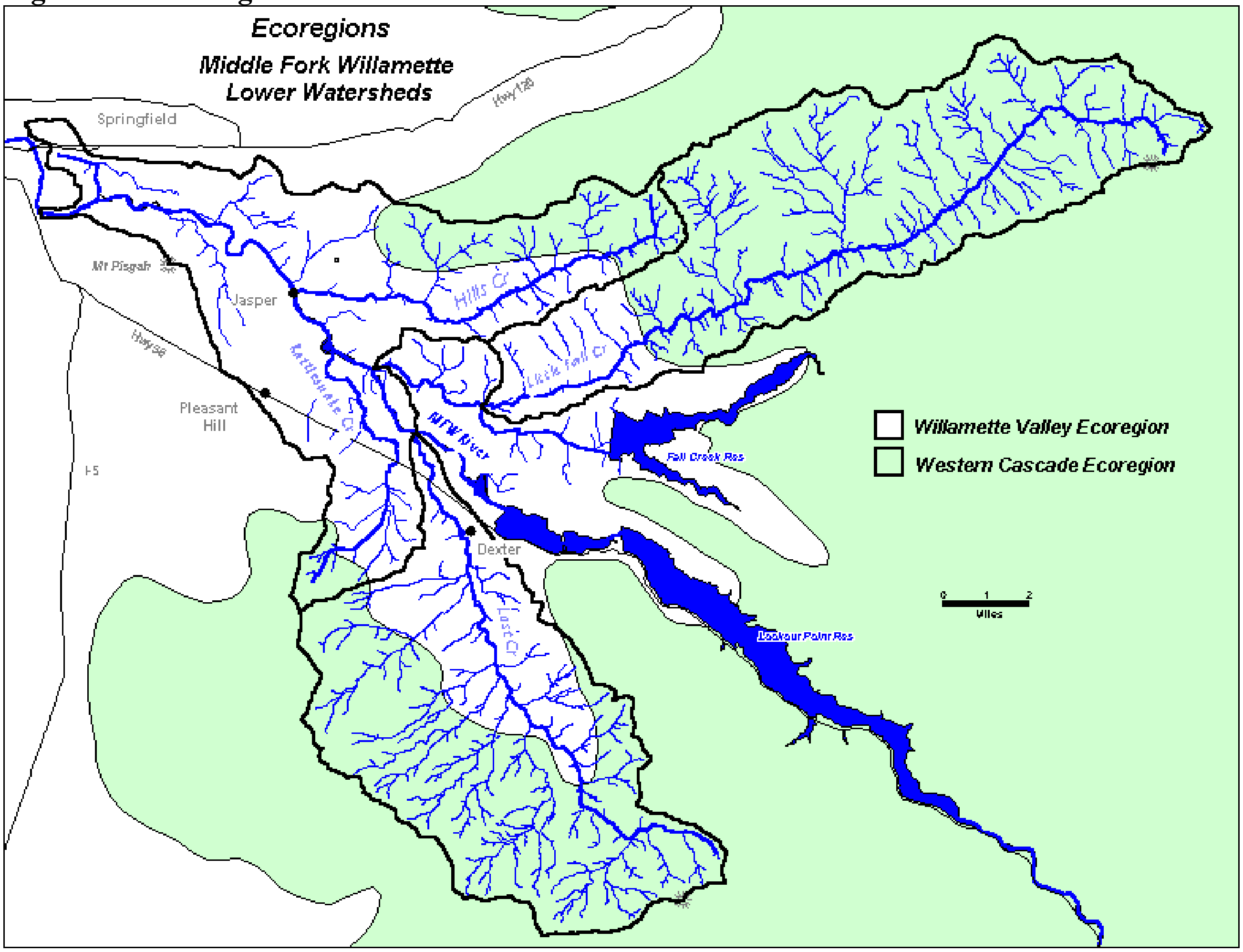
Following the methods used by Weyerhaeuser for Little Fall and Hills Creek, riparian stand types for the entire Assessment Area were grouped into three categories of large wood recruitment potential listed in table 3-2.

Table 3-2. Large wood recruitment potential categories for riparian stand types.

HIGH RECRUITMENT POTENTIAL	MODERATE RECRUITMENT POTENTIAL	LOW RECRUITMENT POTENTIAL
CMD	CMS	CSD
CLD	CLS	CSS
MLD	HLD	HSD
MMD	HMD	HSS
	MLS	HLS
	MMS	HMS
		MSD
		MSS
Order of Three Letter Code is: Type/Size/Density Type:C= Confier, H=Hardwood, M=Mixed Size: L=Large, M=Medium, S=Small Density: D=Dense, S=Sparse See table 3-1 above for definitions of type, size, and density		

Rather than simply lumping current riparian stand types into categories of large wood recruitment potential, the OWEB method determines large wood recruitment potential by comparing current riparian stand types with those that are potentially or typically present on similar sites for the same ecoregion. This method was not formally applied in this riparian assessment, but it would produce essentially the same results due to the fact that the potential streamside vegetation for the ecoregions of the Assessment Area are all stand types that have high LWD recruitment potential according to the categories in table 3-2.

Figure 3-1. Ecoregions for the Lower Middle Fork Willamette Watersheds.



For the Willamette Valley Foothills ecoregion, the potential streamside vegetation is either MMD or MLD. For the Western Cascades ecoregion, it is either MMD or CLD. The ecoregions boundaries are shown in figure 3-1. By the OWEB method, current riparian stand types that are in the high large wood recruitment category would be considered adequate since the current condition is at least as good as the potential condition. Other riparian stand types would be considered inadequate in terms of large wood recruitment potential since their current condition is below their potential to provide large wood to the stream.

Again, the riparian vegetation along the mainstem Middle Fork Willamette, which is in the Willamette River and Tributaries Gallery Forest ecoregion, is the exception. Potential streamside vegetation in this ecoregion is dominated by hardwoods, specifically the HLD stand type, which is classified as moderate for large woody debris recruitment potential.

3.2.4 Riparian Shading

Riparian shading was estimated from the aerial photographs using the criteria given in Table 3-3. Streams were broken into segments having similar riparian shading (H, M, or L) using the visual indicators listed in table 3-3. 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. For the mainstems of Lost and Little Fall Creeks, shading estimated from photos was compared to values recorded in the field during stream surveys for verification.

Table 3-3. 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

As with riparian stand types, the shading values for Little Fall Creek and Hills Creek were incorporated directly into this assessment from the Weyerhaeuser watershed analysis. The same definitions and methods were used in that analysis, but the photos were from 1993 as compared to 2000 for Lost Creek and the remainder of the Lower Middle Fork Willamette watershed. The same portion of the stream network was used in the shading assessment as in the riparian stand typing (fish bearing streams in Little Fall/Hills Creeks and 2nd order and larger streams in Lost Creek/Lower Middle Fork Willamette).

3.3 RESULTS

The results of the riparian habitat conditions section are organized to address the critical questions.

This Section Dddresses the Following questions:

- What is the current condition of riparian vegetation in the watershed in terms of large woody debris recruitment potential and stream shading?
- How do current riparian conditions compare to potential or typical riparian conditions for the ecoregion?

- What conservation, restoration, or enhancement opportunities are appropriate for different riparian areas?

- The material presented in this section of the report summarizes current riparian vegetation conditions in terms of LWD recruitment potential and shading for each of the 3 watersheds in the Assessment Area. Discussion of restoration/enhancement opportunities are integrated with the presentation of results in the following sections.

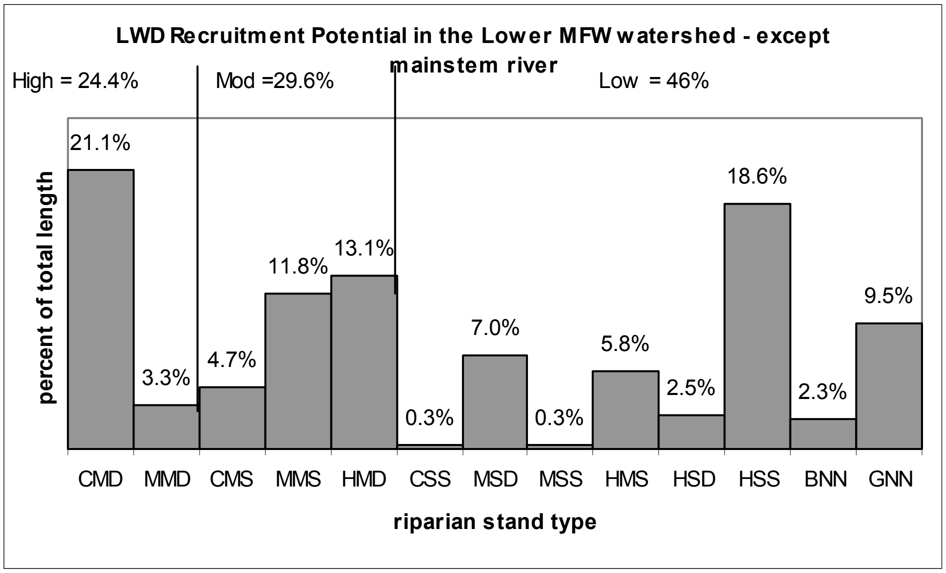
Riparian conditions in the the Lower Middle Fork Willamette watershed are discussed in section 3.3.1.1, Little Fall Creek watershed riparian conditions are presented in section 3.3.1.2, and conditions in Lost Creek watershed are presented in section 3.3.1.3, including discussion specifically relating to the floodplain forests along the river.

3.3.1.1 Lower Middle Fork Willamette Watershed Tributaries

3.3.1.1.1 Lage Wood Recruitment Potential

Figure 3-2 summarizes the riparian stand types that were assessed on the tributary streams in the Lower Middle Fork Willamette watershed. Refer to table 3-2 for definitions of stand type codes. Riparian vegetation along the river is summarized separately.

Figure 3-2. Large woody debris (LWD) recruitment potential in the Lower Middle Fork Willamette watershed.

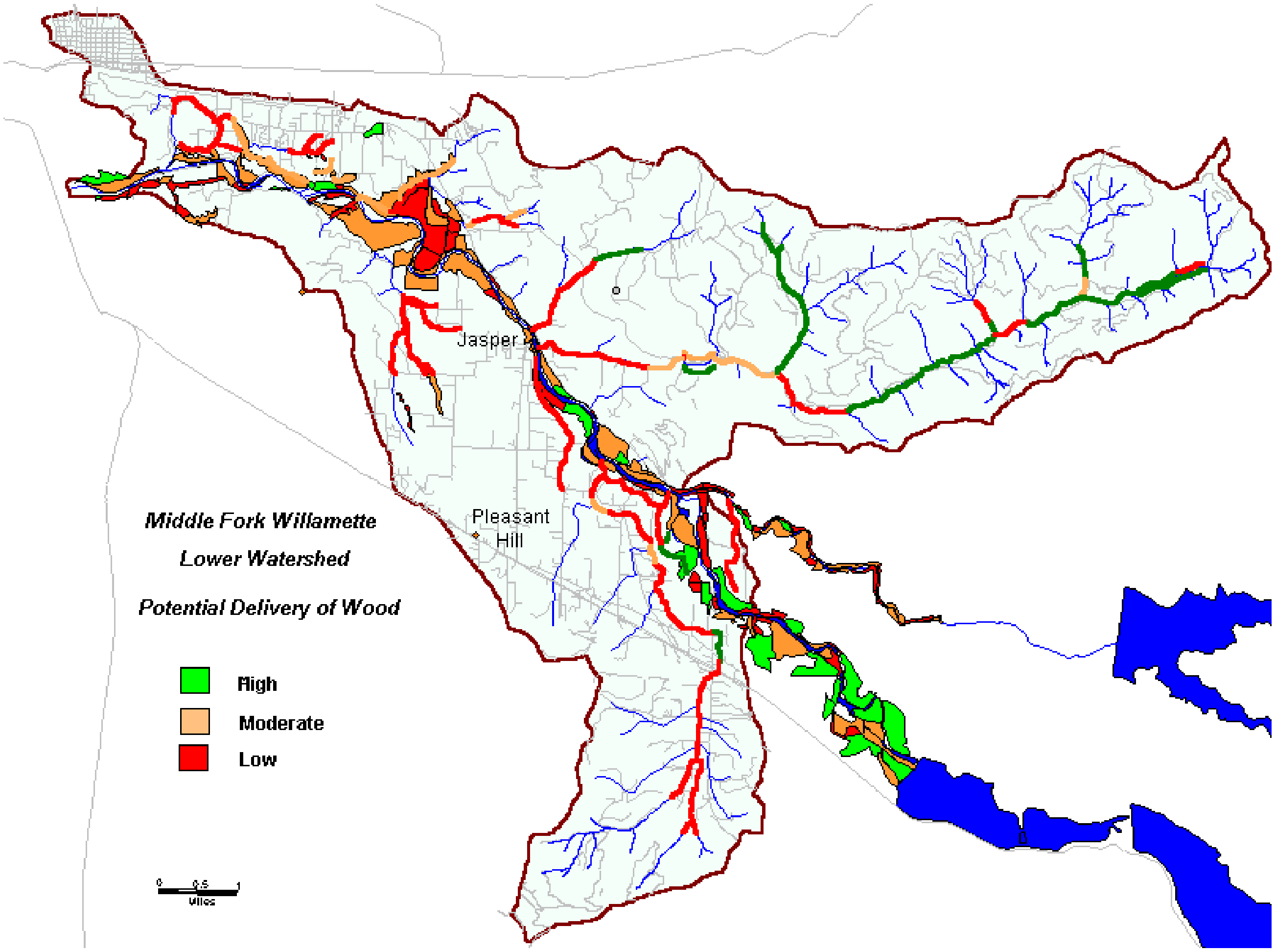


Nearly half of the total assessed length currently has low large recruitment potential, due primarily to small stands. Riparian segments without trees are also a significant component of this category. Where trees are sparse or absent, riparian planting may be appropriate.

Almost thirty percent (29.6%) of the total length currently has moderate recruitment potential. Stands in this category are of medium size, but are mostly sparse. Supplemental planting may be advised in this situation.

About a quarter of the total length currently has high large wood recruitment potential. These are dense conifer or mixed stands of medium size. There are no stands of large trees in this category. Conservation, along with techniques to accelerate development of larger trees to accelerate tree growth, may benefit these stands.

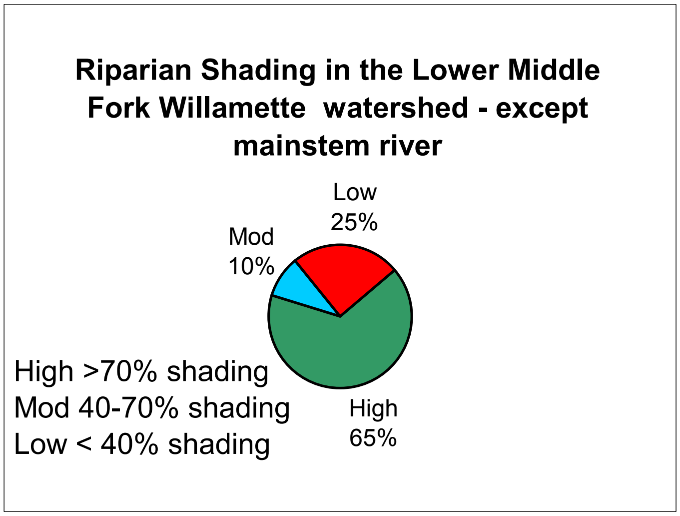
Figure 3-3. The geographic distribution of large wood recruitment potential for the river and tributaries within the Lower Middle Fork of the Willamette watershed.



3.3.1.1.2 Stream Shading

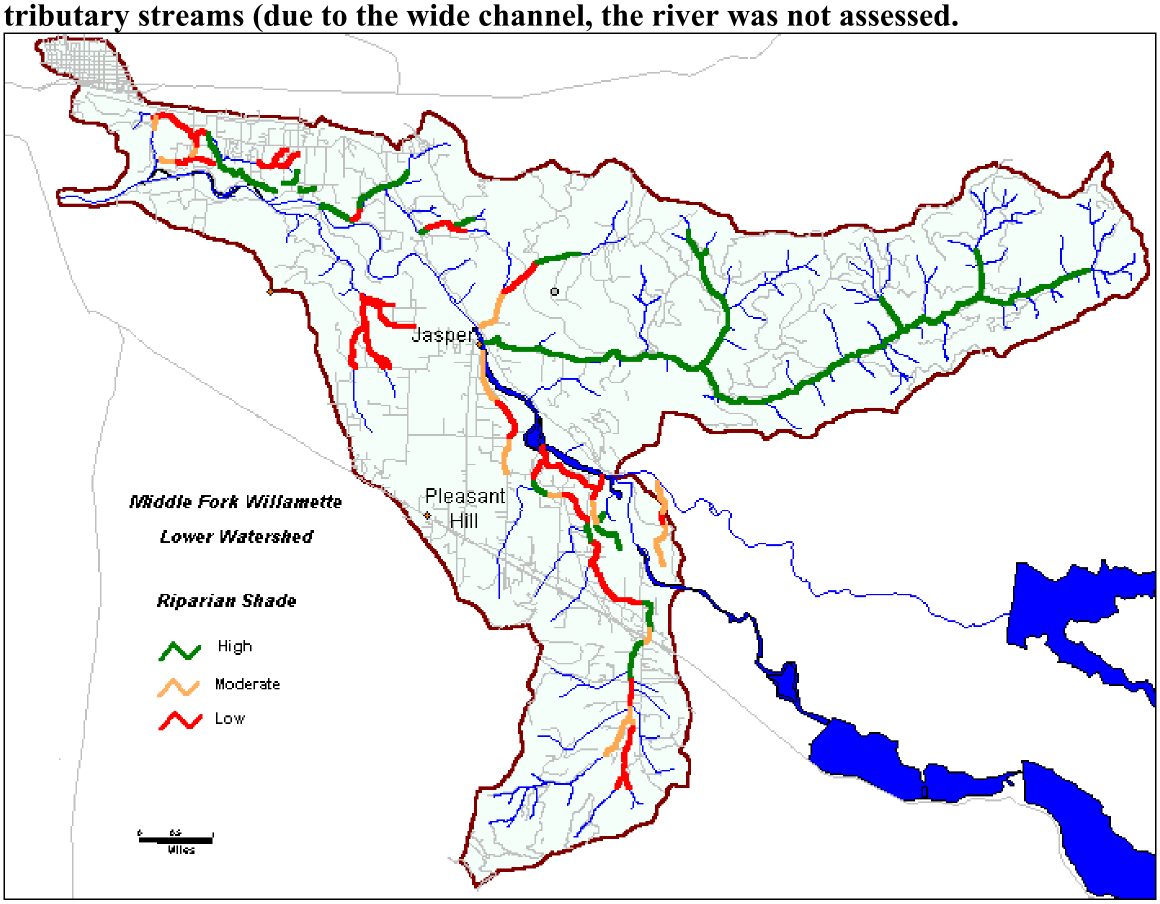
Shading levels were not assessed on the mainstem Middle Fork Willamette River due to its width. Shading levels on the tributaries of the Lower Middle Fork Willamette watershed are summarized in figure 3-4. Two thirds of the stream length has relatively high shading levels. A tenth of the total length is moderately shaded, and a quarter currently has low shading levels.

Figure 3-4. Riparian shading in the Lower Middle Fork Willamette watershed.



The geographic distribution of stream shading on the tributaries of the Middle Fork Willamette River is displayed in figure 3-5 below. Shade is uniformly high throughout Hills Creek accounting for most of the total percentage.

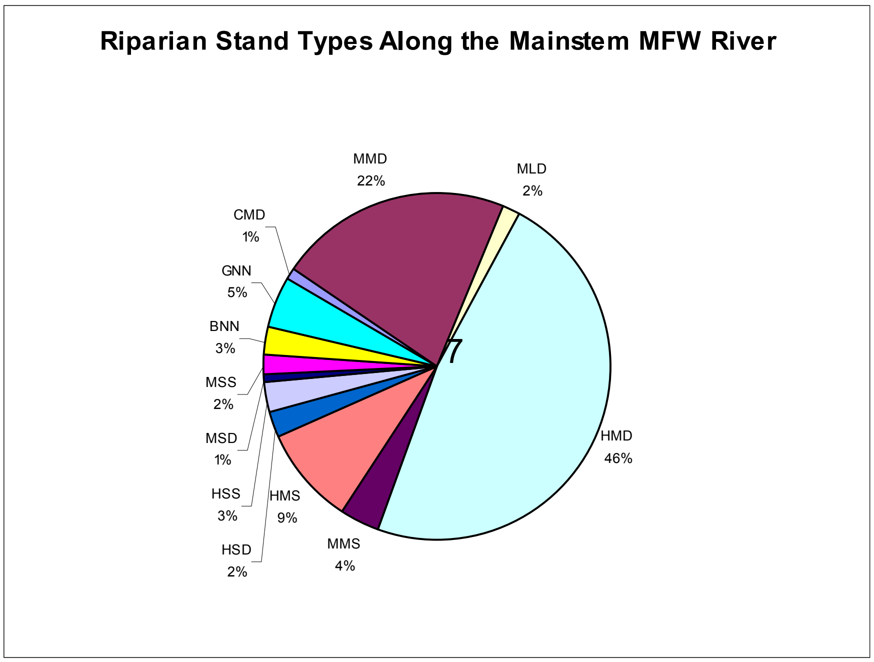
Figure 3-5. Riparian shade levels for the Lower Middle Fork Willamette watershed tributary streams (due to the wide channel, the river was not assessed.



3.3.1.2 Riparian Conditions along the Lower Middle Fork of the Willamette River

Figure 3-6 summarizes the riparian stand types that were assessed along the mainstem Middle Fork Willamette River. Refer to Table 3-2 for definitions of stand type codes. Approximately 2 miles of the mainstem of Fall Creek which connects Little Fall to the Middle Fork Willamette is included in the following data and discussion.

Figure 3-6. Riparian stand types along the Middle Fork Willamette River.



Twenty-four percent of the total area currently has high large wood recruitment potential (MMD and MLD stand types). Fifty percent currently has moderate potential (HMD and MMS stand types). The remaining 26% of the assessed riparian area along the river currently has low large wood recruitment potential. While hardwood-dominant stands are typical of the ecoregion (Willamette River Gallery Forest), the potential tree size-class is large rather than the medium size trees currently present. This may be due in part to timber harvest along the river in the previous century.

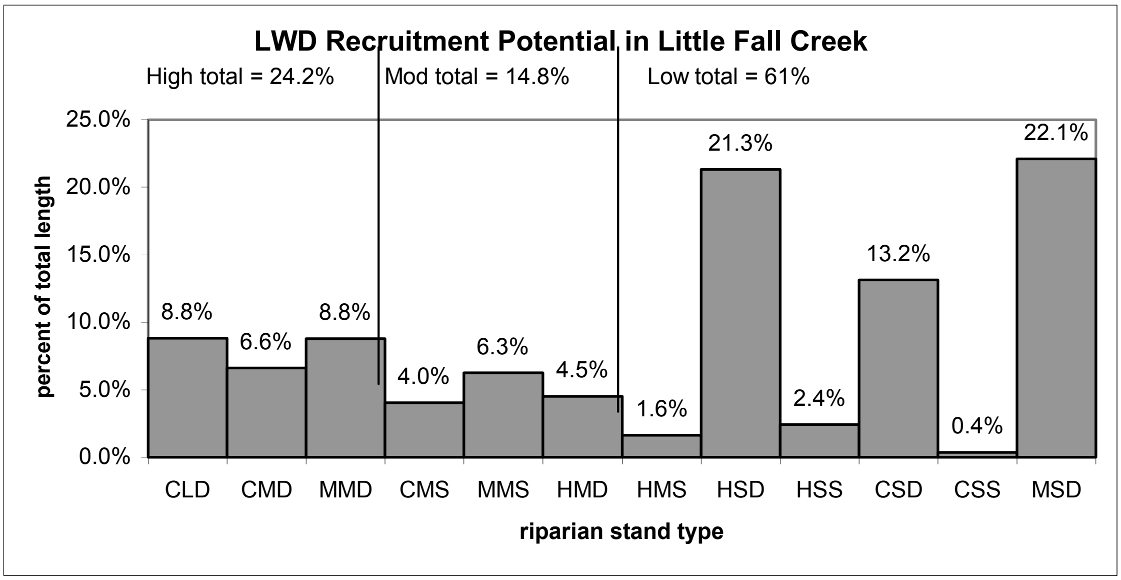
The successional trajectory of riparian forests along the river will be determined primarily by regulation of river flows and by adjacent land use. The previous 40 years of flood control has already had a noticeable effect in some stands where a conifer understory is becoming established on surfaces that were formerly subject to frequent flooding and which are now functioning more as river terraces. Under current river management, the exent of large cottonwood forest will tend to gradually decrease to a narrow fringe along the riverbank. In addition, many stands of hardwood and mixed floodplain forest are being invaded by English Ivy, though often only one or two trees in a stand is currently colonized by the plant. Removal of this invasive species is advised before it becomes more widely established.

3.3.1.3 Little Fall Creek Watershed

3.3.1.3.1 LWD Recruitment Potential

Figure 3-7 summarizes the riparian stand types that were assessed in the Little Fall Creek watershed. Refer to table 3-2 for definitions of stand type codes.

Figure 3-7. Large woody debris (LWD) recruitment potential in Little Fall Creek.



Of the total riparian length that was assessed, 61% currently has low large wood recruitment potential. The main factor affecting recruitment potential in this case is the small size of the stands. Five out of six stand types in this category are various types of small size stands. This probably reflects past harvest activities in the watershed. However most of the stands are dense, and so may develop well over time if protected.

Nearly fifteen percent (14.8%) of the assessed riparian length currently has moderate potential for large wood recruitment. All of these stands are in the medium size class. Only the hardwood stand type is dense, while both the conifer and the mixed stand types are sparse. Supplementary riparian planting may be appropriate in the sparse stands if a developing understory is not currently present.

The remaining 24.2% of the assessed riparian length currently has high large wood recruitment potential. Three stand types are in this recruitment category. All are dense, with moderate or large size trees, and have either conifer dominant or mixed composition. This category is the only one in which riparian stands are currently functioning at the potential for the ecoregion in terms of large wood recruitment. Conservation of these stands, while others stands are recovering may be an appropriate consideration.

Recruitment potential is variable along the mainstem of Little Fall Creek with notable reaches of low potential around Sturdy Creek, in the headwaters, and in the middle of the section of Forest Service ownership. In addition, the total classified length of the Sturdy Creek subwatershed is in the low recruitment potential category as is the majority of the Norton Creek subwatershed. These areas could be investigated for addition of LWD directly to the stream channels as a short-term habitat enhancement measure.

3.3.1.3.2 Stream Shading

Shading levels in the Little Fall Creek watershed are summarized in figure 3-8. The majority of the stream length has relatively high shading levels. About a quarter of the total length is moderately shaded, and only 3% currently has low shading levels.

Figure 3-8. Shading levels in the Little Fall Creek watershed.

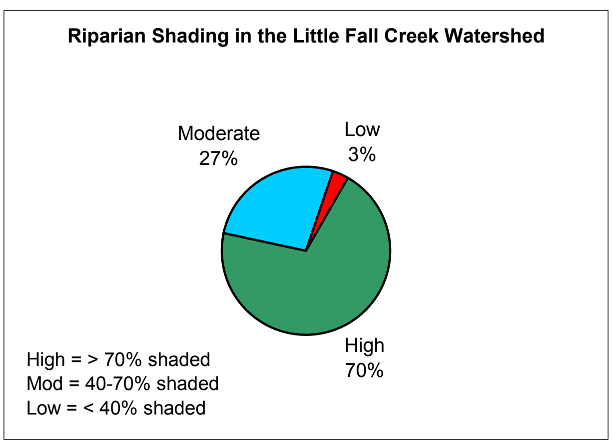
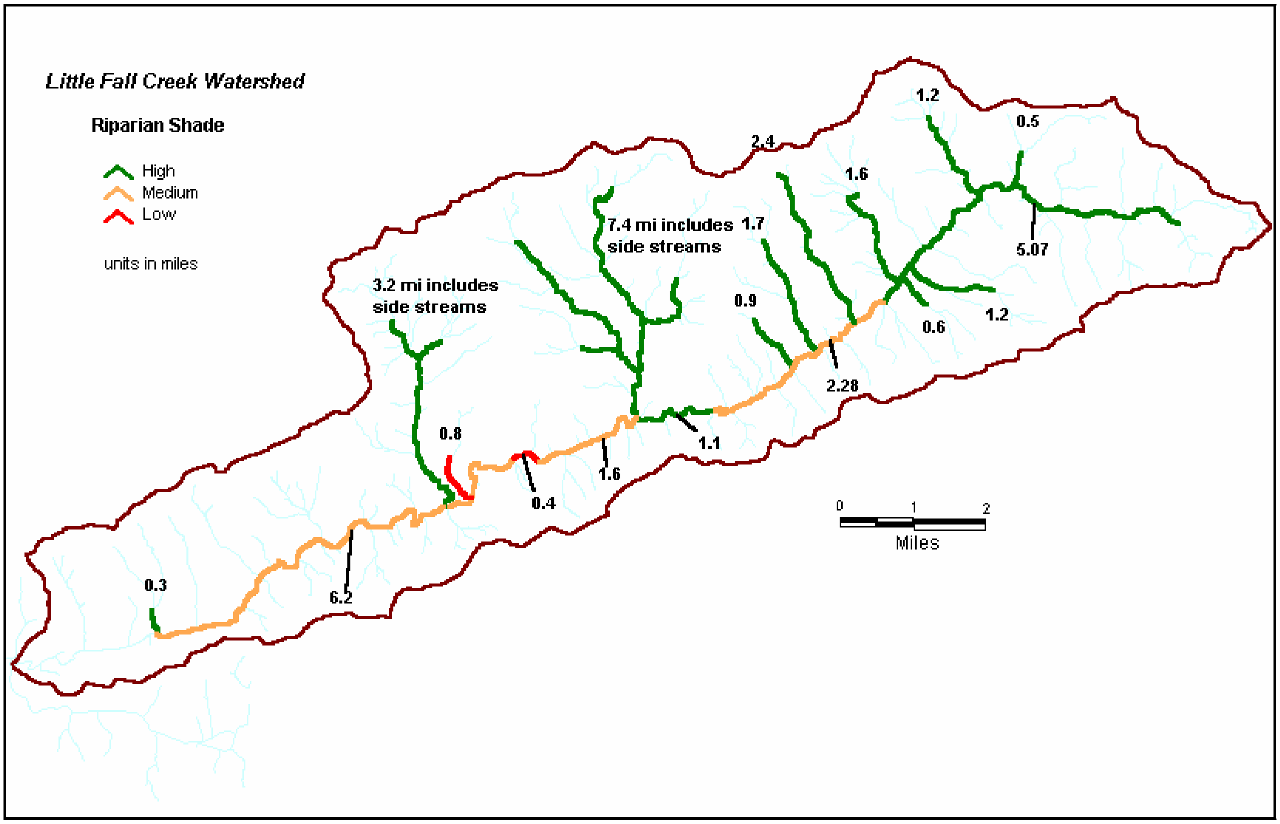


Figure 3-9 displays the geographic distribution of shade levels in the Little Fall Creek watershed. Shading is generally high along the tributaries and in the headwaters of Little Fall Creek. The moderate shading level, representing about a quarter of the total assessed length, occurs exclusively along the mainstem of Little Fall Creek.

Figure 3-9. Riparian shading in the Little Fall Creek watershed.

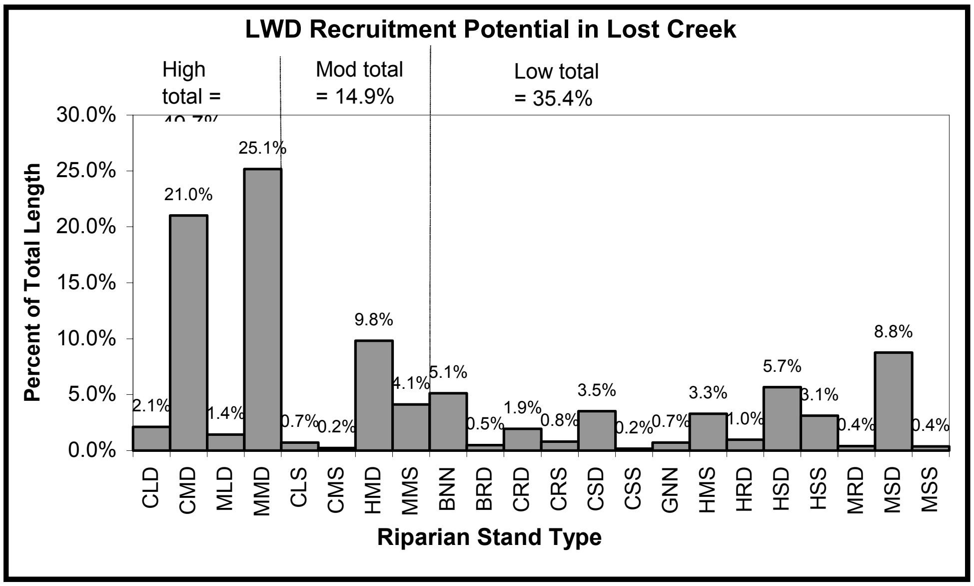


3.3.1.4 Lost Creek Watershed

3.3.1.4.1 Large Wood Recruitment Potential

Figure 3-10 summarizes the riparian stand types that were assessed in the Lost Creek watershed. Refer to table 3-2 for definitions of stand type codes.

Figure 3-10. Large woody debris (LWD) recruitment potential in Lost Creek watershed.



Almost half of the assessed riparian length currently has high LWD recruitment potential. Dense stands of conifer or mixed trees in the medium size class account for most of this category. Only a small percentage is in the large size class. Based on the potential characteristics of the ecoregion, most of the stands with medium size trees can develop large trees over time. Conservation, along with techniques to accelerate development of larger trees, may be appropriate in these stands.

Nealy fifteen percent (14.9%) of the assessed riparian length currently has moderate potential for LWD recruitment. Most of these stands are in the medium size class. Only the hardwood stand type is dense, while both the conifer and the mixed stand types are sparse. Supplementary riparian planting may be appropriate in the sparse stands if a developing understory is not currently present. Hardwood dominant riparian stands were not typical of the ecoregion under natural conditions, except as very narrow strips along constrained channels. Natural succession will likely allow a more typical mixed stand type to develop in most of these areas over time.

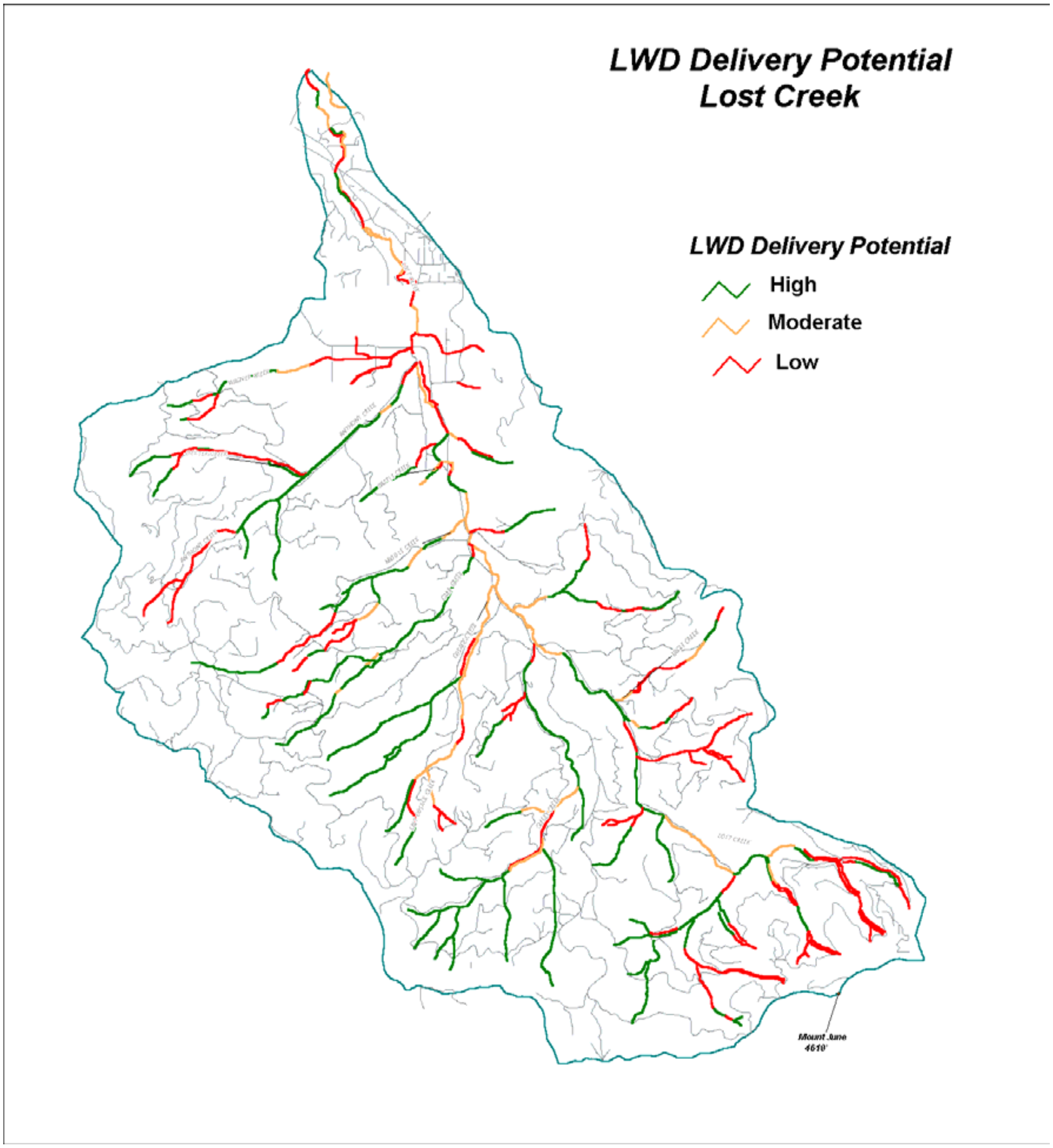
The remaining 35.4% of the assessed length currently has low LWD recruitment potential. In the Lost Creek watershed, this category includes some non-forest stand types such as brush and grass. Small size stands and regeneration size stands account for nearly this entire category, likely reflecting past harvest activities in the watershed. However most of the stands are dense, and so may develop well over time if protected.

The geographic distribution of LWD recruitment potential is shown in figure 3-11.

Recruitment potential is variable throughout the watershed. Most of the mainstem of Lost Creek, including the headwaters currently has moderate or low LWD recruitment potential. Only 2 significant reaches of high potential occur on the mainstem, both above Guiley Creek. The remainder of the mainstem of Lost Creek, which is presently deficient in LWD (see Fisheries Section 4), could be investigated for addition of LWD directly to the stream channels as a short-term habitat enhancement measure.

Of the major tributaries, Carr Creek currently has mostly high LWD recruitment potential along with East Gosage, much of Guiley Creek, and some of Anthony Creek.

Figure 3-11. Large woody debris (LWD) delivery potential within the Lost Creek watershed.



3.3.1.4.2 Stream Shading

Shading levels in the Lost Creek watershed are summarized in figure 3-12. The majority of the stream length has relatively high shading levels. About a tenth of the total length is moderately shaded, and about a tenth currently has low shading levels.

Figure 3-12. Riparian shading in the Lost Creek watershed.

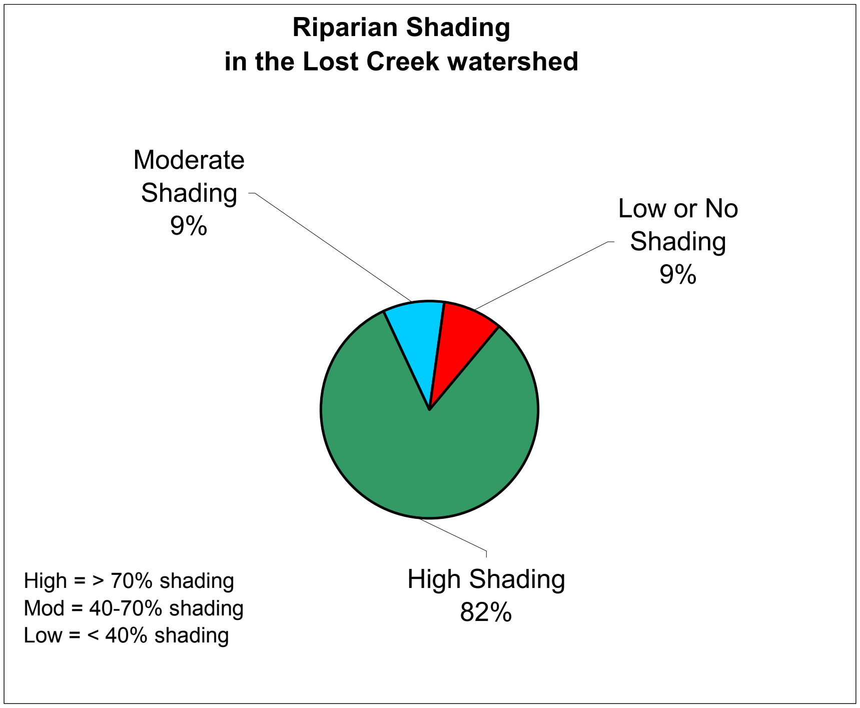
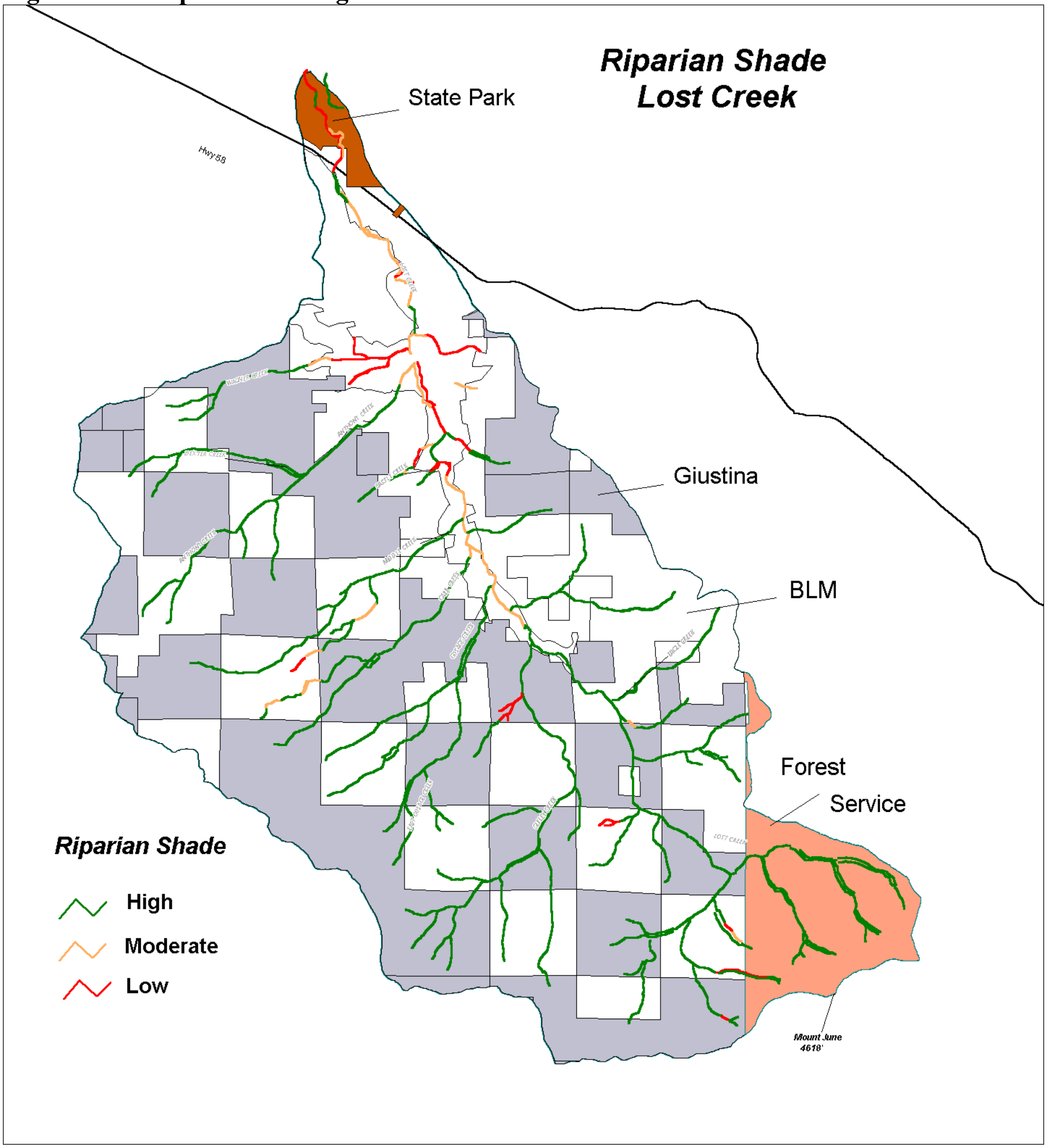


Figure 3-13 displays the geographic distribution of shade levels in the Lost Creek watershed. Shading is generally high along the tributaries and on the mainstem of Lost Creek above Guiley Creek. Moderate and low shading levels are concentrated along the mainstem of Lost Creek, below Guiley Creek.

Figure 3-13. Riparian shading within Lost Creek watershed.



3.4 RECOMMENDATIONS

- The are significant pieces of floodplain forests along the Middle Fork Willamette River. Examples include the floodplain riparian system within Elijah Bristow State Park and other areas with various degrees of protection. Over 70% of the floodplain riparian forests along the river have high to moderate large wood recruitment potential. It is important to connect and extend the intact areas of floodplain forest through voluntary restoration and protection actions. The Council can work with landowners and government agencies to identify priority floodplain areas for restoration and protection.

- Restore streamside areas that are covered in brush, grass, or invasive weeds. Riparian restoration should include planting native trees and shrubs, which will improve stream shading, large wood recruitment, and wildlife habitat. Some key areas for riparian vegetation restoration:

    - The lower mainstem of Lost Creek. The lower portions of Lost Creek have areas with limited riparian shade and large confir trees.

    - The tributaries of within the Lower Middle Fork watershed include large areas in poor riparian condition, particularly areas covered with brush, blackberries, and other invasive species.

    - While shade levels along Hills and Little Fall Creek are, for the most part, adequate, there are opportunities to work with landowners on voluntary riparian restoration to increase native vegetation, especially where blackberries or other non-native vegetation occupies the riparian area.

4.0 AQUATIC HABITAT AND FISH POPULATIONS

4.1 INTRODUCTION

This section examines current and historical river and stream habitats and fish populations

4.2 METHODS AND KEY QUESTIONS

The assessment of current and historical aquatic habitat and fish populations was based on existing reports, other information, and interviews with resource professionals. Detailed stream channel habitat information for Lost and Little Fall Creeks were based on the Council's 2001 stream habitat inventories (Ecosystems Northwest 2001).

The section is organized by the following key questions:

1. What fish species occur in the Assessment Area?
2. What habitats do fish in the Assessment Area use?
3. What are the sensitive fish species?
4. What are the current and the historic stream habitat and fish conditions?
5. What are the effects of the dams on fish habitat and populations?
6. What are the remaining data gaps in our knowledge of fish habitat and populations?
7. What are the restoration opportunities for stream habitat?

4.3 RESULTS

The results of this section are organized by key questions.

4.3.1 What Fish Species Occur in the Assessment Area?

Table 4-1 lists the fish species that have been described as occurring in the Assessment Area. (Note that species here means life-history forms of species such as the fall chinook being different than the spring chinook.) The native species are fish that have evolved in fresh water systems of the Pacific Northwest and were able to find their way into the upper portions of the Willamette basin. The process and details of natural species occurrence in the Assessment Area (or any area) is not well understood. But it is thought that the upper Willamette system has undergone various changes over time such as basin capture away from the Umpqua system (J. Ziller Oregon Department of Fish Wildlife, Springfield, OR, and J. Ebersole, Environmental Protection Agency, Corvallis, OR, pers. comm.), catastrophic flooding from the Pleistocene floods originating from huge glacial lakes in Montana (see http://www.idahogeology.org/iceagefloods/iafidesc.html) and eventually semi-isolation with the formation of Willamette Falls. As these processes occurred over tens of millions of years, species were constantly probing into new areas and evolving life history patterns to adapt to the new areas. The native fish species listed in Table 1-1 are the product of those catastrophic changes and also reflect the available habitat types that existed or currently exist in the Assessment Area. Native species are thought to have been in the Assessment Area at the time of Euro-American contact about 1850 (J. Ebersole, EPA Corvallis, pers. comm.). Bull trout have been extirpated, Oregon chub is now listed as "endangered" under the Federal Endangered Species Act (ESA) and spring chinook is listed as "threatened" under ESA. Several others are considered "sensitive" as to their continued stability.

The introduced fish species in Table 4-1 are a list of those that are known to have been purposefully introduced or have found their way by other than the "natural ways" described above. The genus *Oncorhynchus* or the salmonids were stocked by the State of Oregon at least as early as 1919 (US Army Corps of Engineers 2000). At that time there seems to have been less concerns about non-native introductions of species. Of the salmonids, only steelhead successfully reproduce in the wild and now occur in the Assessment Area. The other introduced fish species are collectively known as "warm water" fish and are those that have been introduced purposefully or accidentally or by migration once these fish were introduced elsewhere (e.g., the mainstem of the Willamette). It is noteworthy that these warm water species are rarely if ever described in fluvial surveys of the river or streams of the Assessment Area and therefore may not be a major concern. But these species are thought to occur in the reservoirs; probably seeking warmer back waters there. Most of the introduced warm water species were probably introduced for recreational fishing opportunities. Indeed, species such as bass likely provide a recreational fishery of a measurable level of value to the public.

Table 4-1. Native and introduced fish in the Assessment Area.

Native species:		Introduced species [1]:	
Common name	**Scientific name**	**Common name**	**Scientific name**
cutthroat trout	*Oncorhynchus clarki*	coho salmon [3]	*Oncorhynchus kisutch*
rainbow trout	*O. mykiss*	winter and summer steelhead [2]	*O. mykiss*
spring chinook salmon	*O. tshawytscha*	fall chinook salmon [3]	*O. tshawytscha*
Pacific lamprey	*Lampetra tridentata*	sockeye salmon [3]	*O. nerka*
western brook lamprey	*L. richardsoni*	warmouth sunfish [4]	*Lepomis gulosus*
dace species	*Rhinichthys* spp.	bluegill sunfish [4]	*L. macrochirus*
northern pike minnow	*Ptychocheilus oregonensis*	pumpkinseed [4]	*L. gibbosus*
largescale sucker	*Catostomus macrocheilus*	brown bullhead [4]	*Ameiurus nebullosus*
redside shiner	*Richardsonius balteatus*	mosquitofish [4]	*Gambusia affinis*
sculpin species	*Cottus* spp.	yellow perch [4]	*Perca flavescens*
Oregon chub	*Oregonichthys crameri*	smallmouth bass [4]	*Micropterus dolomieu*
sandroller	*Percopsis transmontana*	largemouth bass [4]	*M. salmoides*
whitefish	*Prosopium williamsoni*	white crappie [4]	*Pomoxis annularis*
bull trout [5]	*Salvelinus confluentus*	black crappie [4]	*P. nigromaculatus*

[1] Species listed as introduced to the main channel Willamette River and thought to also likely occur in the at low densities, no longer occur, or occur in the reservoirs of the Assessment Area. Other species may also occur.

[2] Winter steelhead are native to the lower portions of the upper Willamette system, but for unknown reasons, are not thought to have reached the Middle Fork Willamette system by natural means (by 1850). Winter and summer steelhead are now stocked and naturally reproducing populations of winter (and possible summer) steelhead exist in the Assessment Area.

[3] Stocked by the ODFW during the 1950s and 1960s but failed to establish returning runs. Also called silver salmon.

[4] Warm-water species introduced into the Willamette basin but not thought to occur at high densities in the fluvial (flowing) sections of the Middle Fork Willamette River or tributaries but probably occur in the reservoirs.

[5] Bull trout are thought to originally have used the Assessment Area, perhaps during fluvial migrations but are now gone.

Altman et al. 1997 lists five additional native species as possibly occurring in the Middle Fork system (i.e., white sturgeon, three-spine stickleback, and leopard dace etc). But these species are not mentioned in the reports reviewed here to suggest they occur at very high numbers.

All native species, except Pacific lamprey and bull trout, were reported as observed in the Assessment Area during surveys performed in 2001 (either habitat surveys or screw trap operations). Bull trout are now considered to be extirpated (locally extinct) from the Assessment Area. Pacific lamprey were noted in Little Fall Creek during habitat surveys in 1993. The sighting of an Oregon chub was from the surface during the Middle Fork Willamette habitat survey and was therefore not definitive (the surveyor noted the species with a question mark). However, a population of Oregon chub is reported re-established by ODFW in a beaver pond below Fall Creek Dam (US Army Corps of Engineers 2000), other populations occur in the backwaters of the Middle Fork Willamette near Lost Creek (BLM 1997), and some are thought to occur in the backwaters of the Middle Fork near Springfield (P. Thompson, local wetlands consultant, pers. comm). None of the introduced species were observed during any of the 2001 stream surveys.

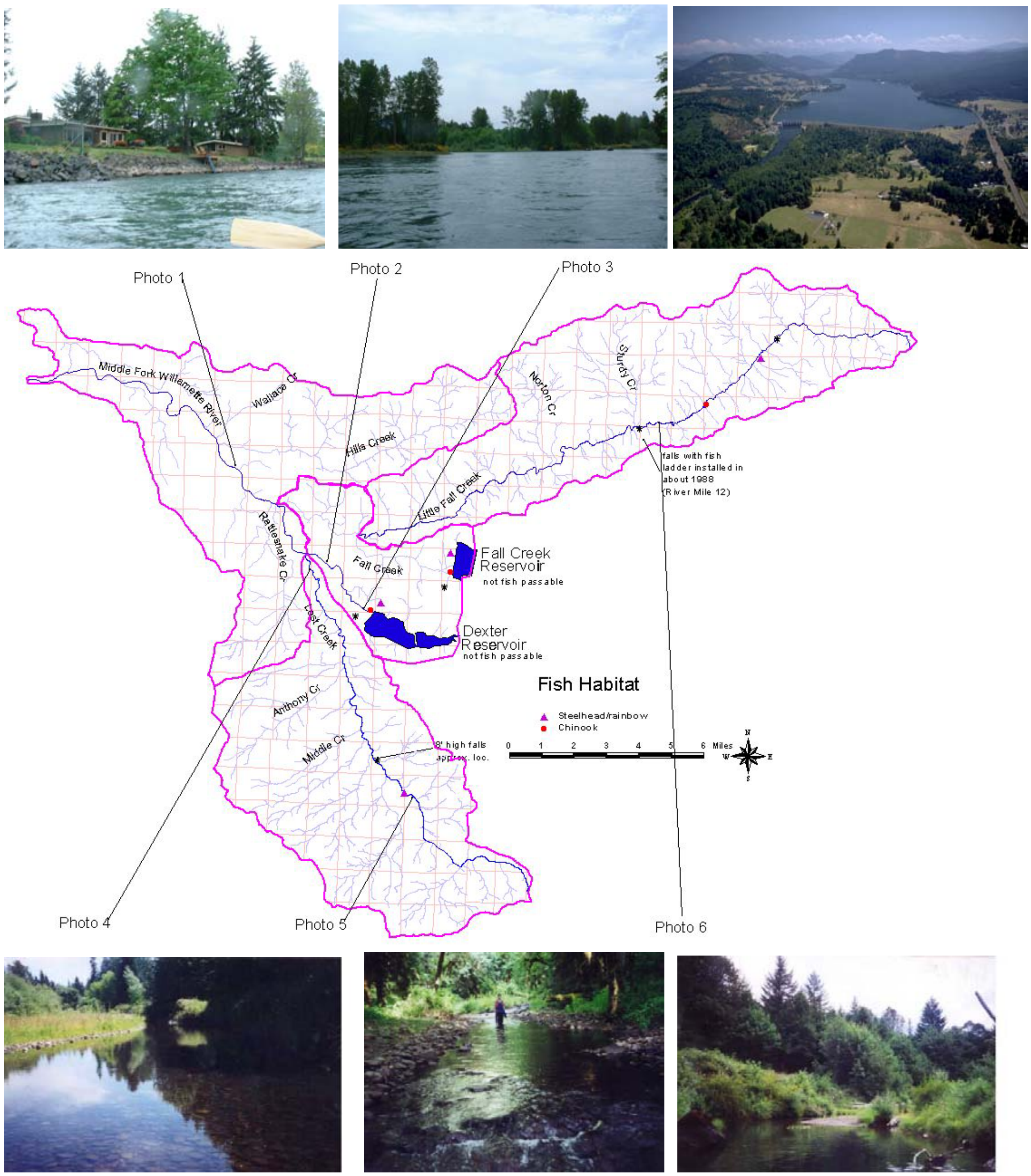


Figure 4-1. Fish habitat in the Assessment Area with named streams and watershed boundaries. Photo points show locations of photographs of typical habitat. Symbols indicate upper extent of chinook and steelhead at the base of the dams and in Little Fall and Lost Creeks based on the 2001 surveys.

4.3.2 What Habitats do Fish in the Assessment Area Use?

Appendix 9-1 presents descriptions of habitat for each native fish species. A number of websites describing fish life histories are also provided there. Below is a generalized summary of fish use and habitats in the Assessment Area.

Chinook do not appear to use Lost Creek and no anadromous fish use is thought to occur in any other of the tributaries. Cutthroat use is not shown on this map as they are expected to use most tributaries. Their extent may be approximately described as occurring to within one mile of the watershed boundaries where any of the following occur: channel gradients begin to exceed 15 %, 4-foot or higher vertical falls began to occur, or where the drainage area becomes smaller than 100 acres.

The six photos in Figure 4-1 are distributed among four major fish habitat types in the Assessment Area: 1) the large and fast-flowing habitats of the main channel of the Middle Fork, 2) the reservoir habitats, 3) the backwater or off-channel habitats of the Middle Fork, and 4) the small habitats of the tributaries.

Photo 1, a downstream view, shows private lands along the lower portion of the Middle Fork. This is an example of bank hardening used to protect homes from bank erosion that is widespread in the lower sections. Habitats in the main stem are mainly uniform glides, long and shallow pools or riffles which are somewhat indistinguishable from each other. Rainbow, cutthroat, suckers and whitefish are the common resident fish in the main stem and probably utilize pocket pool microhabitats. Adult steelhead, chinook, and lamprey will also use the main channel during their upstream migrations. Juvenile steelhead, chinook and lamprey will use this area during downstream migrations.

Photo 2, an upstream view, shows the relatively undisturbed riparian zone in the upper portions of Middle Fork Willamette River near the Dexter Dam. This photo is of the river channel where two side channels rejoin to reform the main channel. The habitat is similar to photo 1, but with more side channels and less channel constraint by revetments. This photo was taken May 23, 2002 during the main part of the spring chinook run and the boat barely visible near the top is of a drift boat fishing for the hatchery-reared chinook.

Photo 3 is a US Army Corps of Engineers aerial photo of Dexter Dam and Dexter Reservoir. The reservoir and particularly its backwaters are the habitat of the warm water fish. The reservoir pool itself is not thought to provide very much habitat for native fish. Downstream migrating smolts swim through the reservoir pool and resident trout use the reservoir. Recreational boating and camping are cited as one of the beneficial uses of the reservoirs. Fall Creek Reservoir is probably the more popular of the reservoirs in the Assessment Area.

Photo 4 shows an upstream view of the mouth of Lost Creek and is representative of backwater, slow-velocity habitats of that occur along the Middle Fork and in the lower portions of tributaries. Here common species are dace and redside shiners. One may also find Northern pikeminnow, suckers, sand rollers, and possibly the rare Oregon chub. Backwater habitats also provide habitat for pond turtles and other amphibians. This photo was taken during the 2001 habitat survey of Lost Creek.

Photo 5 is an upstream view of a pool-riffle sequence in the upper portions of Lost Creek. Here the common species are cutthroat, steelhead and/or rainbow and sculpins. This photo shows low-flow conditions and is from the habitat surveys of 2001.

Photo 6 shows an upstream view of a low-gradient portion of the upper portion of Little Fall Creek. Here the pools were particularly deep with good complexity from woody debris. This section is located above a former fish barrier falls that had a ladder constructed around it in 1988. Adult chinook salmon were observed this far up in the system for what appears to be the first time during the 2001 surveys. Additional species that occur here are steelhead/rainbow, cutthroat trout, and sculpin. Two dace were also reportedly sighted during snorkel surveys in 2001.

4.3.3 What are the Sensitive Fish Species?

Sensitive species are those listed by either the State of Oregon as sensitive (Connolly 1992, Weavers 1992) or listed under the Endangered Species Act (ESA) or under consideration to be listed under the ESA. These species are generally of concern to "society" because they are reported to be declining in populations and therefore thought to be in some level of danger of becoming extinct. In some cases, the species are listed as sensitive because little information is known about their exact status. The sensitive fish species are described in Table 4-2; see also Appendix 9-2.

Table 4-2. Fish species in the lower Middle Fork Willamette watershed with some level of sensitive status.

Common Name	Federal. or state status	Notes
spring chinook	LT	All of Middle Fork Willamette is included as critical habitat. Dexter and Fall Creek dams block passage to more productive upstream habitat. Some fish are transported above the dam and some proportion of smolts appear to survive downstream passage through the turbine. Warm water releases (above 55 F) during incubation are thought to impair much of the downstream habitat. Large numbers of hatchery stocks may have mixed with any remnant native populations. The role of Little Fall Creek, the largest undammed tributary to the Middle Fork Willamette) is discounted as a refugia for wild stocks because of past low escapement and mixing of hatchery fish or of hatchery stock fish. The snorkel surveys of 2001 suggest increased use of Little Fall by naturally spawning chinook.
Oregon chub	LE	Occurs in backwaters and side channels of lower Middle Fork Willamette. Side channels and backwaters habitat was normally maintained by periodic flooding. Flood control by the dams likely has reduced the extent of habitat.
steelhead	--	Winter steelhead are listed as federally threatened in the Upper Willamette. However, critical habitat designations do not include any of the Upper Willamette basin above the Calapooia River (downstream in the Willamette mainstem at Albany, Oregon). Steelhead in the Middle Fork Willamette River are not native and have recently been introduced by stocking. Winter steelhead have established a naturally reproducing population. Summer steelhead are stocked for recreational fisheries but may also be establishing a naturally reproducing population. One issue of concern is stocked steelhead juveniles migrating downstream and competing with native steelhead juveniles.
cutthroat	C?	Willamette River native cutthroat are not currently listed, but are under consideration by US Fish and Wildlife Service. The larger fluvial cutthroat that inhabit larger rivers and move between smaller tributaries and rivers during spawning may have declind in numbers. Data are insufficient to draw clear conclusions about population declines.
Pacific lamprey	SoC	Abundance of lamprey has declined along with other anadromous salmonids due to general deterioration of habitat, blockage by dams and culverts. As lamprey also rear in organic sediments for several years, they have similar habitat needs as Oregon chub and are also susceptible to pollutant accumulation occurring in sediments.
sandroller	SoC	A single individual was documented in Lost Creek screw trap in the spring of 2001. Listed as a stock of concern by ODFW due to suspected low numbers. Relatively little is know about the habitat needs, life history, population numbers, or trends.

SoC=Species of Concern State of Oregon, C=Candidate Species federal, LT=Listed Threatened federal, LE=Listed Endangered federal

4.3.4 What are the Current and the Historic Stream Habitat and Fish Conditions?

This section synthesizes the available data on stream and fish conditions—mainly the survey data. Other good summaries on fish include those by the ODFW (Connolly et al, 1992) and by the U.S. Army Corps of Engineers (2000). Good historic land use summaries are available for the Lost Creek watershed (BLM, 1997); the Weyhaeuser (1997) watershed analysis of Little Fall Creek provides good summaries of stocking and land use history. Andrus and Walsh (2002) provide history of channel modifications of the lower Middle Fork near Springfield.

In summary, major known, historic events that likely have contributed to imparied stream habitat and function are numerous. Little Fall Creek includes a history of a splash dam operation at river mile 8 on Little Fall Creek about 1900. Salvage log removals from the channel was common practice duirng 1960's and 1970's and probably occurred on private lands, but no specific records exist for Little Fall Creek. The Forest Service removed wood on their lands in 1979 (Weyerhaeuser, 1997). Lost Creek had dams and water diversions for a log flume at about river mile 7.5 on Lost Creek (records researched by E. Fredette). Splash damming occurred on Lost Creek during 1879 through 1903 (BLM, 1997). The riparian forests along most of the mainstem and lower tributaries of Lost Creek are also thought to have been largely destroyed by a fire in 1900 (BLM, 1997). Because these watersheds are at relatively low elevations in the Cascades, early and intensive logging also likely occurred over accessable areas of the watershed (BLM, 1997). Log drives on the Lower Middle Fork Willamette River are described by Andrus and Walsh (2002)

4.3.4.1 Available Data for Fish and Stream Habitat Conditions

Surveys have been performed in the Assessment Area for fish and habitat beginning in the 1930's. The surveys are that were reviewed for this assessment are summarized in Table 4-3 and the results are described in Appendix 9-3. This list is moderately comprehensive but does not include all reports or summaries (e.g., Mattson 1948 and Parkhurst et al 1950, Hutchison et al, 1966).

Table 4-3. Stream habitat and fish surveys completed within Assessment Area.

Location	survey dates	type of survey / information	source / report
Middle Fork	1964	habitat: data summaries and descriptions of field visits	Thompson 1965, Oregon State Game Commission
Middle Fork	1966	fish summary	Thompson et al. 1966, Oregon State Game Commission
Middle Fork	1977, '78,'90	fish: electrofishing raw data	ODFW files
Middle Fork	2001	habitat: Aquatic Inventory Methods	Stein2001, ODFW
Middle Fork	1999	aerial photo interpretation of the lower 7 miles of river plus electrofishing data	Andrus and Walsh 2002
Lost Creek	1938	habitat: data summaries and descriptions of field visits	Hanavan et al. 1938, US Fish and Wildlife Service
Lost Creek	1959	habitat: 1 page summary	Thompson 1965, Oregon State Game Commission
Lost Creek	1990-95	habitat summary data	report not located
Lost Creek	2001	habitat: Aquatic Inventory Method; fish: snorkel surveys	Ecosystems Northwest, 2002
Little Fall Cr	1936	habitat: data summary and description of field visit	no cite obtained but may be Fish and Wildlife Service
Little Fall Cr	1959	habitat: data summary and description of field visit	Fish Commission of Oregon 1960
Little Fall Cr	1981	habitat: survey summary fish: survey summary	Erickson 1983, US Forest Service
Little Fall Cr	1984	habitat: summary	Hutchison et al. 1984, ODFW
Little Fall Cr	1990	habitat: summary	Ross and Moser 1990 US Forest Service
Little Fall Cr	1993	habitat: reach summaries and data summaries	Berry et al 1993, US Forest Service
Little Fall Cr	1994	habitat summary memo	Willamette National Forest 1994
Little Fall Cr	2001	habitat: Aquatic Inventory Methods fish: snorkel surveys	Ecosystems Northwest 2002

Significant findings, organized by the Middle Fork Willamette River, Little Fall and Lost Creek, include the following:

Middle Fork Willamette:

- Spring chinook salmon were abundant in the Middle Fork before the construction of the dams. Thompson et al 1966 speculated that the chinook run in the Middle Fork Willamette may have exceeded the McKenzie runs. Most fish continued upstream of the Assessment Area to spawn before the dams were built.

- There are conflicting reports of spawning in the Middle Fork below the dams. For example, Thompson et al 1966, when discussing steelhead and spring chinook use of habitat below the dams, states that "considerable spawning takes place in the river below Dexter." The Oregon Fish Commission (1960) report states that summer water temperatures in the Middle Fork near Lowell were near 70 F during 1950 to 1954 (before the construction of the dams). The report considers temperatures over 60 F to be "too high for the successful holding of spring chinook." (This statement may be based on observations of survival of trapped adults in the Dexter holding pools.) The report also states that surveys by boat and plane prior to 1953 "revealed no evidence of salmon spawning in the area from Lookout Point Dam downstream to the Coast Fork." However a survey in 1954 (after dam completion) found 12 spring chinook redds below Lookout Dam. The 2001 ODFW habitat survey (Stein, 2001) also reported chinook redds and fry below the dams. The Middle Fork Willamette Subbasin Fish Management Plan (Connolly et al., 1992) further reports that 219 chinook redds were counted in 1971, but questions whether any chinook hatching was successful as many of the eggs were coated with a fungus. Connolly et al. also cite release water from the dam at temperatures above 55 F during egg incubation as reason for minimal success below the dams.

- Electrofishing surveys in the river channel show nearly even numbers of cutthroat and rainbow trout. Approximately 10 % were noted to be hatchery fish. Sizes of fish ranged from 10 to 40 cm in length.

- The quantitative habitat survey performed in 2001 found low wood counts, abundant and deep pools, agriculture and residential development along the stream in the lower reaches, but good side channel and floodplain habitat in the upper reaches.

Little Fall Creek:

- The earliest survey is from 1936 (ODFW no date—ODFW has a version of the data that were retyped but have no date). This survey mentioned that coho may have used the stream as reported by local residents (though coho are not thought to have been stocked before the 1950s). The use of Little Fall Creek by salmon was questioned in the time of the 1936 report because of the steep gradient and the numerous obstructions. The 1959 survey (Oregon Fish Commission 1960 citing an earlier report, Parkhurst el al 1950) states that "silver and chinook salmon may have used this stream many years ago." Later surveys to 1984 all mention the high falls at about river mile 12 as a likely barrier to fish. A second falls and several logjams above the falls at mile 12 are mentioned as possible barriers. A fish ladder was built around the falls in 1988 and a summer steelhead was observed in a single pool above the falls in 1990 (Ross and Moser, 1990). The second falls had jump pools blasted into it and the logjams were also removed. No notes of anadromous fish above these second structures occur in the subsequent reports. In 1992 and 1994, steelhead-spawning surveys noted redds above the first fish ladder. In 2001, both chinook salmon and steelhead were observed above the first fish ladder.

- The only record noting Pacific lamprey in the Assessment Area was a sighting in 1993 at river mile 9.3 of Little Fall Creek (Berry et al, 1993).

- A number of log structures were placed in Little Fall Creek during the 1980s. The 2001 survey noted that many of these structures appeared to have moved, probably during the 1996 floods. Some were still providing function, others were reduced in their function (Ecosystems Northwest, 2001).

- The 2001 surveys counted low but consistent numbers of juvenile chinook in Little Fall Creek. ODFW stocked 239 adult chinook in 2001 (G. Taylor, USACE fish biologist, pers. comm.) but these fish would not have spawned by the time of the 2001 surveys (June). The presence of fry suggests that some level of natural reproduction of chinook occurs throughout the surveyed reaches.

- The 2001 survey found that pools were not highly abundant but were relatively deep. The substrate was a mix of all sizes and high amounts of bedrock and high amounts of sand and silt occurred in Reaches 3 and 4. Riprap was present on the private lands. Habitat tended to lack complex structure in the lower four reaches from low wood and low off-channel habitat. The fish densities, especially of 0 to 3" size class steelhead/rainbow, were high in the upper reaches. ODFW had released 30,000 summer steelhead smolts to Little Fall in 2000 but none were released in 2001, (D. VanDyke, ODFW fish biologist, pers. comm) suggesting successful natural spawning of steelhead.

Lost Creek:

- Earliest surveys describe very poor management for fish (Hanavan et al., 1938). Poor conditions included high amounts of sand and mud, an impassable dam at river mile 7.5, most of the water diverted from the river to a log flume, and flushes of sawdust and bark entering the stream.

- Salmon and steelhead were reportedly seen and caught in Lost Creek about 1910 to 1920 as reported to Hanavan et al (1938) by local residents. (Though steelhead may have actually been salmon as steelhead are not thought to have been introduced until 1953.) In 1938, whitefish, suckers and chub were abundant and cutthroat occurred in the upper parts of the stream.

- A comparison of pool depths from various surveys indicates Lost Creek has shown steady declines in the numbers of deep (> 3 feet) pools. The number of pools at least 3 feet deep per mile declined from 22 in 1938 to 11 in 1990 (ODFW summary data on file at Springfield, OR) to 4.5 in 2001.

- Dace and redside shiners were recorded in the upper portions of Lost Creek in 1990, but were only recorded below the 8-foot falls at river mile 8.5 during 2001. It may be that dace and redside shiners were displaced from the upper reaches during the 1996 high flows and have not yet been able to recolonize above the falls.

- The 2001 survey noted entrenched channels in the lower reaches of Lost Creek with finer substrates and organic sediments. Bank erosion and riprap were noted to be slightly elevated in the first two reaches. All of the surveys noted that habitat lacked complex structure and particularly wood. The earlier surveys generally noted high side channel area (e.g., 10 %) but the 2001 survey counted not more than 6 % side channels in any reach. Pools were not particularly deep in the upper reaches and some evidence of filling was noted. Fish densities were good. Dace and redside shiners were the most abundant fish in the lower reaches and cutthroat was the most abundant fish in the upper reaches.

4.3.4.2 Results from the 2001 Aquatic Inventory Surveys

The earlier surveys prior to 2001 have been summarized by BLM (1997, see also Appendix 9-3). This section summarizes the 2001 survey data. In 2001, the Middle Fork River downstream from Dexter Dam, Lost Creek upstream to about river mile 12 and Little Fall upstream to about river mile 16 were surveyed using the ODFW's Aquatic Inventory method (Moore et al, 1997). This method inventories all wetted surfaces of the steam and categorizes the stream into one of six major habitat types. These types are in turn classed into a set of subtypes so that 22 individual habitat types are possible. Each habitat type is measured for dimensions and depth, wood is counted, and substrate is assessed. In selected areas, channel dimensions are taken and riparian conditions measured. Fish surveys by snorkeling were also performed in Lost and Little Fall Creeks. The data were entered into computers and a program of analyses was run to produce a data summary. The data are summarized by reaches -- sections of the stream selected to be geomorphically similar (usually a reach is broken at a point where a large tributary enters the mainstem). The data summaries can be used to assess the stream condition for pool area, pool depths, wood counts and substrate among other things. The data summaries are evaluated against threshold criteria in Table 4-4 (Foster et al, [no date]). Also reach summaries are presented along with maps in Appendix 9-4.

Table 4-4. Quality of habitat for streams surveyed in 2001 within Assessment Area.

Measure	Undesirable	Desirable	Little Fall Creek	Lost Creek	Middle Fork Willamette
Pools					
Scour pool area (% if total stream area)	< 10	> 35	13-43	17-54	26-49
Pool frequency (channel widths between pools)	>20	5-8	6.4-24.7	6.4-10.5	2.1-4.9
Residual pool depth (m)	<0.3	>0.6	0.86-1.30	0.47-0.83	1.1-2.4
Complex pools (pools w/LWD pieces >3) / km	<1.0	>2.5	0.6-6.3	0.3-4.0	1.0-1.9
Riffles					
Width / depth ratio	>30	<15	21	29	50-118
Gravel (% area)	<15	>35	18	28	40-56
Silt-sand-organics (% area)	>25	<12	27	16	0-2
Shade					
Reach average (percent) [1]	<60	>70	75	65	31-41
Large woody debris (15 cm x 3 m minimum piece size)					
Pieces / 100 m stream length	<10	>20	4.8	2	2.0-7.9
Volume / 100 m stream length	<20	>30	47.9	4	2.7-13.2
"Key" pieces (>60 cm dia. & > 10 m long) / 100 m	<1	>3	1.4	0.1	0.2-0.7
Riparian conifers					
Number >20 in dbh / 1000 ft stream length	<150	>300	2.2	0.1	0
Number > 35 in dbh / 1000 ft stream length	<75	>200	0.5	0.04	0

Ranges of values for streams represent the range among the reach means. Single values are the mean for the entire survey. Reach values are presented in Appendix F-4.

The data summaries in Table 4-4 indicate the following:

- Pool area, frequency and depth are generally in the desirable range. Pool depths in Lost Creek tend to be somewhat shallow, particularly in the upper reaches.

- Riffles tend to have wider width-to-depth ratios than desirable, suggesting deposition, aggradation, or bedload mobilization. These may be results from the 1996 floods. Such a result is unexpected for the Middle Fork as stream reaches below reservoirs often show gravel and sediment depletion and channel degradation. The desirable range for width to depth ratio may better reflect that for a smaller stream than the Middle Fork, as larger rivers may be expected to have wide width to depth ratios.

- There appears to be adequate shade along the smaller tributaries.

- There tends to be low amounts of wood in all streams. There are exceptions, however. Wood volume was notably high in the upper three reaches of Little Fall Creek.

- There are very few conifer trees next to the streams. Part of this result can be explained by the fact that these streams are at relatively low elevations where deciduous trees are relatively common. Still, hardwoods of diameter greater than 12 inches were generally less that 35 per 1000 feet of stream in the two tributaries. Most of the riparian forests on the tributaries were small deciduous trees. Indeed, riparian zones in either rural residential areas or agricultural areas are often cleared of natural forests.

4.3.4.3 Results from Andrus and Walsh study of the Lower Middle Fork Willamette River

Andrus and Walsh (2002) performed an assessment of the rivers and associated channels in the Eugene-Springfield area. The study area included portions of the McKenzie, the Willamette and the lower 7 miles of the Middle Fork Willamette rivers. The assessment was an evaluation of channel types, aquatic and riparian habitat, water quality, hydrology, aquatic organisms, and restoration opportunities.

Changes in channel condition and habitat were determined from aerial photographs from the year 1944 (pre-dam) and the year 2000 for each of 27 reaches. Overall, the reaches showed loss of various measures of complexity including sinuosity, side channel lengths, alcove habitat, and gravel bars (Table 4-5).

Table 4-5. Summary of physical characteristics of river reaches in 1944 and 2000.

Middle Fork Willamette River (reaches #22-25)	Year 1944	Year 2000	Percent change
Main channel; length of thalweg (miles)	7.12	6.98	-2
Main channel; length of chord distance (miles)	5.47	5.58	+2
Sinuosity	1.30	1.25	-4
Side channel; length (miles)	1.39	1.24	-11
Alcove; length (miles)	1.22	0.79	-35
Gravel bar; length of main channel bank (miles)	5.99	2.17	-65

Two of the three reaches of the Middle Fork were scored in the top seven reaches (out of a total of 27 reaches) showing the greatest loss of complexity. Losses of habitat complexity were related to construction of riprap, reduced flood flows, gravel mining, and channel engineering.

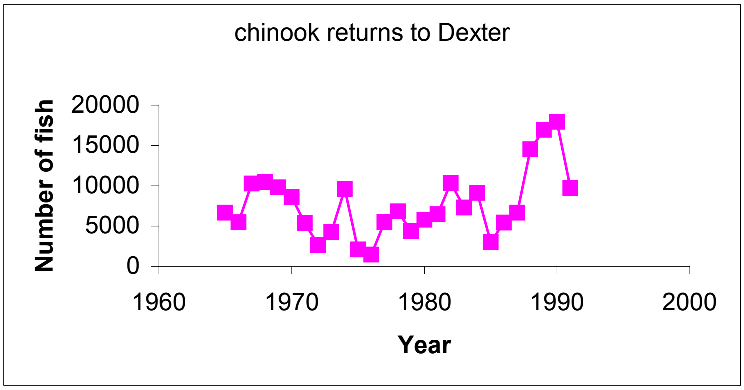
Vegetation types evaluated for 500 feet each side of the river using the 1944 and 2000 aerial photos showed that there were sharp declines in the area of hardwoods greater than 40 years old, bare substrate, and grass. The reports cited reduced peak flows that had allowed vegetation to encroach upon the river edges, and harvests of older trees for timber and development. Rural residential and urban development was only 0.3% of the area in 1944 because of the flood hazard but increased to 7.3% by 2000.

4.3.4.4 Trends in the Fish Population Data

There is very little quantitative data by which to examine trends in the population of fish in the Assessment Area. The best information on salmon returns is the data on the capture of return of adult steelhead and Chinook over time at the two dams (Figure 4-2).

The returns of chinook are currently a mix of natural and hatchery reared fish. Beginning in 2002, hatchery fish will be distinguished from naturally reared fish (G. Taylor, fish biologist USACE, pers. comm.). In 1947, Mattson (1948 cited in Connolly et al 1992) derived an estimated return of 2,550 fish or 21 % of that passing Willamette Falls, though the runs in the 1920's and 30's were thought to be five times this figure. Therefore, the post dam period of hatchery management shows increased fish returns and no obvious trends over time.

By 1996 the returns of steelhead to Fall Creek were hovering at or below 10 fish per year (Figure 4-2). Most of the other data available for fish specific to the Assessment Area do not allow a statement of trends to be readily made as they have not been repeatedly collected over time. Periodic, quantitative surveys of fish have some level of cost/effort and have not been performed.



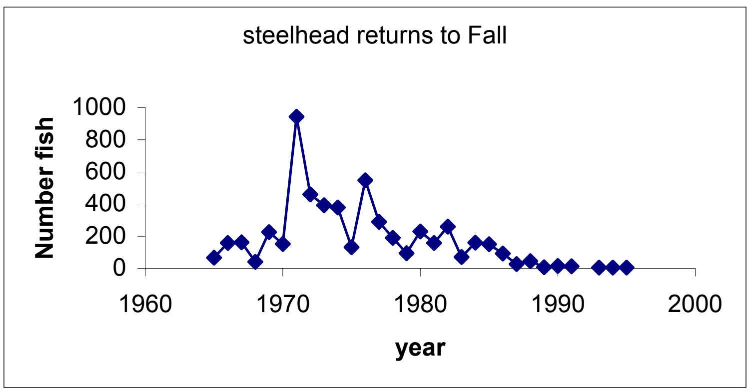


Figure 4-2. Returns of chinook and steelhead to fish traps at base of dams (Connolly et al, 1992 and Weyerhaeuser 1997).

4.3.5 What are the Effects of the Dams on Fish Habitat and Populations?

4.3.5.1 Background on Dams

Both the mainstem of the Middle Fork Willamette and Fall Creek have dams that are located in the upstream portions of the Assessment Area. The Lookout and Dexter dams began operations in 1954 and Fall Creek started operations in 1966. The dams are three of a series of dams that were part of a Congressional authorized program of water resource development during the 1930's through the 1950's. At least three acts gave the authorization to the U.S. Army Corps of Engineers to build and operate a series of dams in the Willamette basin. The Willamette Basin Project eventually built 13 dams on tributaries to the Willamette and also performed bank stabilization, levees and channel clearing at 171 sites downstream of the dams. At least 4 additional dams were authorized but were subsequently deauthorized and never built. Though this was a project costing hundreds of millions of dollars, Congress provided relatively few specific operating criteria. As a consequence, the Corps attempts to balance operation of the system for all authorized purposes, including flood control, electric power, irrigation, navigation, and flow augmentation for water quality, fish, wildlife, and recreation (U.S. Army Corps of Engineers, 2000).

4.3.5.2 Fish Passage

It was anticipated historically that the dams would have negative consequences for anadromous salmonids and therefore "mitigations" were part of the authorizations. But the consequences now appear to be somewhat larger than anticipated and the mitigations have not had their originally intended effects. The dams' negative effects are primarily preventing or inhibiting upstream passage of adults to spawning grounds and downstream passage of juveniles enroute to the ocean (smolts). The project mitigations included designs for fish passage or in other cases, the construction of several fish hatcheries to artificially rear and stock fish as a replacement for the loss of wild fish. However, the fish passage designs have generally only been partially successful or at least there have been technical complications and the fish passage operations have failed to produced the anticipated results (US Army Corps of Engineers, 2000). The hatchery program was highly successful in producing and rearing juveniles, however competition, genetic introgression, and disease transmission resulting from hatchery fish production may inadvertently result in adverse impacts to weaker, wild stocks. Furthermore, collection and utilization of wild for broodstock may result in additional negative impacts to small or dwindling natural populations (cited from the National Marine Fisheries Service website:
http://www.nmfs.noaa.gov/prot_res/PR3/Fish/salmon_impacts.html).

Upstream migrating winter steelhead and spring chinook are trapped at Fall Creek Dam and at Dexter Dam for either hatchery use or transport to upstream areas (US Army Corps of Engineers, 2000). Release flows are managed to encouraged fish to enter raceways and swim to constructed holding pools. Here they are swept into another tank and anesthetized and sorted. (The length of time the fish may be held is unclear but at one time was several months. This created problems early on and in some years only 50 % of the fish survived; Oregon Fish Commission 1960). Non-target fish are released into the tail water but steelhead and salmon are put into a 1000-gallon tank truck and most are transported to hatcheries. The trapping and trucking is not a perfect solution as physical injury and stress occurs to the adult fish.

In Fall Creek some fish are transported and released back into Fall Creek about 2 miles upstream of the reservoir. These fish spawn naturally in the Fall Creek system. Most trapped fish are transported to the McKenzie or Willamette Hatcheries and either used as brood stock or transported out to various other locations (US Army Corps of Engineers, 2000). A number of physical injuries and stress with the holding of fish in warm waters are listed as problems with the trapping and trucking process.

Naturally produced, downstream migrant chinook salmon and winter steelhead in the Fall Creek system must pass through the Fall Creek Reservoir and then past Fall Creek Dam. The original design for downstream fish passage through specially designed tubes proved ineffective (survival was 68 % but many survivors were damaged) (US Army Corps of Engineers, 2000). Instead smolts exit through "regulating outlets." But survival is low during passage. In an experimental release of one million smolts to the reservoir, 25 % survived passage through the reservoir to the dam and 16 % eventually survived passage downstream of the dam through the regulating outlets (US Army Corps of Engineers, 2000). It appeared that increased smolt survival may have been achieved via drawing down the reservoir starting in July during the years 1992 to 1998. But due to the large recreation use at Fall Creek, drawdowns prior to Labor Day were stopped. Still, lowering the reservoir levels after September appeared to help survival. Eventually it was decided that the poor smolt survival issue would instead be mitigated by releasing 100,000 marked smolts below the dam (US Army Corps of Engineers, 2000).

Lookout Point Dam did not have a special design channel or conduit system for passing smolts; the turbine was designed to pass fish directly through it. In any event, the original idea behind the releases of chinook above Hills Creek Reservoir was not to re-establish runs above Dexter and Lookout Point Dams but was originally proposed to enhance food source for bull trout food as bull trout prey on chinook fry. Somewhat unexpectedly, chinook smolts began passing downstream through Lookout Point Dam suggesting that re-establishing chinook runs into the Middle Fork Willamette may be possible. A current study is underway to attempt to quantify smolt survival past Lookout Point Dam. Smolts are indeed surviving passage through the turbines, but it has been difficult to quantify a survival rate (T. Murtagh, ODFW fish biologist, pers. comm).

Importantly, 2002 should be the first year where all returning chinook that were of hatchery origin are fin clipped. The ratios of fin clipped to non-fin clipped fish that are captured at the dam sites will give an indication of how well the naturally spawned fish are performing.

4.3.5.3 Alterations to Stream Conditions Downstream of the dams

In addition to the fish passage problems, the dams also have created alterations to the stream downstream of the dams. These alterations include affecting water quality, specifically warmer stream temperatures during spawning and incubation, and habitat changes, specifically reduced sediment transport, reduced flood flows, and perhaps trapping of woody debris from upstream sources.

Following the listing of various species under the Endangered Species Act, the Army Corps of Engineers was required to assess the effect of the Willamette Basin Project on ESA-listed species. The assessment produced a several hundred-page document that is available on the internet (U.S. Army Corps of Engineers, 2000; https://www.nwp.usace.army.mil). The document describes the history of the project, the operations of the dams, fish passage efforts and reviews life histories of the listed species. The assessment concluded that the operation of the Project is likely to adversely affect several listed fish species and one listed species of plant (e.g., Upper Willamette chinook ESU, Upper Willamette steelhead ESU, Columbia River bull trout DPS, Oregon chub, Upper Willamette cutthroat trout ESU—not currently listed, but under consideration, and the plant, *Howellia aquatilis*).

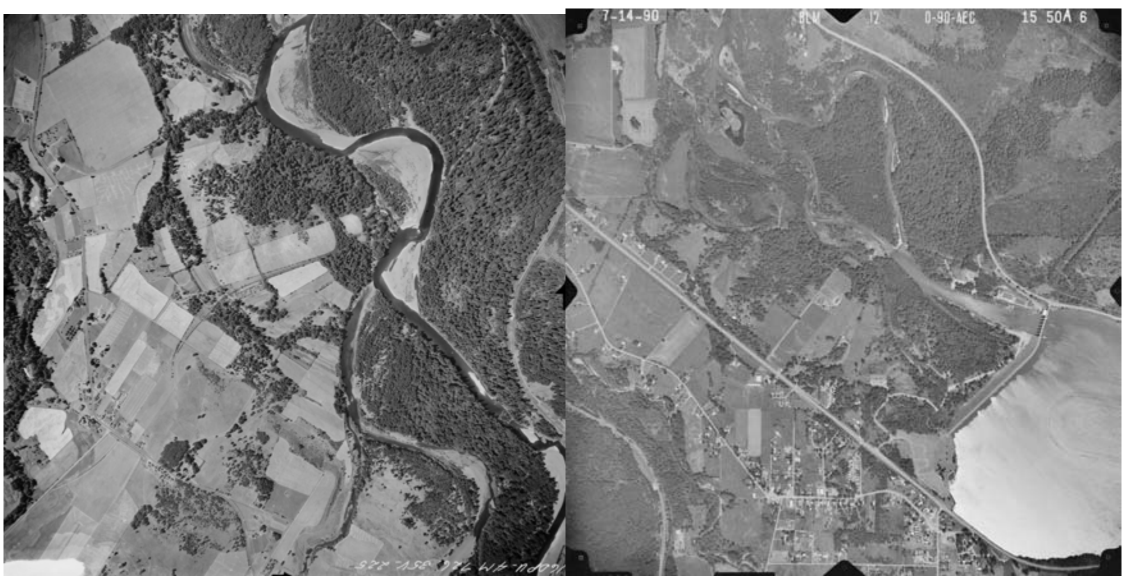


Figure 4-3. Aerial photo of the Middle Fork Willamette River before (left) and after (right) construction of Dexter Dam in 1954. Left photo is 1944; right is 1990. The dam is thought to be reducing sediment supply and the ability of the channel to create new side channels.

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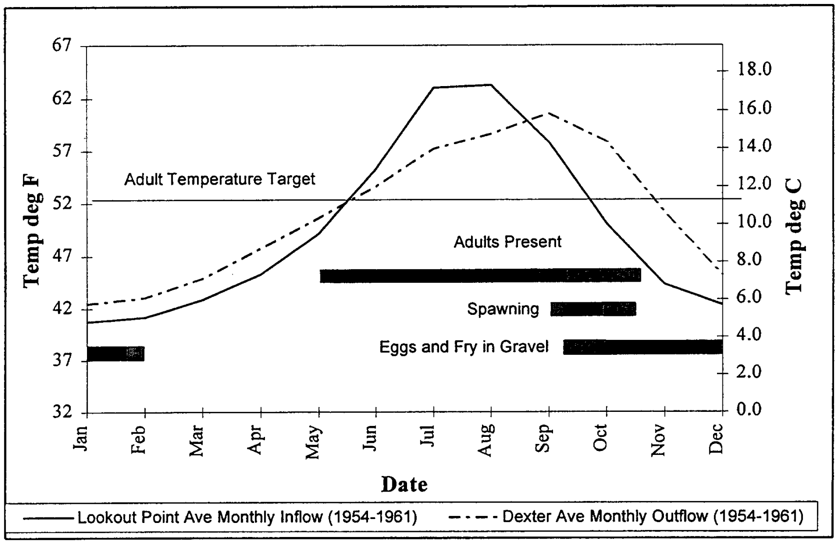

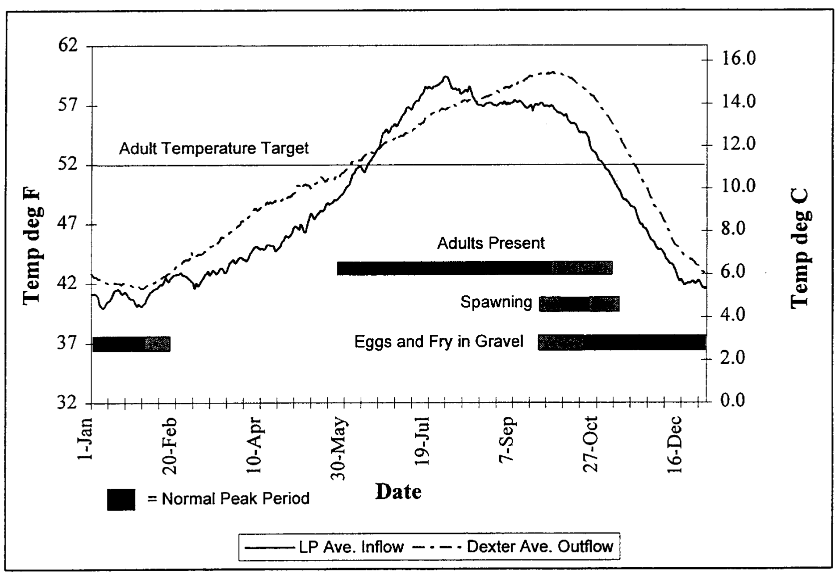

Figure 6-13. Monthly (top) and daily (bottom) average water temperatures in the Middle Fork Willamette River, Oregon, measured above Lookout Point Reservoir and below Dexter Dam, before (top) and after (bottom) construction of Hills Creek Dam (USACE 1997). General chinook salmon life stage periodicities are also indicated.

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Figure 4-4. Effect of Dexter and Lookout Point Dams on stream temperature. Copy of page 63 from Chapter 6 of the US Army Corps of Engineers (2000) biological assessment. The main issue is increased temperatures (greater than 55 F) during egg incubation.

Types of changes that may be expected or have occurred to channels and habitats following dam construction include depletion of fine sediment and channel degradation, loss of habitat and pool complexity, and loss of side channels and bar formation. Figure 4-3 suggests that channels may have stabilized and vegetation has established itself over areas that would have had periodic flooding. Loss of side channels may be more associated with channelization and dike construction that the operation of the dam (See chapter on wetlands). But due to the decreased magnitude and frequency of flooding, dynamic channel changes and periodic side channel scour would be expected to be reduced.

The effects of the dams on fish are readily apparent as to their blocking upstream access to habitat. But the effects on downstream habitat and fish are not easy to quantify or know with certainty. It appears the electroshocking data show trout using the downstream habitat, but still little can be conclusively stated about the effects on the populations. It may best be stated that changes in flow patterns would likely have moderating effects on habitat complexity. That is, with reduction in floods, one would expect reduction in a number of channel maintaining processes such as pool and side channel scour, bar formation, flooding of floodplains, bank cutting, and woody debris recruitment.

The effects of temperature, particularly increased temperature during the fall when spawning and egg incubation occurs is shown in Figure 4-4. The US Army Corps of Engineers (2000) biological assessment presents data (table 6-9 in their document) showing 55 F as the upper optimal temperature for incubation and the upper tolerant temperature of 58 F. Also there have been reported observations (anecdotal but not documented) of poor emergence and development of fungus on developing eggs in the mainstem (Connolly et al, 1992).

4.4 RECOMMENDATIONS

New and more focused questions always arise after a review of existing data and information. A listing of questions whether properly cast or not, can help to focus further discussion, enlist the help of experts, and help to design future information gathering activities. Data are information that can be used to answer questions. General questions are listed first followed by a listing of data gaps.

4.4.1 What are the remaining data gaps?

General questions include:

- How successful is wild spring chinook spawning in the main channel below the dams or in any tributaries below the dam? Can anything be done to improve their success?

- How has the reduction in flood magnitude and frequency affected maintenance of side channel habitat, deep pool maintenance, bar formation and floodplains below the dams? If the effects are significant, can the releases from the dams be altered more toward a historic flood regime in order to improve habitat? Towards this end, the Corps has been attempting to manage dam releases for fish since 1999 and holds weekly discussions with other agencies (G. Taylor, Corps fish biologist, pers. comm.). Have the new releases had positive effects?

- Are the population data currently being collected on fish accurate enough to assess changes and aid decision-making about conditions in habitat?

- Can the dams be managed to improve fish passage? The current consultations between the US Army Corps of Engineers and the US Fish and Wildlife Service and National Marine Fisheries Service per Section 7 of ESA are discussing this question this year. A biological opinion is expected early in 2003. How can the watershed council help on a local effort to effect new management operations based on the biological opinion?

Key data gaps include:

- Trends in populations of native fish, particularly in areas thought to be undergoing change of habitat.

- Channel sediment budget.

- Spawning and emergence success of spring chinook below the dams and in tributaries.

4.4.2 What are the Restoration Opportunities?

Aquatic habitat restoration opportunities include:

- Side channels that are separated from the main channel by dikes or revetments could be reconnected to the river channel.

- Restoration of floodplains and bar formation through “floods” created by pulsed dam releases.

- Steam-side shading or management for conifers or mature hardwoods stands in floodplain areas. Removal of non-native blackberries and other vegetation to encourage native riparian vegetation establishment.

- Engage the Corps of Engineers in their ongoing attempts to better understand the effects of the dams on habitat and fish.

- Seek ways to encourage natural processes of wood recruitment to the channel. This may involve some artificial wood additions, but should only be attempted in areas that would clearly benefit. Such areas may be heads of pools in smaller tributaries such as Lost or Little Fall Creek.

5.0 WETLAND HABITAT CONDITIONS

5.1 INTRODUCTION

This section of the watershed assessment presents information on wetland habitats and restoration opportunities within the Lower Middle Fork of the Willamette Assessment Area. Where possible, this chapter outlines the type, magnitude, and location of wetland habitats.

5.2 METHODS AND KEY QUESTIONS

The assessment of wetlands was based on existing reports, other information, and interviews with resource professionals. Primary sources for wetland information are noted below.

The section is organized by the following key questions:

1. What is the extent of wetlands in the analysis area?

2. What are the trends in wetlands and wetland conditions?

5.2.1 Wetlands Information Sources

The U.S. Fish and Wildlife Service initiated the National Wetlands Inventory (NWI) in 1979. In 1989, the State of Oregon entered into a cost-sharing agreement with the FWS to speed the mapping process. Wetlands and deepwater habitats (streams, lakes, estuaries, etc.) are mapped on a USGS quad map base; most are at a scale of 1:24,000. Only those wetlands and other waters that are visible on high altitude aerial photographs are mapped, and most maps date to the mid-1980s. The maps are reportedly good but some errors are to be expected. For example, smaller wetlands can be missed or wetlands can be obscured by trees. Locations are approximate and no field verifications were typically performed.

The FWS defines wetlands as "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have at least one of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Cities and local agencies perform additional mapping, called the Local Wetlands Inventories. These inventories are performed to aid in planning and landuse decisions. These inventories involve ground surveys. Springfield has performed local wetlands inventories. However, most of the Assessment Area is outside of the urban growth boundary of Springfield and has not been surveyed in the field for wetlands. The wetland data is coordinated by the Oregon Division of State Lands (http://statelands.dsl.state.or.us/wetland_nwi.htm).

5.3 RESULTS

The results of the wetland habitat conditions section was organized to address the critical questions.

5.3.1 What is the Extent of Wetlands?

The wetlands as identified on the National Wetlands Inventory and on at least one local inventory are show in Figure 5-1. These wetlands are summarized in Tables 5-1 and 5-2. Most of the wetlands occur along the Middle Fork of the Willamette River, with the greatest area in the lower portions near Springfield. About 90 % of the wetlands are non-permanent (e.g., having surface water for only a portion of a year). Finally, there are certainly additional wetland sites that have not been identified.

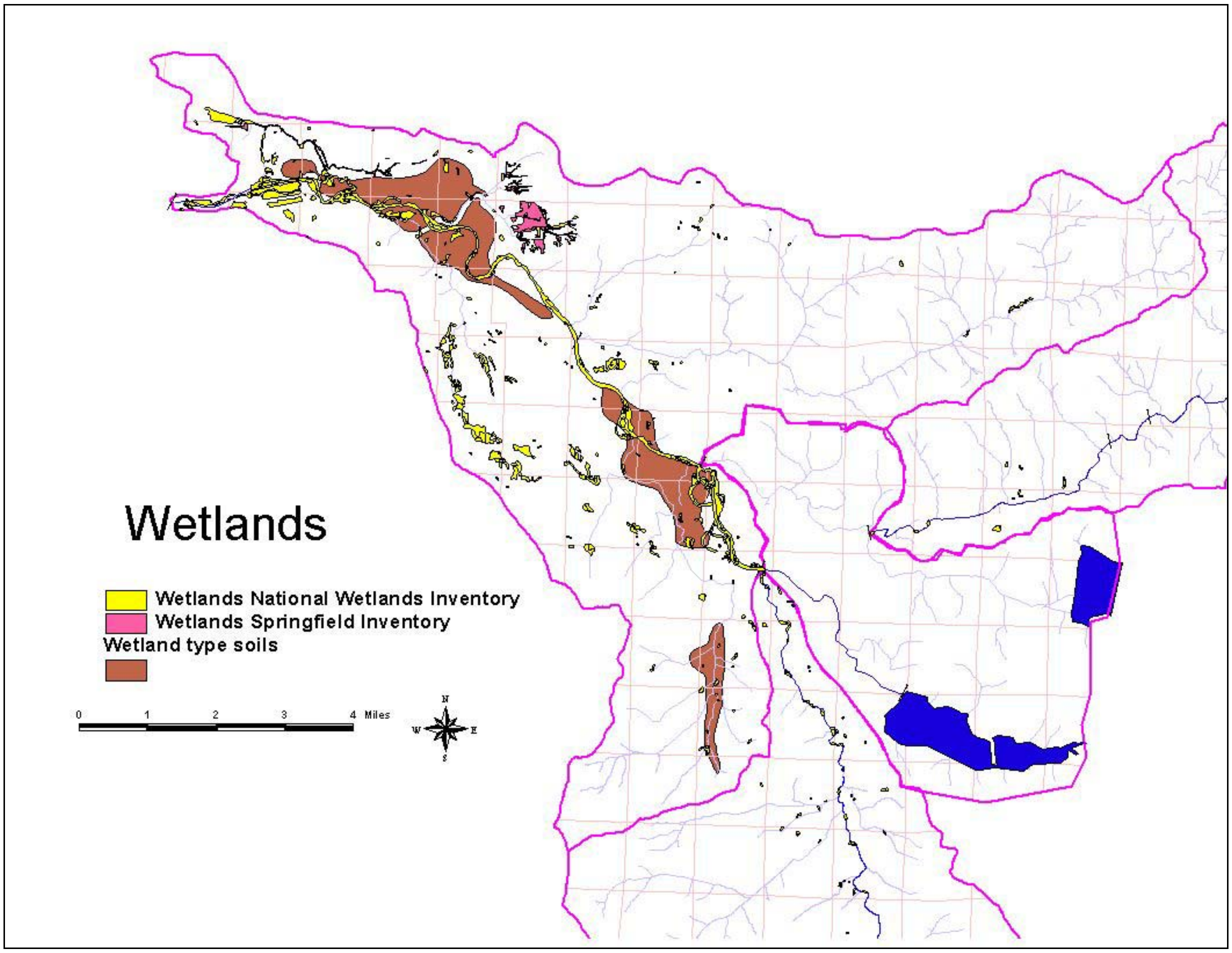


Figure 5-1. Some of the wetlands in the analysis area. The yellow shows the extent of wetlands on the National Wetlands Inventory. The red is additional inventory work performed by the City of Springfield as part of a development project. The brown includes a generalized wetland area derived from the General Land Office survey records reviewed by E. Fredette. It appears to correspond fairly well to wetland type soils (fluvents, hydric soils and other flat loams) and also approximates portions of the 500-year floodplain near Springfield. It is likely that much of these original wetlands have been drained. Wetlands along the Middle Fork Willamette between the confluence of Lost Creek and Dexter Dam are not included here, but see Figures 5-3 and 5-4 below.

Table 5-1. Wetland types and acres in the National Wetlands Inventory.

		Acres by watershed			
Flood regime	**Wetland type**	**Little Fall**	**Lost**	**Lower MFW**	**Total**
permanent	Lacustrine	0	0	80	80
	Palustrine	5	5	106	116
Subtotal		**5**	**5**	**186**	**196**
non-permanent	Palustrine	5	16	260	281
	Palustrine forested/shrub	4	28	414	446
	Riverine	1	8	392	401
Subtotal		**11**	**52**	**1066**	**1128**
Ttotal		**16**	**57**	**1253**	**1325**

Table 5-2. Wetland acres in the Springfield Inventory.

Wetland type	**Acres**
Palustrine emergent	119
Palustrine forest/shrub	24
Riverine	25
Total	**168**

5.3.2 What are the Trends in Wetland Conditions?

Historically with settlement and more recently with agriculture and urbanization, wetlands have declined in extent and in condition. Wetlands are often drained or filled to create more economically useful land or they are often lost by changes in hydrology such as draining fields for agriculture, channelization of rivers, or the regulation of river flow through the construction of dams. The data for wetlands does not allow a specific statement to be made about their loss in the Assessment Area but several lines of evidence suggest that various land use and construction practices have contributed to loss of wetlands.

The dams appear to be a large contributor to the loss of wetlands by reducing the off-channel creation of habitat normally performed by floods. The construction of the dams in the Willamette River Basin has helped to significantly reduce flood flows. A graph of flood flows from the main stems of the Willamette River at Albany is the longest and most complete record for floods in the Willamette Basin (Figure 5-2). Records also exist for the Middle Fork, but show mostly years after 1947. Figure 5-2 shows the decrease in flood flows following the start of dam construction about 1954. The reduction in flood flows is thought to have reduced side channel area as side channels are thought to be created during high floods. With loss of side channels, wetland habitat is also changing or disappearing. Without high flows, the side channels fill in and become separated from the main channel flow. The side channels eventually become standing water or dry up and begin to succeed to more upland marshes or seasonal wetlands.

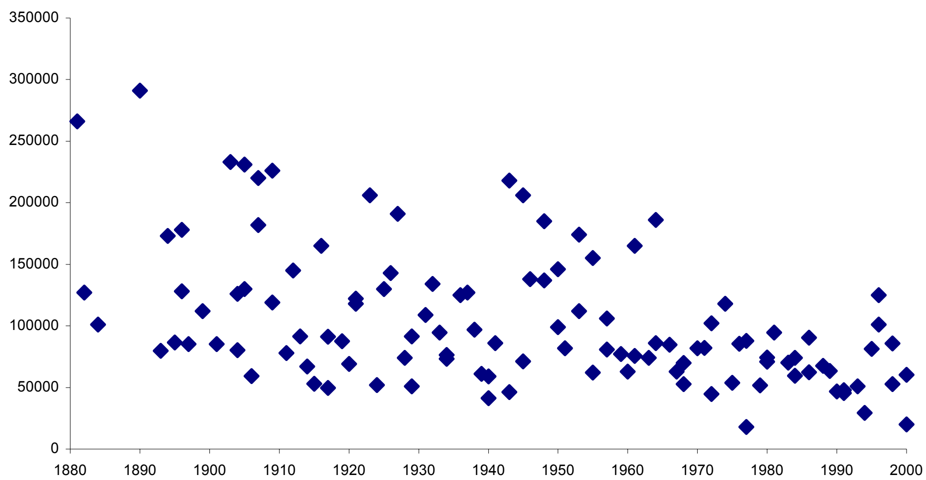


Figure 5-2. Flood flows in cubic feet per second recorded on the Willamette River at Albany, Oregon by year of flow. Flood data also exist for the Middle Fork at Dexter and at Jasper, but these data do not show the complete record prior to 1947. The Jasper and Dexter data are somewhat different compared to the Albany data, but the general patterns are similar. The Jasper and Dexter data show an even greater decline of flood magnitude following the construction of dams in 1954.

A review of aerial photos over time including pre-dam and post-dam periods can be used to view changes in side channel and wetland areas. Two areas in the Middle Fork Willamette are shown in the following two sets of aerial photos. The first set is of the confluence of the Middle Fork and Fall Creek (Figure 5-3). This area is indicated on the National Wetlands Inventories map (Figure 5-1) as having a concentration of wetlands. The second area is just downstream of Dexter Dam (Figure 5-4). This area was not included in the wetlands inventory layer shown in Figure 5-1, but appears to be a side channel complex. This complex is likely the result of the Middle Fork Willamette historically flowing out of the steep and confined reaches of the Cascade Range and entering the flatter, more open valley bottom of the Willamette Valley where the channel had opportunities to shift across the broad valley floor.

Both sets of photos show a complex pattern of channel changes over time. In 1936, the channel is characterized by multiple channels and recent bar formation. By 1944, the channel appears to coalesce into more of a single channel, but large recently formed bars are visible on the inside of meanders. In 1954, there was a wide wetted channel, now the bars have changed shape and show some signs of vegetation. In the period before 1954, there had been frequent flooding of moderate sized floods and several large floods, which provided the mechanism for frequent channel shifts, multiple channels, and deposition of wide gravel bars (See the Hydrology Section). It is difficult to associate specific flood years with specific changes in the photos. For example, 1936 appears to show the effects of recent floods, but the Albany data indicate a period prior to 1936 as one of frequent but relatively low intensity floods. However, it is probably safe to speculate that the flood cycle prior to 1954 was of greater magnitude and frequency and it is associated with dynamic channel changes either as multiple channel formation or as main channel bar formations.

By 1968 dams had been implemented to regulate flow and control floods. Following flow regulation from the dams, one might expect a loss of side channels and bar formations. Interestingly, the photo shows what appears to be a significant increase in side channels and bar formation. This counter-intuitive result may be explained by the flood of 1964. The flood data for Dexter and Jasper gauges on the Middle Fork indicate that 1964 still was a moderate sized flood despite the existence of dams. Though the 1964 flood was smaller in terms of peak flow than floods of the 1940s and 50s, we do not know the extent of flooding that occurred. By 1990, no additional large floods were recorded for the the Middle Fork; this likely contributed to the channel closing in and losing side channels that were formed during the 1964 event.

Figure 5-5 shows wetlands in the area of about the confluence with Fall Creek. Also shown are areas that were reportedly diked or where bank hardening was carried out. Such bank improvements were observed to be contributing to the loss of side channel in other areas of the Middle Fork Willamette downstream below Jasper.

Another contributing source of side channel and wetland loss is the various channel modification activities performed in the basin. These activities include bank hardening, dike construction, dredging, and even splash damming. Ed Fredette assembled information on channel modifications from a review of the Division of State Lands permit records, aerial photographs, and historical records of logging activities (Table 5-3).

Table 5-3. Miles of channel modified for major streams within the Assessment Area.

Watershed	Dredging	Diking	Roads	Rip-rap	Splash dams	Total miles
Middle Fork Willamette (Dexter Dam to Wallace Cr)	0.1	1.6	1.2	1	0	3.9
Little Fall	0.1	0	8.1	0.4	8.5	17.1
Fall Cr below Fall Cr Dam	0.2	0	1.8	0.1	7.2	9.3
Hills	0.2	0	6.5	0.2	0	6.9
Rattlesnake	2.3	0	1.0	0	0	3.3
Lost Creek	0.2	0	5.8	0.2	9.2	15.4
Total miles	**3.1**	**1.6**	**24.4**	**1.9**	**24.9**	**55.9**

Figure 5-3. Aerial photos of the confluence of Middle Fork Willamette River and Fall Creek over time. Middle Fork Willamette flows from the bottom of each photo towards the top and then left. Fall Creek enters from the top right. Dexter and Lookout Point Dams were constructed in 1954.

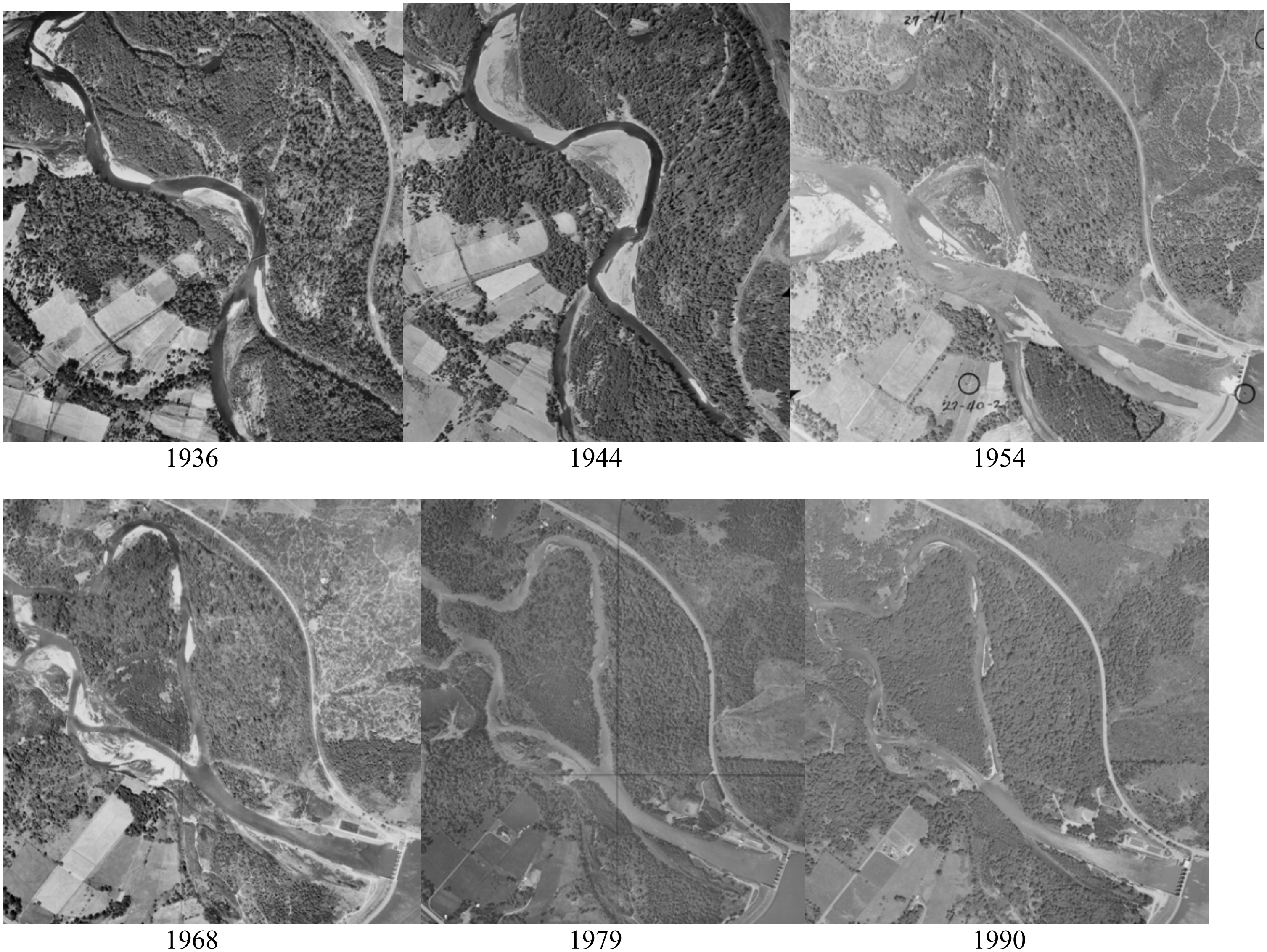


Figure 5-4. Aerial photos over time taken just downstream of the present location of the Dexter Dam.

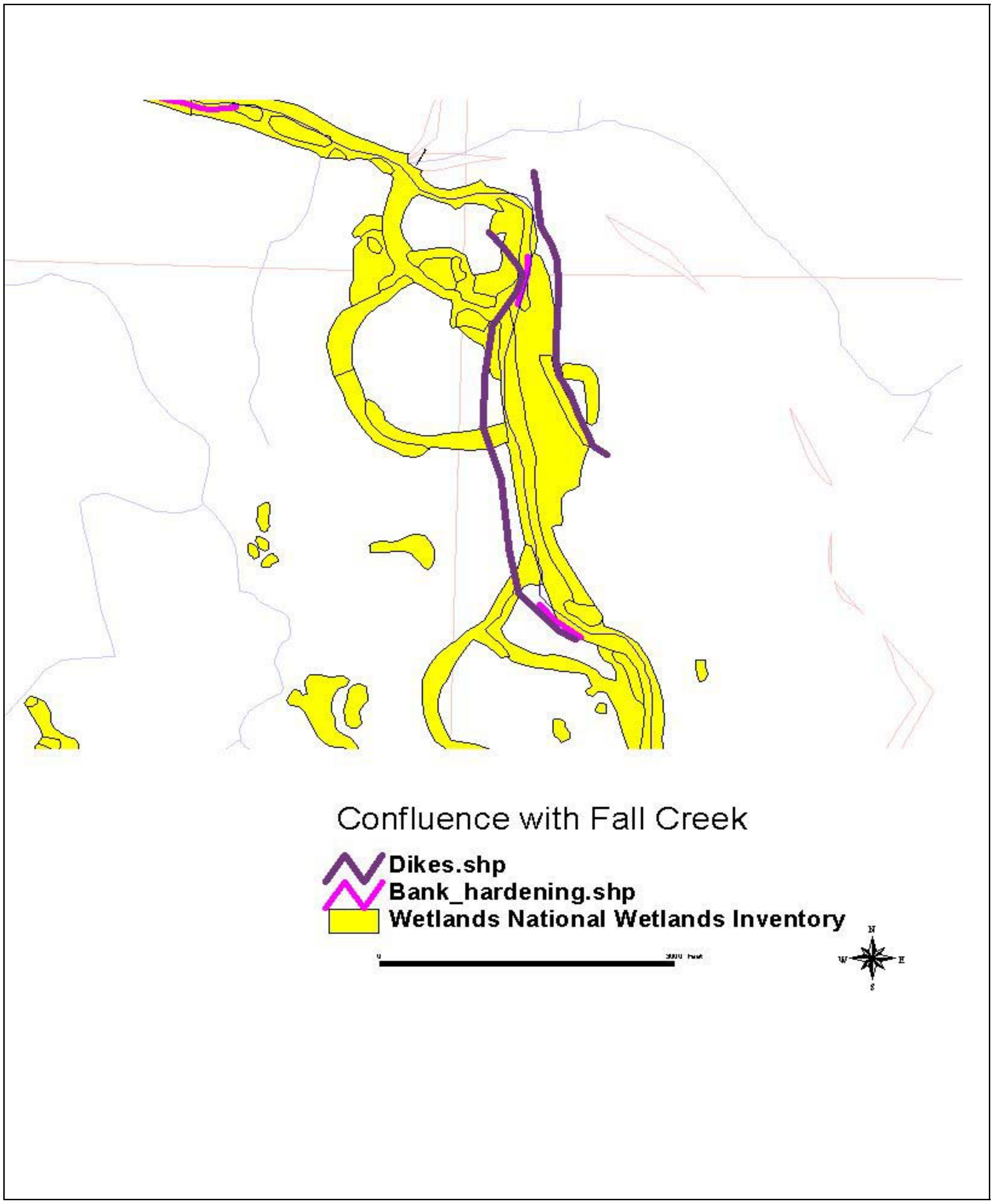


Figure 5-5. The area around the confluence of Fall Creek and the Middle Fork of the Willamette River showing detail of wetlands and bank improvements that may contribute to side channel and wetland loss. The bank hardening and dike construction are approximate locations and are based on survey of Division of State Lands records by E. Fredette. The dates of construction or current conditions are unknown. But this document's analysts visited a similar structure downstream and that structure appeared to be contributing to side channel loss.

In addition to the dams, other threats to wetlands include invasion by non-native plants and active development (filling and draining) particularly on private lands. The Oregon Natural Heritage Program performed an inventory of wetlands in the Willamette Valley in 1996 (http://www.sscgis.state.or.us/data/themes.html). Noteworthy conclusions from the report include:

"Throughout the Willamette Valley, riparian zones and wetlands are actively being developed. This was observed numerous times during the course of this project. Section 404 (wetland fill permit) violations appear to be commonplace. Privately owned wetlands and riparian areas throughout the Valley deserve increased protection from degradation and development….

"…Public lands in the Willamette Valley need to be protected from degradation. Restoration activities could be attempted at non-native dominated areas on public lands, although protecting native habitat should clearly take precedence over restoration. Small emergent wetland sites are scattered throughout the Willamette Valley, both in and between the priority wetlands. These sites should be a focus of protection along with the forested riparian zones. Hydrological threats to these areas also need to be addressed. Large native emergent wetlands were not found outside of public lands."

The City of Springfield has extended their urban growth boundary to include an area north of the community of Jasper. The city has plans for development of residential housing and light industry and has improved roads part way to the area (J. Reed, watershed resident, pers. comm.). During the planning process the additional wetlands shown as red in Figure 5-1 were identified as wet meadows. If the current development plans are followed, the wetlands will probably be lost; the city is planning to address this loss via mitigation. The city is seeking a mitigation site where existing wetlands would be enhanced or new wetlands constructed.

5.4 RECOMMENDATIONS

5.4.1 Restoration opportunities for wetlands

There are a number of wetland restoration opportunities within the Assessment Area.

Wetland restoration opportunities include:

- A number of areas have undergone bank hardening or dike construction and have likely contributed to side channel deterioration and wetland loss. These sites could be reviewed for potential removal or modification to enhance side channel formation and wetland enhancement. The dikes shown in figure 5-5 may be one example for work. There appear to be other areas of rip-rap in the lower portion of the Middle Fork that were visible during visits made to the watershed by the analysts of this document. In a number of instances, the 2001 surveys of Lost and Little Fall Creeks noted bank stabilization that may have been interrupting side channel formation there.

- There is a high density of wetland habitat identified on the National Wetland Inventory that occurs along the lower section of the Middle Fork near the confluence with the Coast Fork. This area has been modified by bank stabilization, diversions, and gravel mining and offers opportunities for restoration and enhancement.

6.0 WATER QUALITY

6.1 INTRODUCTION

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.

This section presents the results of the water quality assessment. The purpose of the water quality section is to summarize the results of a "screening-level" evaluation of existing information to determine what is known about water quality patterns in the Lower Middle Fork, Little Fall Creek, and Lost Creek watersheds. Key data gaps that may require further study are identified, and the section concludes with recommendations on future monitoring and steps that can be taken to improve water quality conditions.

6.2 METHODS AND KEY QUESTIONS

This initial assessment of water quality utilizes simplified methods to screen for potential problems and flag obvious areas of impairment. There are numerous factors that can be considered when evaluating water quality. At the screening level, this water quality assessment is focused on a selected set of factors that are frequently of concern in Oregon watersheds. These factors are: temperature, dissolved oxygen, pH, nutrients, bacteria, turbidity, organic and metal contaminants. Water quality, in terms of these factors, is determined by comparing key indicators to certain criteria derived from the Oregon Water Quality Standards. The criteria are listed in section 6.4.2. Discussion of other water quality related factors such as sediment, hydrology, and habitat modification is presented in other chapters of this report.

Ongoing monitoring by the Lost Creek Watershed Group, the BLM, and the DEQ was the primary source of water quality data. The Middle Fork Willamette Watershed Council also collected extensive supplemental temperature data during the summer of 2001 specifically for this assessment. These data are mainly from the Little Fall Creek and Lower Middle Fork watersheds. Additional data, provided by the Springfield Utility Board, are presented and discussed in section 6.4.4.2.1.1 of this chapter. The Oregon Department of Environmental Quality (DEQ) was the source of information on the importance of surface waters (beneficial uses) and the streams that are currently listed by the agency as "water quality limited".

A number of critical questions guide the assessment process. Results of the water quality assessment are presented in terms of each critical question in the sections that follow.

1. What are the designated beneficial uses for streams in the watershed?

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

3. Are there stream reaches that are identified as water quality limited on the State's 303(d) list? Are there stream reaches that are identified by the state as high quality waters or Outstanding Resource Waters?

4. What do water quality studies or other data indicate about water quality?

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

6.3 RESULTS

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

6.3.1 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 describe their application.

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 6-1 lists the beneficial uses designated for the Middle Fork Willamette River Basin, including the Lower Middle Fork, Lost Creek, and Little Fall Creek watersheds.

Table 6-1. Beneficial uses of water in the Middle Fork Willamette River Basin.

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

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

The DEQ designates water quality factors (physical, chemical, and biological) that are necessary to support the beneficial uses. Table 6-2 provides a partial list of the beneficial water uses in the Middle Fork Willamette River Basin and the factors of concern that are evaluated to determine whether water quality supports each use. Due to the focus of this assessment on the aquatic system, this water quality summary focuses on the beneficial uses related to anadromous and resident trout populations and habitat. These uses, along with salmonid spawning and rearing are often the most sensitive to degradation of water quality and can generally serve as surrogate measures for other uses. Exceptions to this generality are the separate bacteria and nutrient criteria applied to the beneficial use of water contact recreation and a stricter turbidity standard for drinking water (see the drinking water section of this chapter).

Table 6-2. A partial list of beneficial uses of waters and the water quality factors of concern (ODEQ, 2002).

Beneficial use	Factors of concern	
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 contact recreation	Algae Aquatic weeds Bacteria (fecal coliform)	Nutrients pH
Water Supply	Toxics Bacteria	Turbidity

6.3.2 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, 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 state water quality standards have regulatory implications, whereas the screening level criteria, where different, do not.

Table 6-3. Summary of water quality criteria applicable to anadromous and resident trout issues in the Lower Middle Fork Willamette, Lost Creek, and Little Fall Creek watersheds.

Water Quality Parameter	Beneficial Uses Affected	State Water Quality Criteria* (Numeric or Narrative)	Screening Level Evaluation Criteria	Issue of Concern for Lower Middle Fork Willamette River and Tributaries?
Bacteria – Fecal Coliform	Water contact recreation Water supply	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	126 E. coli/100ml (30-day log mean with a minimum of 5 samples or no single sample over 406 E. coli/100ml.	Springfield municipal water supply
Biological criteria	Resident fish and aquatic life	Waters shall be of sufficient quality to support aquatic species without detrimental changes in resident biological communities	None specified	None documented, no data

Water Quality Parameter	Beneficial Uses Affected	State Water Quality Criteria* (Numeric or Narrative)	Screening Level Evaluation Criteria	Issue of Concern for Lower Middle Fork Willamette River and Tributaries?
Dissolved oxygen	Resident fish and aquatic life Salmonid spawning and rearing	Cold water aquatic resource: 8.0 mg/L and 11.0 mg/L during spawing	Minimum of 8.0 mg/L	
Habitat modification	Resident fish and aquatic life Salmonid spawning and rearing	Creation of conditions that are deleterious to fish or other aquatic life are not allowed	None specified	See Fish and Habitat Chapter Little Fall Creek listed as "need data" by DEQ
Flow modification	Resident fish and aquatic life Salmonid spawning and rearing	Creation of conditions that cause detrimental changes in the resident biological community is not allowed.	None specified	Permitted withdrawals may exceed natural streamflow during summer. See Hydrology Chapter
pH	Resident fish and aquatic life Water contact recreation	6.5 to 8.5	6.5 to 8.5	
Sedimentation	Resident fish and aquatic life Salmonid spawning and rearing	Formation of bottom or sludge deposits deleterious to fish, aquatic life, public health, recreation, or industry are not allowed.	None specified	See Fish and Habitat Chapter Little Fall and Lost Creeks listed as "need data" by DEQ
Temperature	Resident fish and aquatic life Salmonid spawning and rearing	The 7-day moving average of the daily maximum water temperature shall not exceed the following values: - Salmonid fish rearing: 64 ° F. - Salmonid spawning, egg incubation, spawning, and fry emergence: 55 ° F.	7 day moving average of daily maximum shall not exceed 64 ° F	MFW from mouth to Dexter dam listed as water quality limited. Little Fall and Lost Creeks listed as "need data" by DEQ
Total dissolved gas	*Resident fish and aquatic life	*Concentration of total dissolved gas not to exceed 110% of saturation *liberation of dissolved gas not to cause objectionable odors or be deleterious to uses of such waters	None specified	
Toxics	Resident fish and aquatic life Water supply	Very detailed criteria subject to ongoing revision	Above detection limits or above specific levels for 7 metals	See appendix for criteria, concern for drinking water
Turbidity	Resident fish and aquatic life Water supply Aesthetics	No more than 10% increase over background	50 NTU above background	

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. NTU=nephelometric turbidity unit.

6.3.3 Are there Stream Reaches that are Identified as Water Quality Limited on the State's 303(d) list? Are there Stream Reaches that are Identified by the State as High Quality waters or Outstanding Resource Waters?

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 is appropriate. 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. The next section describes the water quality limited stream segments for the Lower Middle Fork Willamette, Lost Creek and Little Fall Creek watersheds.

Table 6-4 outlines the 303(d) listed streams and parameters for the Lower Middle Fork Willamette, Lost Creek and Little Fall Creek watersheds. 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 where monitoring was completed; the listings are not based on a systematic and comprehensive assessment of the water quality status of the entire three watersheds. Oregon DEQ recently updated the 303(d) list, but finished before the data contained in this report could be submitted.

Table 6-4. Summary of 303d listing status for major stream segments in the Assessment Area Oregon DEQ (2002).

Water Quality Parameter	Middle Fork Willamette River mouth to Dexter Lake	Little Fall Creek mouth to headwaters	Lost Creek mouth to headwaters
Bacteria	Meets standard		
Biological criteria			
Dissolved oxygen	Meets standard		
Habitat modification		Need data	
Flow modification	Need data		
pH	Meets standard		
Sedimentation	Need data	Need data	Need data
Temperature	Listed as water quality limited	Need data	Need data
Total dissolved gas			
Toxics			
Turbidity			

While there are no stream reaches in the Assessment Area specifically identified by the state as high quality or Outstanding Resource waters, the overall water quality of the Middle Fork Willamette River watershed is recognized as being some of the highest quality water of the entire Willamette River Basin. The Jasper Bridge water quality monitoring site (maintained by the DEQ) on the Middle Fork Willamette River scored 93 out of a possible 100 points and showed an increasing trend in the score over the past 10 years. The site is ranked in the "excellent" category compared to other sites across the state (2000 Oregon Water Quality Assessment Section 305b Report).

6.3.4 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. As a consequence, large amounts of high quality information are required to make conclusive statements about the status of water quality in a landscape as diverse as this Assessment Area. With the exception of temperature data, there is limited water quality information for the Assessment Area.

The following sections focus on the listed parameters to summarize what existing data indicate about the status of water quality in the Lower Middle Fork Willamette, Lost Creek, and Little Fall Creek watersheds. Tables 6-5 through 6-7 list the location and types of monitoring from each watershed that provided the source data for this assessment. Figure 6-1 shows the location of all monitoring sites which were sources of data for this assessment. Site numbers on the map correspond to site numbers listed in the data tables below.

Figure 6-1. Water quality monitoring sites in the Assessment Area.

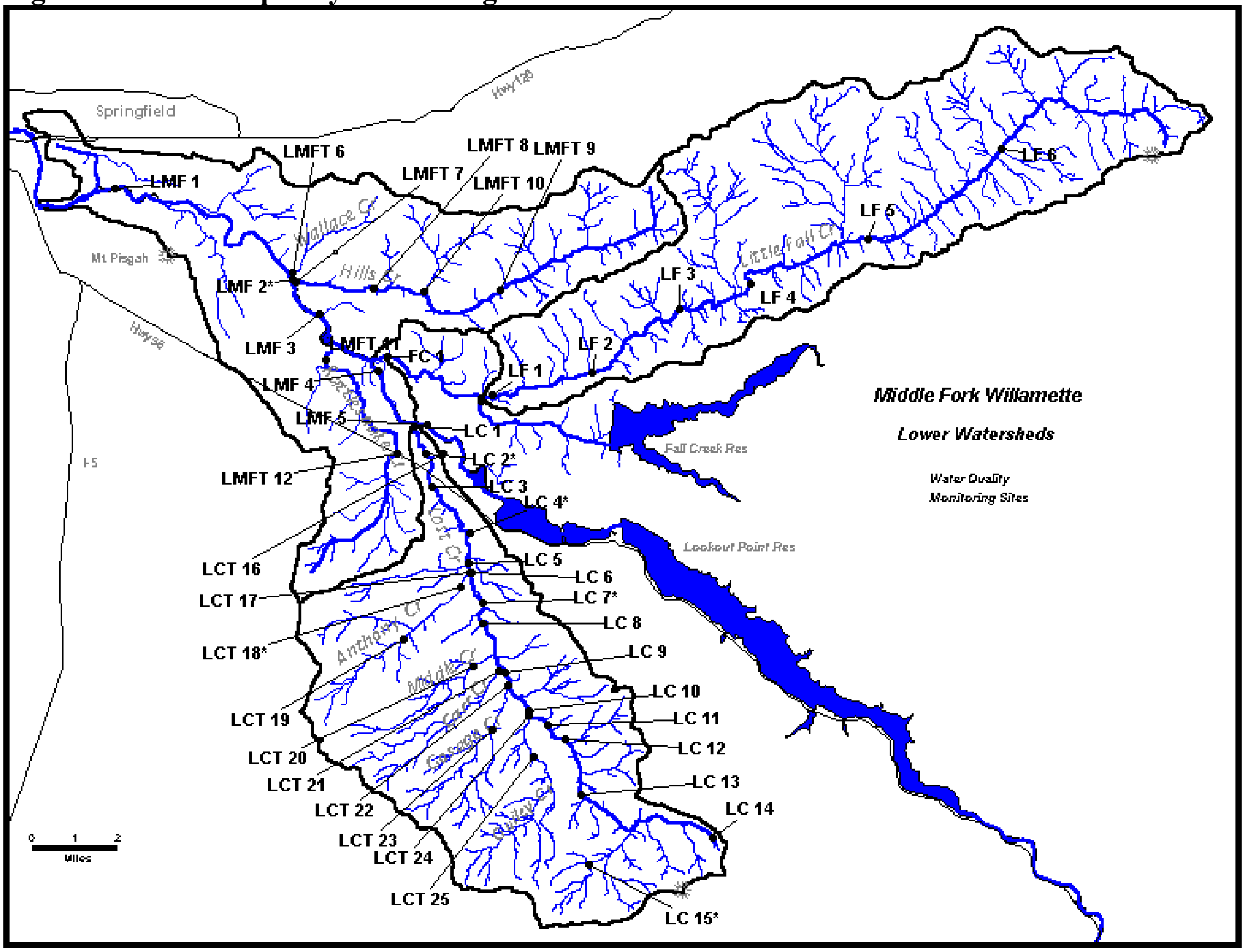


Table 6-5. Water quality monitoring sites in the Assessment Area watershed.

Site #	Site Location	River Mile from mainstem mouth	Parameters	Data Years	Agency	Criteria Exceedance
	Mainstem sites in upstream order					
LMF1	MFW near millrace inlet, approx rm 2.0	1.89	temp, turb, bact, ph, DO, cond,	2000	SUB	DO, pH,
LMF2	MFW at Jasper Bridge	7.85	monthly ambient many parameters	many	DEQ	temp
LMF3	MFW at Jasper Park elev. 535'	9.01	continuous summer temperature	2001	MFWWC	temp
LMF4	MFW above Fall Cr. Elev 560'	11.15	continuous summer temperature	2001	MFWWC	temp
LMF5	MFW above Lost Cr. Near boat ramp elev. 595'	13.15	continuous summer temperature	2001	MFWWC	temp
	Tributary sites in upstream order					
LMFT6	Wallace Cr. Mouth elev. 535'	7.73	continuous summer temperature	2001	MFWWC	no
LMFT7	Hills Cr. At Jasper road bridge elev. 540'	7.98	continuous summer temperature	2001	MFWWC	temp
LMFT8	Hills Cr. At river mile 2 bridge elev 680'		continuous summer temperature	2001	MFWWC	temp

Site #	Site Location	River Mile from mainstem mouth	Parameters	Data Years	Agency	Criteria Exceedance
LMFT9	Hills Cr at 3rd bridge BLM boundary elev 1030'		continuous summer temperature	2000, 2001	BLM	temp
LMFT10	Cedar Creek, trib to Hills Cr, mouth elev 765'		continuous summer temperature	2001	MFWWC	temp
LMFT11	Rattlesnake Creek at 1st bridge above mouth elev 550'	9.77	continuous summer temperature	2001	MFWWC	temp
LMFT12	Rattlesnake Creek at Hwy 58		continuous summer temperature	2001	MFWWC	temp
FC1	Fall Creek mouth elev. 570'	11.1	continuous summer temperature	2001	MFWWC	temp
FC2	Fall Creek above Little Fall elev. 610'	11.2	continuous summer temperature	2001	MFWWC	temp

MFWWC = Middle Fork Willamette Watershed Council; MFW = Middle Fork Willamette River

Data were obtained for this assessment from twelve monitoring sites in the Asessment Area. Two additional sites on Fall Creek were also monitored even though they are technically outside the Assessment Area boundary.

Table 6-6 . Water quality monitoring sites in the Lost Creek watershed.

Site #	Site Location	River Mile from mainstem mouth	Parameters	Data Years	Agency	Criteria Exceedance
	Mainstem sites in upstream order					
LC1	Lost Creek mouth, elevation 590'	12.88	continuous summer temperature	1998-2001	Lost Cr. group and MFWWC	temp
LC2	Lost Cr. At Elijah Bristow S.P. bridge	0.79	temp (grab), pH, DO, turb.	1999 - 2001	Lost Creek group	
LC3	Lost Cr. At 38404 Dexter Rd. El. 625'	1.75	continuous temp, pH, DO, turb.	1999-2000	Lost Creek group	temp
LC4	Lost Cr. At Barbre/Rogers road corner	3.35	temp (grab), pH, DO, turb.	1999 - 2001	Lost Creek group	
LC5	Lost Cr. Below Wagner Cr. Elev. 700'	4.16	continuous summer temperature	1999 - 2000	Lost Creek group	temp
LC6	Lost Cr. Above Anthony Cr. Elev. 720'	4.4	continuous summer temperature	2001	MFWWC	temp
LC7	Lost Cr. At 81894 LC rd.	5.2	temp (grab), pH, DO, turb.	1999 - 2001	Lost Creek group	
LC8	Lost Cr. At Lost Creek road bridge, elev. 750'	5.78	continuous summer temperature	1999-2000	Lost Creek group	temp
LC9	Lost Cr. At 80933 LC rd, above Carr Cr. Elev. 820'	7.31	continuous temp, pH, DO, turb.	2000-2001	Lost Creek group	temp
LC10	Lost Cr. At 80655 LC rd, below Guiley Cr. Elev. 860'	8.42	continuous temp, pH, DO, turb.	1999-2001	Lost Creek group	temp
LC11	Lost Cr. Above Guiley Cr. Elev. 935'	9.09	continuous summer temperature	2000-2001	Lost Creek group	none
LC12	Lost Cr. Below Eagle Cr. At quarry elev. 1000'	9.7	continuous summer temperature	1998-2001	BLM	temp '98 only
LC13	Lost Cr. At SE bend in road at rock outcrop elev. 1220'	11.1	continuous temp, pH, DO, turb.	1999-2001	Lost Creek group	none
LC14	Lost Cr. Headwaters road xing NE 1/4 sec. 29 elev 2770'	14.77	continuous summer temperature	1999	Lost Creek group	none
LC15	Lost Cr. Headwaters road xing SE 1/4 sec. 26 easternmost stream in hairpin turn	12.57	temp (grab), pH, DO, turb.	1999-2001	Lost Creek group	none
	Lost Cr. tributary and other sites in upstream order					
LCT16	Elijah Bristow State Park Pond elev. 610'	1.04	continuous summer	1999,	Lost Creek	warm -

Site #	Site Location	River Mile from mainstem mouth	Parameters	Data Years	Agency	Criteria Exceedance
			temperature	2000	group	chubpond
LCT17	Anthony Creek mouth elevation 715'	4.38	continuous summer temperature	2001	MFWWC	temp
LCT18	Anthony Cr. Near bridge at rm. 0.4 Lost Valley Ed. Center		temp (grab), pH, DO, turb.	1999-2001	Lost Creek group	
LCT19	Anthony Cr. Approx. rm.2.5 at BLM boundary sec 31 elev 1020'		continuous summer temperature	1998-2001	BLM	temp
LCT20	Middle Cr. At bridge rm.0.5	6.71	continuous summer temperature	1998-2001	BLM	temp '98 only
LCT21	Carr Cr. At Lost Creek road bridge elev. 800'	7.01	continuous summer temperature	2001	MFWWC	none
LCT22	Gosage Cr. At Lost Creek road bridge elev. 820'	7.68	continuous summer temperature	2001	MFWWC	temp
LCT23	Gosage Cr. At east/west fork confluence rm 1.2 elev. 1020'		continuous summer temperature	1998-2001	BLM	none
LCT24	Guiley Cr. Mouth elevation 900'	8.56	continuous summer temperature	2001	MFWWC	none
LCT25	Guiley Cr. Rm 1.0 sec. 15 BLM boundary		continuous summer temperature	1998-2001	BLM	none

Data for the assessment was obtained from a total of 25 sites in the Lost Creek watershed.

Table 6-7. Water quality monitoring sites in the Little Fall Creek watershed.

Site #	Site Location	River Mile From mainstem mouth	Parameters	Data Years	Agency Source	Criteria Exceedance
	Mainstem sites in upstream order					
LF1	Little Fall Creek mouth elev. 623'	0.2	continuous summer temperature	2001	MFWWC	temp
LF2	Little Fall Creek rm 3 elev. 700'	3.1	continuous summer temperature	2001	MFWWC	temp
LF3	Little Fall Creek rm 5.5 past 1st br. Elev. 850'	6.1	continuous summer temperature	2000, 2001	BLM	temp
LF4	Little Fall creek rm 8.2 above Norton Cr. Elev 950'	8.3	continuous summer temperature	2001	BLM	temp
LF5	Little Fall Cr. At Fish Ladder elev. 1200'	12.2	continuous summer temperature	2001	MFWWC	none
LF6	Little Fall Cr. At upper FS boundary elev. 1480'	16.56	continuous summer temperature	2001	MFWWC	none

Six sites were monitored on Little Fall Creek.

6.3.4.1 Water Temperature

Because of the ongoing and extensive data collection effort, most of the water quality discussion focuses on analyzing patterns of water temperature. Only data from continuous water temperature monitoring sensors are utilized for this analysis. The monitoring data demonstrate that the main streams of each watershed have summer water temperatures exceeding 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 Chinook, steelhead, and resident trout are rearing in the watersheds, which corresponds to the DEQ standard of 64 ° F. for the 7-day moving average of the daily maximum water temperatures.

6.3.4.1.1 Water Temperature Data Analysis – Lower Middle Fork Willamette Watershed

Figure 6-1 illustrates the locations of continuous water temperature monitoring sites in the Lower Middle Fork Willamette watershed. The data collected at these sites was used to determine whether the water temperature of the associated stream segment exceeded the standard. Data from these sites are presented and discussed in this section of the report. Although technically outside the watershed boundary, data from the mouth of Fall Creek and Lost Creek are analyzed here in the context of the effects on temperature patterns in the mainstem Middle Fork Willamette River.

The monitoring data indicate that the mainstem Middle Fork Willamette River exceeds the standard for summer water temperature from the mouth to Dexter Lake. This confirms the listing of that stream segment as water quality limited on the 303(d) list. In addition, new data collected last summer indicate the lower 2 miles of Hills Creek also exceeds the standard as well as the lower segment of Cedar Creek, a major tributary to Hills Creek. Stream temperatures which were very close to the limit also were recorded in the lower 4 miles of Rattlesnake Creek. This segment of Rattlesnake Creek may exceed the standard in some years.

Data from 3 monitoring sites in the mainstem Middle Fork Willamette River and the mouths of the two major tributaries are presented in the figure 6-2 and discussed in the text below.

Figure 6-2. Summer water temperature patterns in the Middle Fork Willamette River and major tributaries (horizontal line depicts State standard).

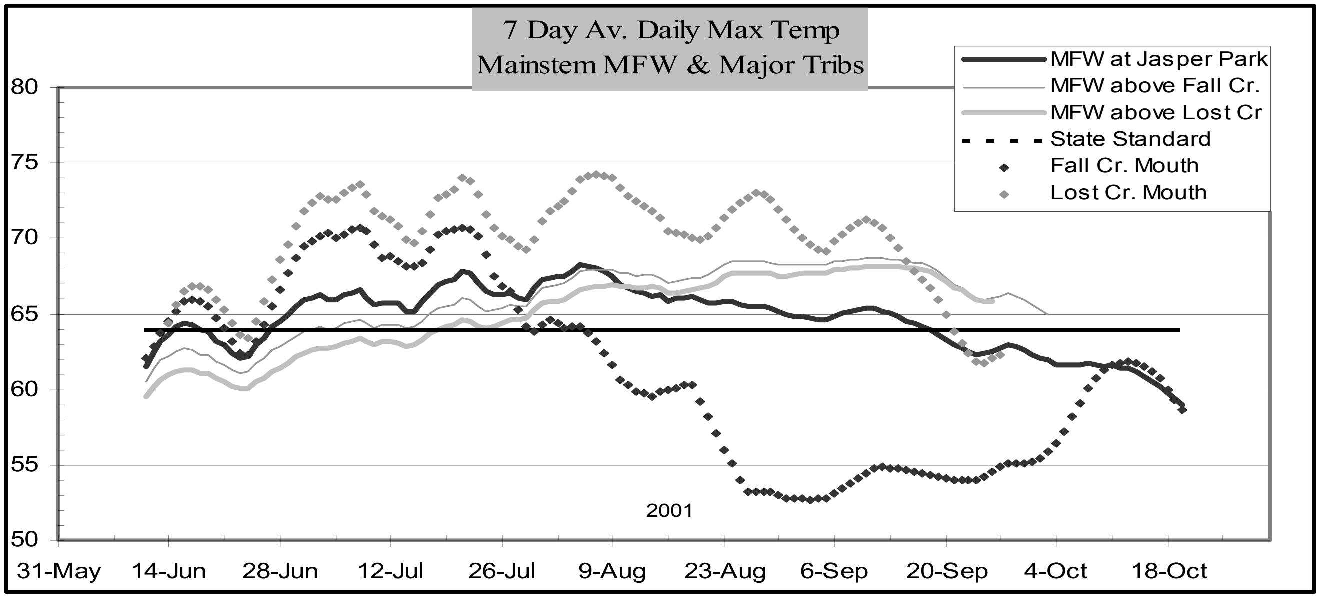


Figure 6-2 indicates that, by the last week of June 2001, water temperature in the Middle Fork Willamette at Jasper had exceeded State standards. Exceedance at the next site upstream, above Fall Creek, occurred approximately one week later. The site above Lost Creek did not exceed the standard until around mid-July. Through June and July, all sites show the same pattern of fluctuation, though with a greater magnitude of fluctuation in the tributaries compared to the mainstem of the river. This reflects the broad control that air temperatures exert on water temperatures.

Figure 6-2 also illustrates an unusual situation in the Lower Middle Fork Willamette watershed. Water temperature at the mouth of Fall Creek is strongly influenced by the timing of the drawdown of Fall Creek Reservoir. In summer 2001, the drawdown began during the first week of August (per. comm. with Fall Creek dam operator). During this period, the temperature at Fall Creek mouth began to decline steadily, while temperatures at other locations were rising. By mid-August, the colder water of Fall Creek had reduced temperature in the Middle Fork Willamette downstream of the Fall Creek confluence enough to reverse the normal pattern of temperature increases in the downstream direction. This input of cold water in the middle of summer also caused temperature in the Middle Fork Willamette at Jasper to meet the standard again earlier in the season than at upstream sites.

In addition to the releases from Fall Creek Reservoir, water temperature in the mainstem Middle Fork Willamette is influenced by releases from Dexter Reservoir. This influence is detected in the data after approximately September 1. After that date, water temperature in Lost Creek, which had been 6 to 10 degrees warmer than the Middle Fork Willamette earlier in the summer, begins a steady decline driven by falling average air temperature and reduced solar exposure. Temperature in the Middle Fork Willamette remains elevated for another 3 weeks and still had not met the standard by October 1.

A final anomaly to note is the steep rise in the water temperature of Fall Creek after October 1. This is due to the top layer of warm reservoir water finally discharging through the dam outlet two months after the drawdown began. By mid-October, the drawdown apparently was complete, and a more typical stream temperature regime had returned.

Figure 6-3 below shows data from Hills Creek, another tributary which enters the mainstem MFW just below the lowest monitoring site at Jasper Park.

Figure 6-3. Summer water temperature patterns in Hills Creek subwatershed. Horizontal dashed line depicts the State water quality standard.

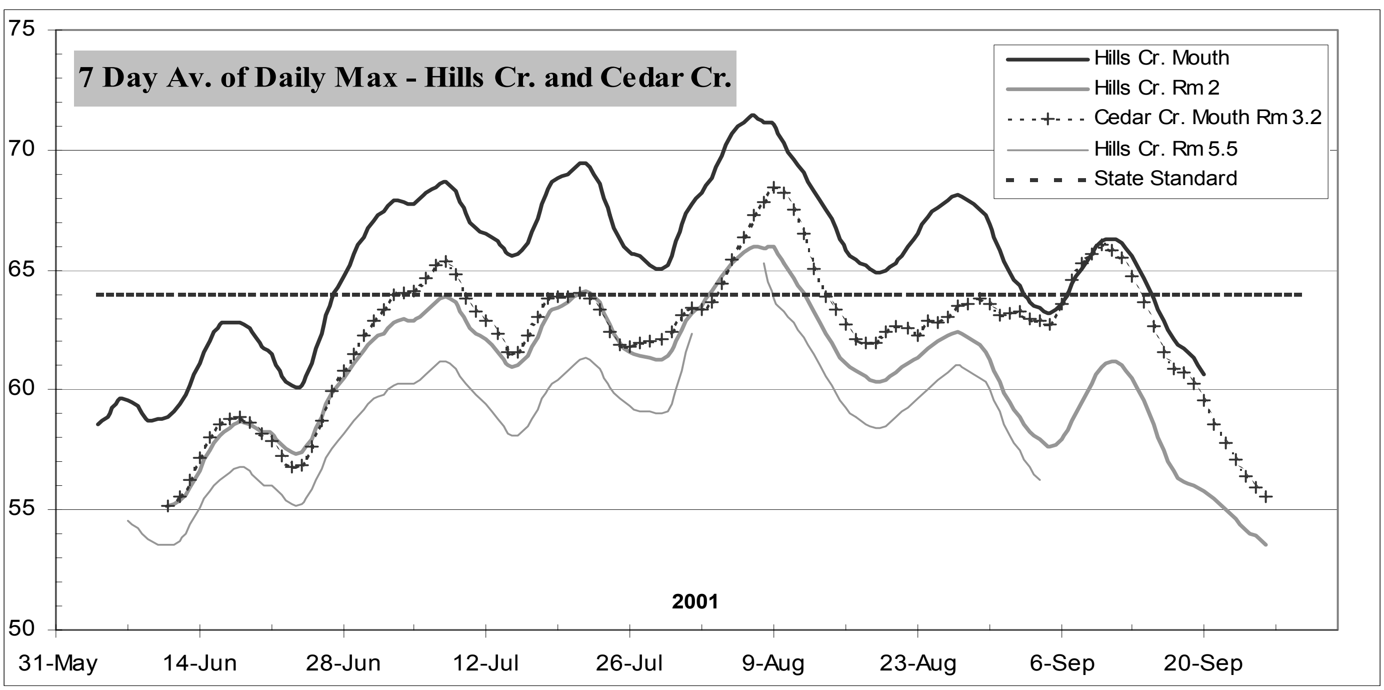
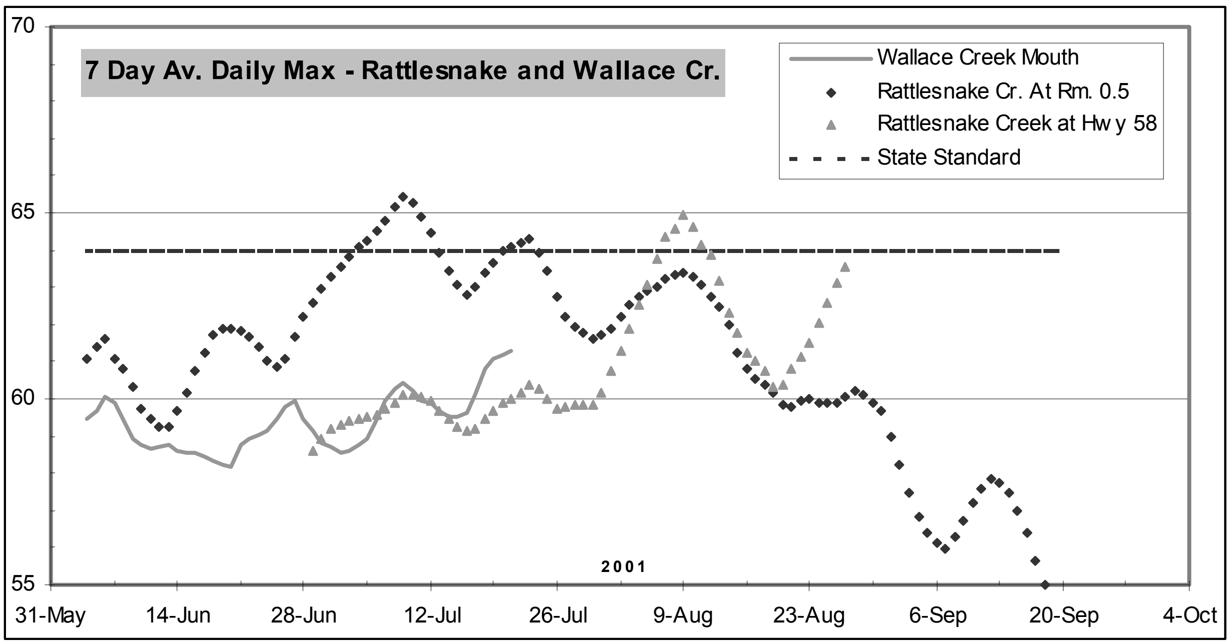


Figure 6-3 indicates Hills Creek at the mouth exceeds the water temperature standard all summer, from late June through mid-September. Only 2 miles upstream however, the water temperature exceeded the standard for just 10 days during the hottest period of the summer. At mile 5.5, water temperature may have exceeded the standard briefly, but there is the possibility that the sensor at this site was not fully immersed in the water at this time, thus the gap in the recorded data. Cedar Creek enters Hills Creek at mile 3.2. Throughout the summer, temperature in Cedar Creek is typically warmer than the next site downstream in Hills Creek at river mile 2. Thus, Cedar Creek is contributing to the cumulative effect of high temperatures at the mouth of Hills Creek.

Figure 6-4 displays water temperature data for the 2 remaining tributaries in the Lower Middle Fork Willamette watershed, Wallace Creek which enters the river at Jasper Bridge, and Rattlesnake Creek which joins the river 2 miles further upstream.

Figure 6-4. Summer water temperature patterns in Wallace and Rattlesnake Creeks. Horizontal dashed line depicts the State water quality standard.



The two sites on Rattlesnake Creek, approximately 3 miles apart, are asynchronous in the timing of their seasonal peak temperature. The lower site apparently peaked in early July, the only site in the Assessment Area to exhibit this timing. The upstream site peaked during the first week of August, which is consistent will all other sites monitored in the Assessment Area. At both sites, the temperature barely exceeded the State standard for a brief period.

The reasons for the unusual temperature pattern at the lower Rattlesnake Creek site are not clear. Perhaps there is a greater proportion of groundwater to surface water inflows to this reach of the stream in late summer compared to the upstream site. This would help explain the cooler temperatures of August and September, but does not account for the much warmer temperatures at the lower site during July. There is another unusual aspect of the temperature pattern at the upstream site as well. At most other sites in the Assessment Area (excluding those affected by reservoir releases), the earlier seasonal peaks, in the second and third weeks of July, had a maximum value within 2 or 3 degrees of the peak which occurred during the first week of August. However, at this site, those earlier peaks were about 6 degrees cooler.

The period of record for Wallace Creek is relatively short. The lower mile of this tributary typically dries up in the summer. At the time the sensor unit was retrieved in mid-July the flow was already beginning to alternate between surface and subsurface.

6.3.4.1.2 Water Temperature Data Analysis – Lost Creek Watershed

Temperature data are relatively abundant in the Lost Creek watershed. Figure 6-1 illustrates the location of continuous temperature monitoring sites in the Lost Creek watershed.

Table 6-8 below displays a summary of temperature data over the period of record for eight sites on the mainstem of Lost Creek. Some sites have as many as four years of data, some have only one year. To help provide a context for this year's data, only those sites with data for 2001 are included in this table. From this comparison, it is apparent that temperatures recorded in 2001 were typical.

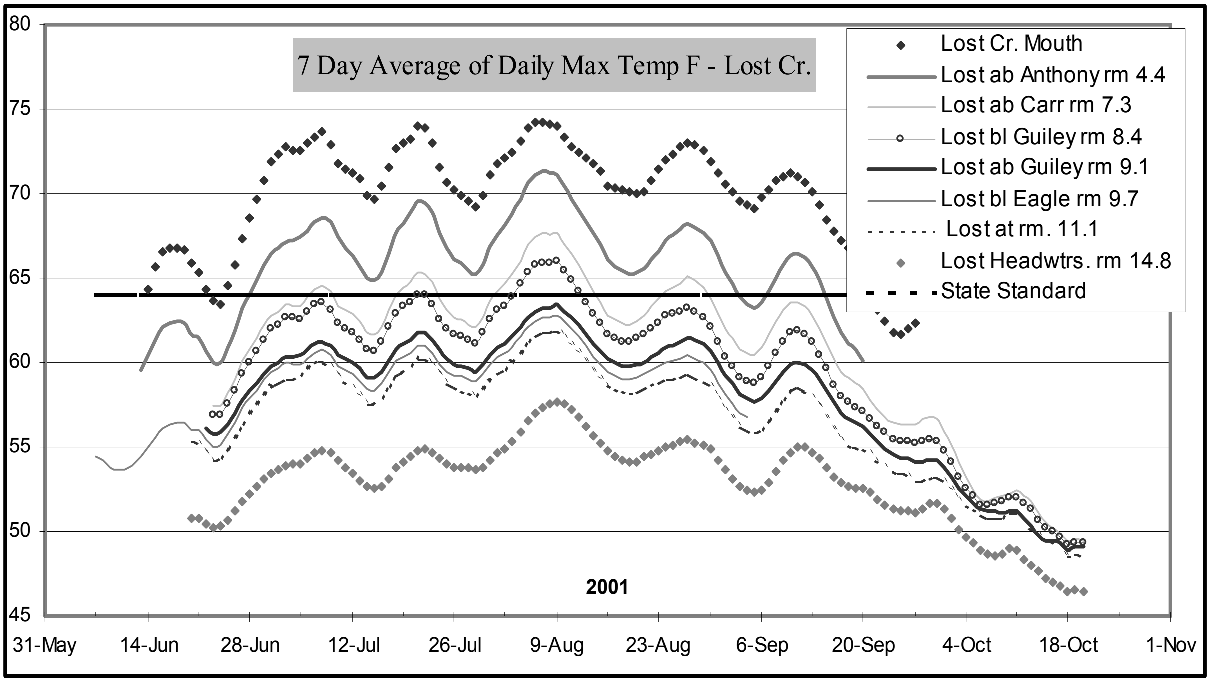
Table 6-8. Multi-year data summary of eight water temperature monitoring sites on Lost Creek.

	Lost Mouth – LC1			Lost Above Anthony – LC 6	Lost Above Carr – LC 9	
	1999	**2000**	**2001**	**2001**	**2000**	**2001**
START DATE	6/16/99	6/18/00	6/14/01	6/13/01	6/18/00	6/23/01
END DATE	11/11/99	12/31/00	10/3/01	9/26/01	12/31/00	10/26/01
DATA DAYS	149	197	112	106	197	126
Days 7 Day Avg Max > 64 °F, 1/1 to 12/30	**91**	**99**	**97**	**74**	**45**	**28**
MONTHLY MAX						
June	69.1	73.4	71.2	66.4	75.2??	60.3
July	73.6	75.2	75.6	71.4	73.4??	67.1
August	73.6	73.4	75.0	72.6	68	68.9
September	66.9	68	73.6	69.3	64.4	66.4
October	61.9	64.4			60.8	58.6
November	51.1	53.6			51.8	
December		46.4			46.4	
MAX of 7-DAY Av Max	**72.6**	**74.2**	**74.2**	**71.3**	**72.4**	**67.7**

	Lost below Guiley LC 10			Lost above Guiley LC 11		Lost below Eagle at Quarry LC 12			
	1999	**2000**	**2001**	**2000**	**2001**	**1998**	**1999**	**2000**	**2001**
START DATE	6/13/99	7/13/00	6/23/01	8/12/00	6/22/01	7/7/98	6/24/99	6/28/00	6/7/01
END DATE	11/9/99	12/9/00	10/26/01	12/31/00	10/26/01	10/2/98	10/7/99	9/19/00	9/10/01
DATA DAYS	150	150	126	142	127	88	106	84	96
Days 7 Day Avg Max > 64 °F, 1/1 to 12/30	**8**	**14**	**9**	**0**	**0**	**8**	**0**	**0**	**0**
MONTHLY MAX									
June	61.3		59.4		58.1		58.0	62.3	59.2
July	65.1	68	65.8		62.96	67.2	62.3	63.8	62.3
August	66.4	66.2	67.1	60.8	64.04	65.2	63.2	62.9	63.5
September	60.6	62.6	64.0	60.8	62.42	62.6	58.0	59.5	61.2
October	54.3	59	57.0	57.2	55.4		51.3		
November	48.2	50		50					
December		44.6		46.4					
MAX of 7-DAY Av Max	**64.8**	**65.9**	**66.0**	**60.0**	**63.4**	**65.1**	**62.2**	**62.6**	**62.8**

	Lost at river mile 11.1 LC 13			Lost Headwaters river mile 14.77 LC14	
	1999	**2000**	**2001**	**1999**	**2001**
START DATE	6/14/99	7/13/00	6/20/01	6/14/99	6/20/01
END DATE	11/9/99	12/31/00	10/26/01	11/9/99	10/26/01
DATA DAYS	149	172	129	149	129
Days 7 Day Avg Max > 64 °F, 1/1 to 12/30	**0**	**0**	**0**	**0**	**0**
MONTHLY MAX					
June	58.6		58.1	51.6	52.7
July	61.9	62.6	61.7	54.9	55.76
August	62.8	62.6	62.78	57.2	58.1
September	57.6	59	59.9	54.1	56.3
October	53.1	57.2	54.32	49.8	52.7
November	47.7	50		46.0	
December		46.4			
MAX of 7-DAY Av Max	**61.6**	**62.1**	**61.9**	**56.3**	**57.7**

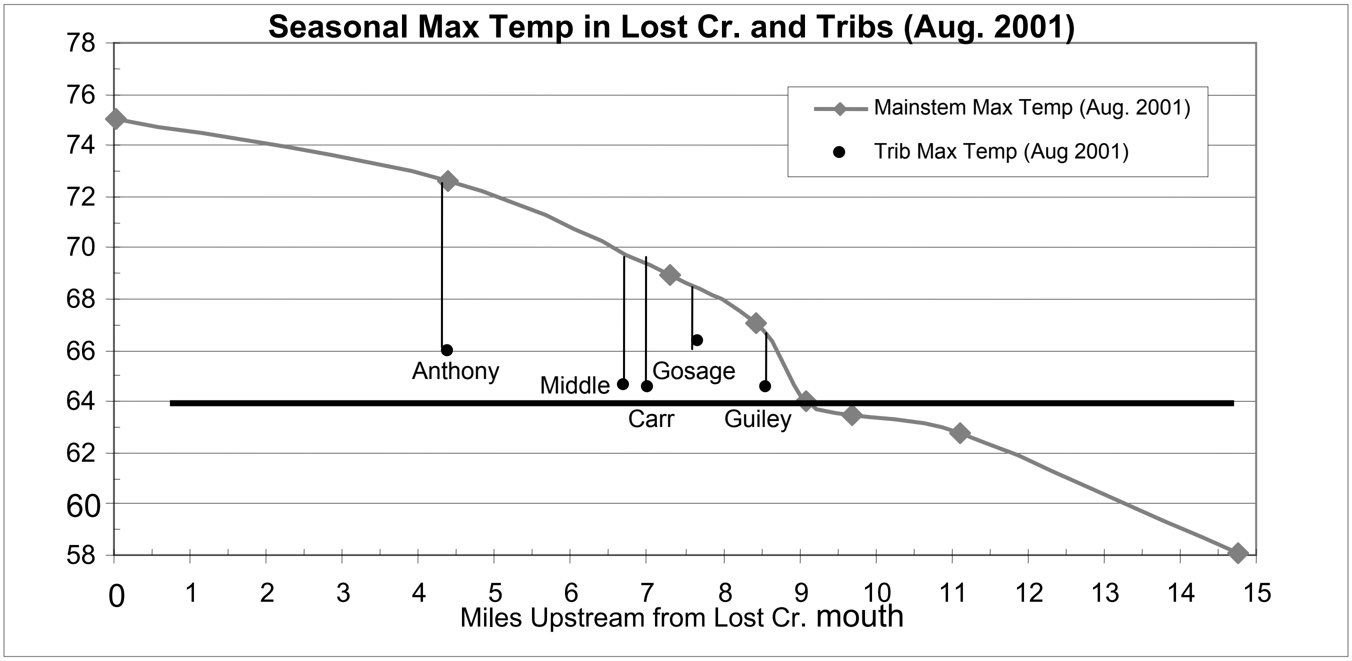
Figure 6-5. The summer pattern of water temperatures for the same array of 8 sites. on the mainstem of Lost Creek (horizontal line depicts State standard).



The two downstream-most sites, near Anthony Creek at river mile 4.4, and at the mouth, are the endpoints of the first segment. In this reach of Lost Creek, water temperature continuously exceeds State standards nearly all summer, from late June to mid-September. The next segment, between Carr Creek at river mile 7.3 and Guiley Creek at river mile 8.4, exceeds the standard primarily only during the hottest period of mid-summer plus a few additional discontinuous short periods. The third segment, consisting of all the sites above Guiley Creek, typically stays below the State standard all summer.

Again the strong similarity in the seasonal pattern of all 8 sites indicates their similar response to the primary driver which is air temperature. The magnitude of that response varies significantly among the sites however. For example, during the initial warming phase of the summer, from late June to early July, a site at the headwaters of Lost Creek gained approximately 5 degrees, while at the mouth, the heat gain was nearly double, almost 10 degrees, over the same period of time. Figure 6-6 presents another view of the variation in heat gain among the Lost Creek sites.

Figure 6-6. Spatial variation in the single daily maximum temperature value across the Lost Creek watershed.



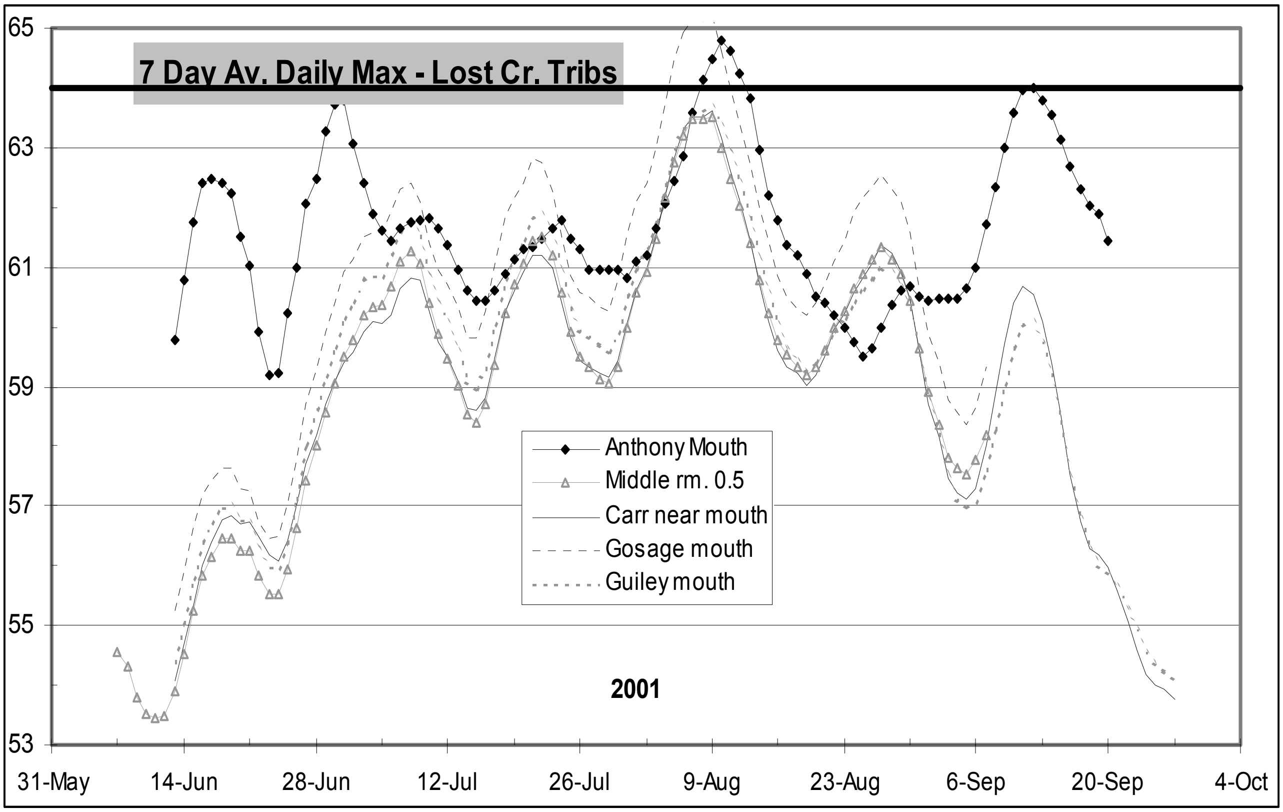
While the previous graph represents a view of the patterns of water temperature fluctuation over time, figure 6-6 presents a "snapshot" view of temperatures along the mainstem of Lost Creek and at the mouths of major tributaries during the warmest day of the year. Again the distinct difference between the upper 4 sites and the lower 4 sites relative to the temperature standard is clear. Another thing to note is that all the tributaries are entering 2 to 6 degrees cooler than the mainstem temperature at their point of confluence with the mainstem.

The slope of the line connecting the measured sites on the mainstem of Lost Creek can also be interpreted to represent the relative rate of heat gain between the sites. For example, from the uppermost point at river mile 14.7 to the next point downstream at river mile 11.1, the temperature increased by 5 degrees over the course of 3.6 miles, an average gain of about 1.3 degrees per mile. From river mile 11.1 to mile 9.7 the increase was only 0.7 degrees total, for an average gain of 0.5 degrees per mile. Between the two points bracketing Guiley Creek, from river mile 9.1 to 8.4, the temperature increased by 3.1 degrees in just 0.7 miles, an average gain of 4.6 degrees per mile. Between the next two points, the average rate of heat gain decreased to 1.6 degrees per mile. Between miles 7.4 and 4.4, the average rate decreased again slightly to 1.3 degrees per mile, perhaps due to the input of cooler water from tributaries. And in the lowest segment between Anthony Creek and the mouth, the average rate of heat gain was only 0.6 degrees per mile, about half the rate of the upstream-most reach.

Explanatory reasons for the relatively rapid heat gain in Lost Creek near Guiley Creek are not obvious. There is apparently no significant riparian canopy gap, change of aspect, or unusually warm tributary input in this short reach. The stream does become wider and shallower with increased bedrock exposure in this reach. Perhaps increased water withdrawal also occurs and these factors together may contribute to the large and rapid increase in temperature. Nevertheless, the pattern is distinct and consistent with temperatures 2-3 degrees F. warmer in Lost Creek below Guiley Creek compared to above. Data indicate that this pattern has been the case during August and September for at least the past 2 years.

Again, these sites on the mainstem of Lost Creek were grouped into three segments of roughly equal length. In the upper segment, from mile 14.7 to mile 9.1, temperature increases about a degree per mile on average. In the middle segment, from mile 9.1 to mile 4.4, the average temperature increase is nearly double at 1.8 degrees per mile. In the lower segment, mile 4.4 to the mouth, the rate of temperature increase is lowest at 0.6 degrees per mile average. Even though shade over the channel is least in this segment (approximately 30% to 50%), at this point in the basin, the stream may have already absorbed close to the theoretical maximum amount of heat from the surrounding air (DEQ reference). Thus the middle reach, where the main tributaries are clustered and where rural residential land use is concentrated, apparently is where the most significant increase in the temperature of Lost Creek occurs. Additional data for Lost Creek tributaries are summarized in figure 6-7 below.

Figure 6-7. Summer temperature patterns of Lost Creek tributaries (horizontal line depicts State standard).



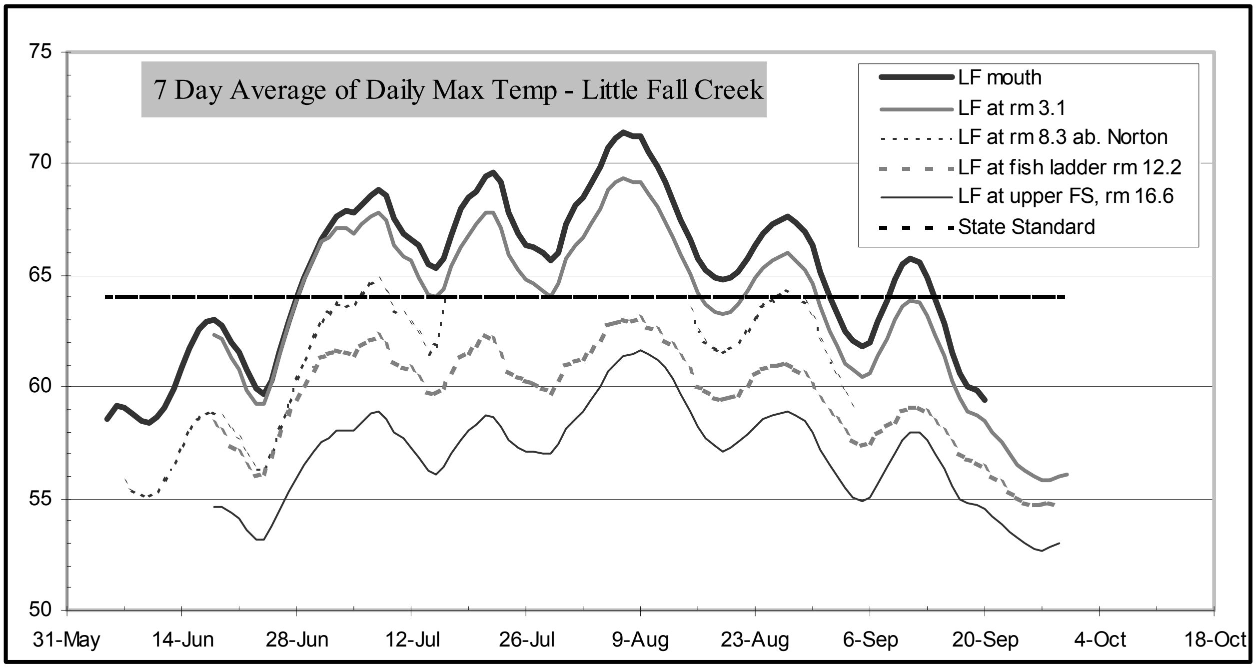
The data in figure 6-7 indicate that Gosage Creek peaked at the highest temperature of all the monitored Lost Creek tributaries during summer 2001. Temperatures recorded at the mouth of both Gosage and Anthony creeks exceeded the State standard slightly for a few days. Temperature at the mouth of Guiley Creek did not exceed the standard in 2001.

The pattern recorded in Anthony Creek differs somewhat from that of the other tributaries. It is much warmer earlier in the summer and again in the late summer compared to the other sites. An examination of the daily data from Anthony Creek also showed an unusual pattern of daily fluctuation in temperature, particularly regarding the timing of the daily maximum temperature.

6.3.4.1.3 Water Temperature Data Analysis – Little Fall Creek Watershed

Prior to 2001, very little water temperature monitoring had been done in the Little Fall Creek watershed. Figure 6-1 displays the location of continuous water temperature monitoring sites in the Little Fall Creek watershed.

Figure 6-8. Summer water temperature patterns in Little Fall Creek (summarizes the results of the monitoring that occurred in the summer of 2001).



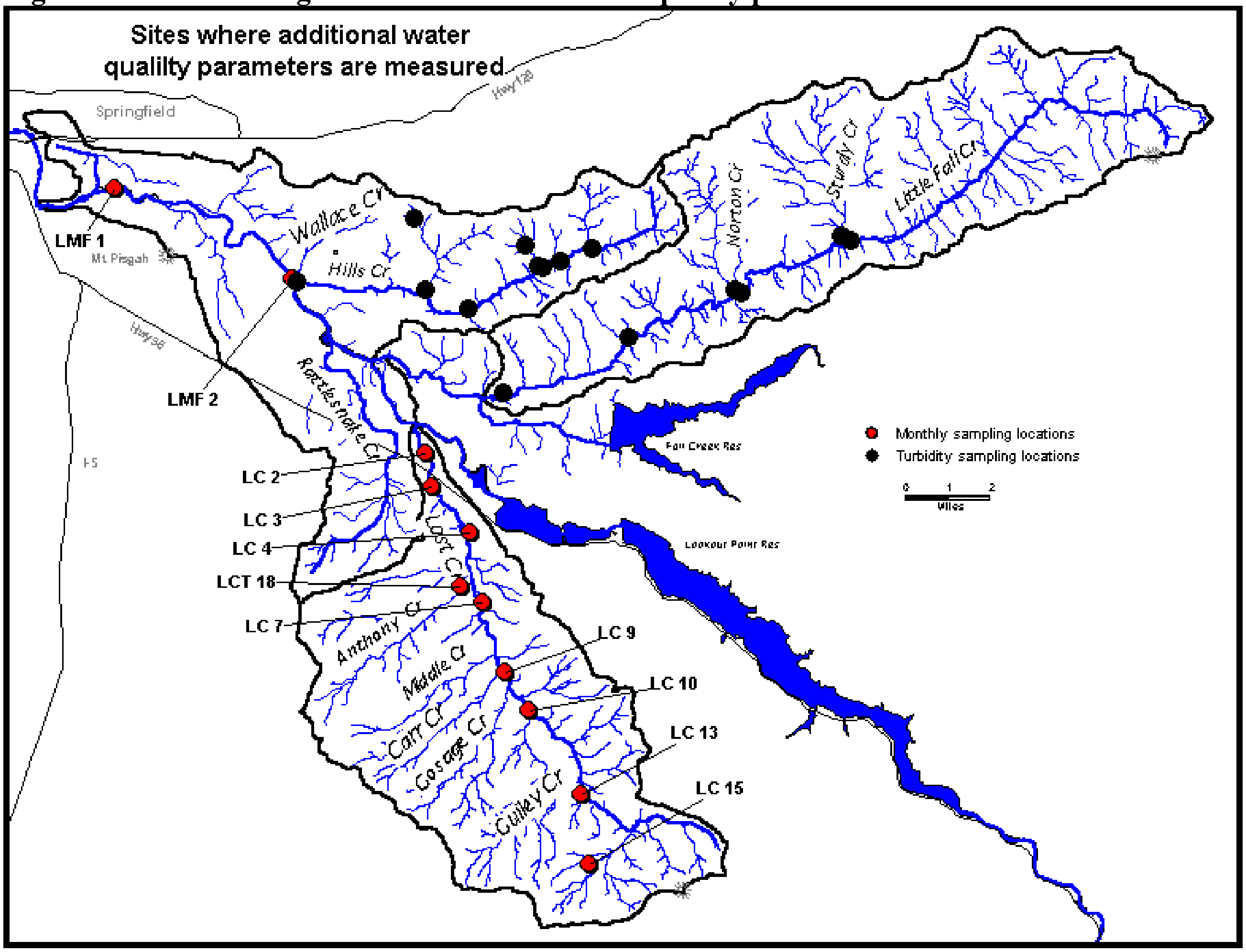
The pattern in lower Little Fall Creek (figure 6-8) is similar to that of lower Lost Creek, with water temperatures exceeding State standards for most of the summer, although both the maximum value and the duration of exceedance are less in Little Fall compared to Lost Creek. Temperatures in the upper watershed remained below the standard. Data from a middle reach site at river mile 8.3 is incomplete due to the likelihood of the unit being out of the water in late July/early August. However, based on a comparison of the pattern of water temperature at this site with the upstream and downstream sites, it is likely that the temperature at this point exceeded the State standard several times during the summer.

6.3.4.2 Other Water Quality Factors

The other water quality factors which are of primary concern for this assessment are: dissolved oxygen, pH, nutrients, bacteria, turbidity, and organic and metal contaminants. Limited data used to evaluate these factors were available from three main sources: the ambient monitoring site operated by DEQ on the Middle Fork Willamette River at Jasper Bridge, the river intake to the municipal water wellfields monitored by the Springfield Utility Board (SUB), and a series of sites in the Lost Creek watershed sampled monthly by the Lost Creek watershed group. All sites monitored dissolved oxygen, pH, and turbidity. Bacteria, nutrients, and contaminants were not sampled in Lost Creek. Only limited grab sample turbidity data collected by Weyerhaeuser, was available for the

Little Fall Creek watershed. Figure 6-9 displays the location of monitoring sites for these additional parameters.

Figure 6-9. Monitoring sites for additional water quality parameters.



6.3.4.2.1 Summary of Other Water Quality Data - Lower Middle Fork Willamette Watershed

DEQ regularly analyzes data from their ambient monitoring site on the Middle Fork Willamette River at Jasper Bridge. As noted in section 6.4.3, the overall water quality of the river at this location is rated as excellent by the DEQ. Specifically, data from this site support the listing of the segment of the river from the mouth to Dexter as officially meeting the water quality standards to support fish and aquatic life for dissolved oxygen, pH, and bacteria. A review of the DEQ data for the Assessment Area also indicate that water quality standards are also met for nutrients, turbidity, and contaminants. Additional data, presented below, indicates that the higher dissolved oxygen standard to support salmonid spawning may not be consistently met in the Middle Fork Willamette River, nor the stricter turbidity limits for proper drinking water filtration.

Additional monitoring of the Middle Fork Willamette River is done by the Springfield Utility Board in order to assure the highest quality of water used for public drinking water supply. This beneficial use is more sensitive to certain factors, particularly bacteria and turbidity, than are fish-related uses, and stricter criteria apply (i.e. < 10 NTU's for drinking water compared to < 50 for fish). The following section summarizes key data from SUB's monitoring program. See the water quality appendix for a more complete report.

Springfield Utility Board Monitoring Results

Water from the Middle Fork Willamette River and surrounding areas recharges the Sprinfield Utility Board's (SUB) wellfield. Geology in the area of the Willamette Wellfield is Younger Alluvium composed of cobbles, course gravel, sand, and a small proportion of silt to a depth of 35-40 feet (USGS, 1964). These deposits are pervious and allow infiltration from streams (USGS, 1973).

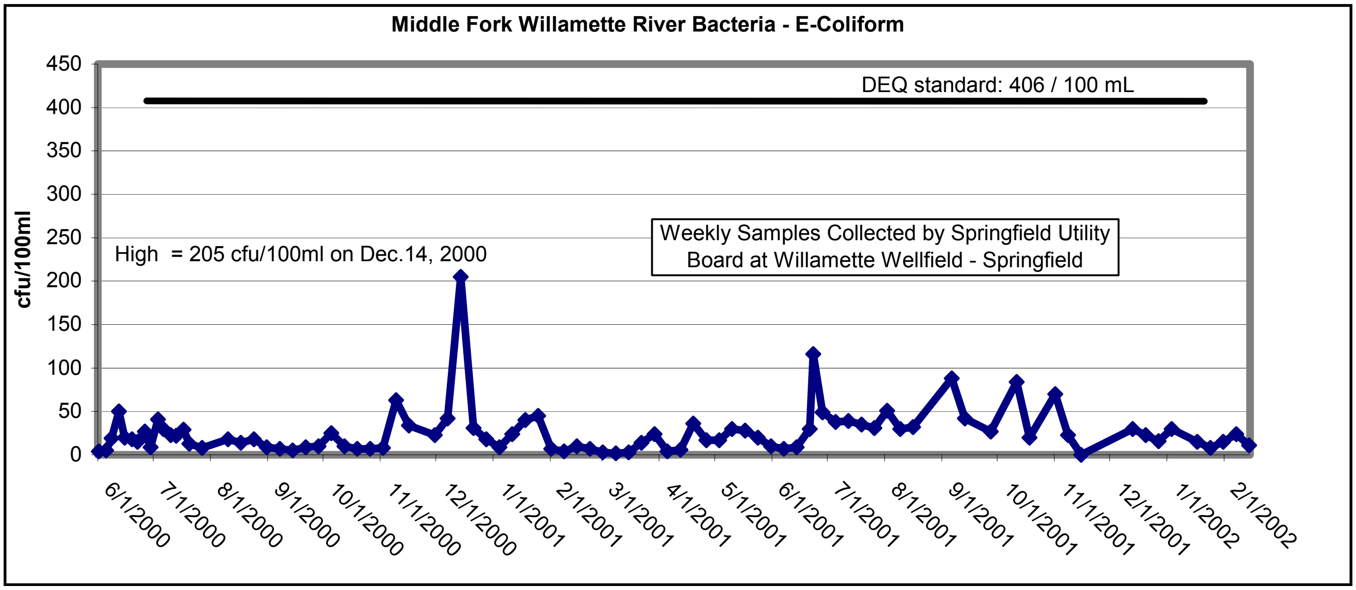
A January 2001 *Topographic Survey* performed for Springfield Utility Board (Poage Engineering & Surveying, Inc, 2001) places the Willamette Wellfield at 464-468 feet above sea level. The (ground) water in this area is reported at 460 feet above mean sea level (USGS, 1969 and 1970). Therefore wells in this area are relatively shallow and productive.

Water from the Middle Fork Willamette River is currently used as recharge to the aquifer in the immediate vicinity of the Willamette Wellfield. Critical recharge for SUB's Willamette Wellfield is also provided by water from Gory Creek, which branches off from the Springfield Mill Race and flows through part of the wellfield (Figure 6-10). The Mill Race is diverted from the Middle Fork Willamette River, just downstream from Clearwater Lane Boat Landing.

Figure 6-10. The Springfield Utility Board wellfield recharge area.

Bacteria: Samples of E-coli and fecal coliform were collected and analyzed weekly from raw river water at the SUB wellfield. Figure 6-11 shows the results of SUB's bacteria (E-Coliform) monitoring. The data indicates that E-coli levels in unfiltered river water are well below the screening threshold of 406 E. coli per 100ml. throughout the sample period.

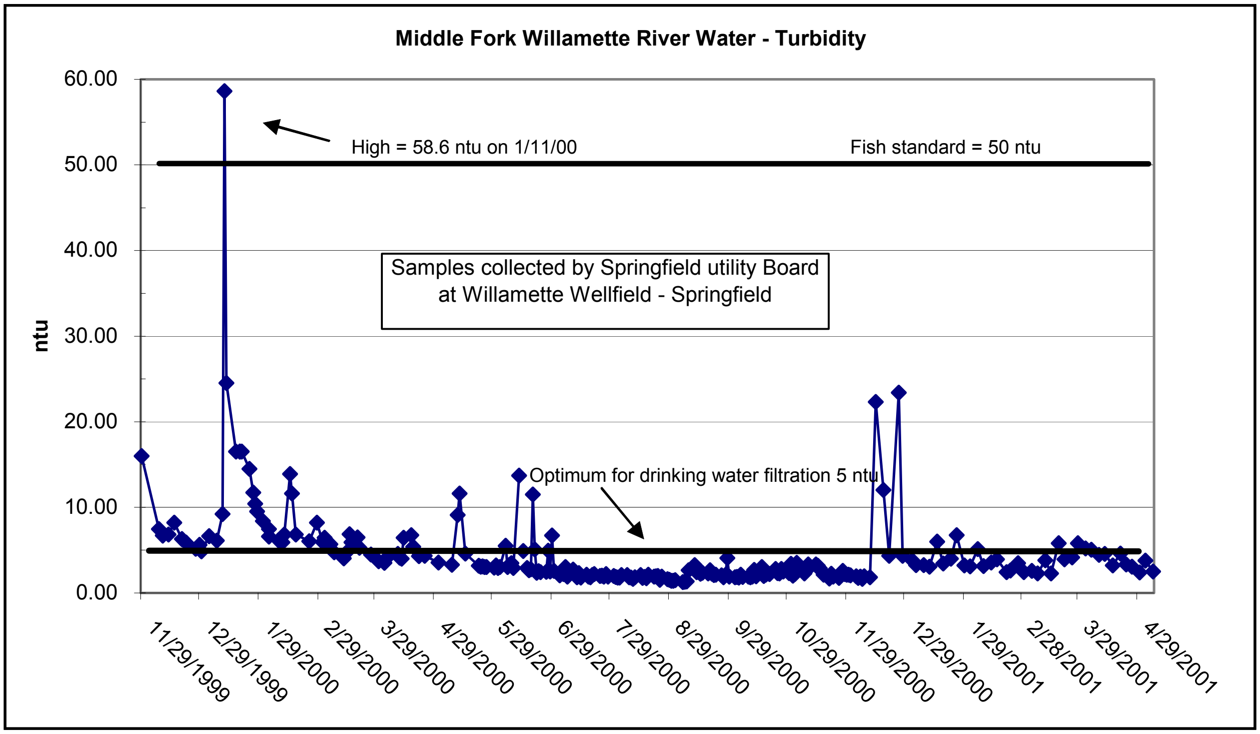
Figure 6-11. Results of E-coli monitoring of Willamette River water at SUB wellfield.



Turbidity: Criteria for turbidity related to fish health in streams is measured at a standard of 50 NTU or less and remains the most sensitive criteria for upstream reaches of the river. However, municipal drinking water is the most sensitive use in the lower reaches, especially near the Springfield Mill Race. Criteria for effective use of filter beds used in production of drinking water through the slow sand filtration process are much lower.

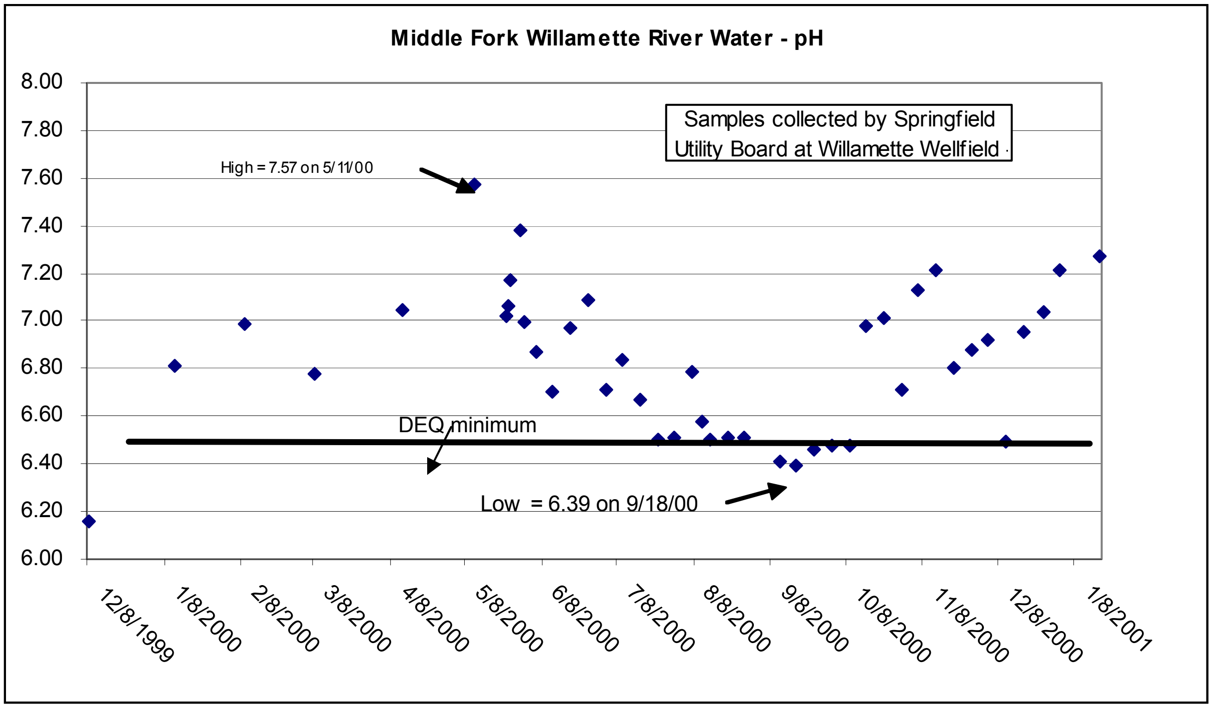
Turbidity increases naturally during storm events and can also be caused by draw down from upstream reservoirs. Filter beds utilized by SUB for public drinking water require a sustainable 5 NTU or less turbidity with a short-term peak of no more than 10 NTU to avoid clogging the beds and impairing the continuous supply of drinking water to the city of Springfield. Figure 6-12 shows the results of frequent (every 2-5 days) turbidity monitoring of the Middle Fork Willamette River at SUB's wellfield from 11/29/99 through 5/07/01. The data indicates that the turbidity standard for resident fish and aquatic life was generally met during this time period. However, the lower criterion for the more sensitive use of public water supply was often exceeded.

Figure 6-12. Turbidity monitoring results – Middle Fork Willamette River at SUB wellfield.



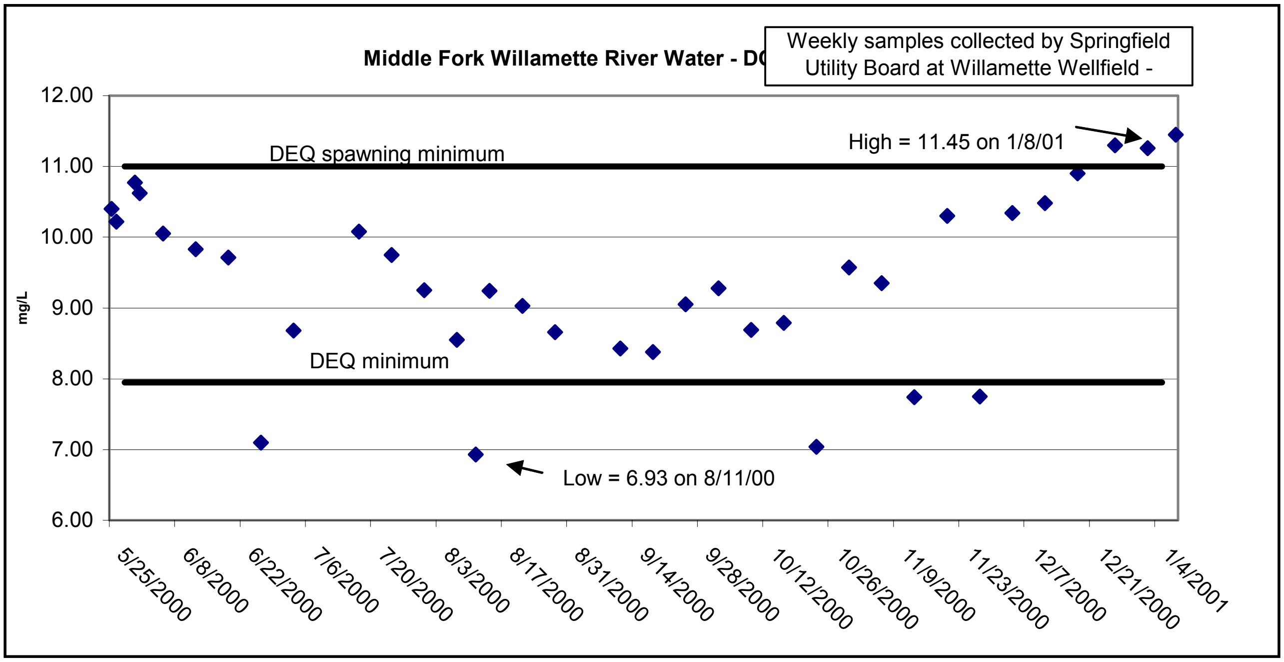
pH: Monitoring of river water pH at the wellfields was done over two different time periods. Weekly samples from 8/18/93 to 7/27/94 show a range of pH values from 7.12 to 8.27, all within the DEQ criteria of 6.5 to 8.5. Another series of samples from 12/8/99 to 1/18/01 show a pH range of 6.39 to 7.57 with several values measured at or below the minimum of 6.5 during the summer of 2000. Figure 6-13 displays this recent pH data.

Figure 6-13. pH values for Middle Fork Willamette river water at the SUB wellfield.



Dissolved Oxygen (DO): Weekly measurement of dissolved oxygen in Middle Fork Willamette river water at the SUB wellfields was done from 5/25/00 to 1/08/01. Figure 6-14 displays the data. Most of the samples were collected during the early morning before 10 am. Since dissolved oxygen has a daily variation with minimum values occurring in the early morning and maximum values occurring in the late afternoon, a morning sampling time will tend to measure values closer to the daily minimum. The DO samples did not meet the minimum criteria of 8 mg/L on five occasions during summer and fall of this sample period. In addition, none of the DO samples met the higher minimum criterion of 11mg/L during the spawning season for Spring Chinook (September – October).

Figure 6-14. Dissolved Oxygen in Middle Fork Willamette river water at SUB wellfield.



Hills Creek Turbidity Data

Turbidity was sampled by Weyerhaeuser from nine sites in the Hills Creek watershed on six different days in the fall and winter of 1996 and 1997. During low to moderate flow conditions, the measured turbidity values ranged from 6 to 31 NTU, with the higher values occurring in the Cedar Creek tributary of Hills Creek. During high flow on November 19, 1997, turbidity was measured at 190 NTU in Hills Creek above Cedar Creek, at 155 NTU in Hills Creek at Jasper, and at 125 NTU in Cedar Creek. These 3 measurements, though taken during storm conditions, are all well above the threshold of concern of 50 NTU. Hills Creek enters the Middle Fork Willamette approximately 6 miles above the Springfield millrace inlet and, during storms, may be contributing to elevated turbidity above 10 NTU in the Middle Fork Willamette River.

See figure 6-9, Monitoring Sites for Additional Water Quality Parameters in section 6.3.4.2 above for locations of turbidity samples.

6.4.4.2.2 Summary of Other Water Quality Data – Lost Creek Watershed

The Lost Creek Watershed Group provided additional water quality data gathered in 1999, 2000, and 2001. Grab samples, collected monthly primarily during summer and fall from various sites identified in Figure 6-1, were analyzed for temperature, pH, dissolved oxygen, conductivity, and turbidity.

The results indicate that water quality standards are generally met for pH and turbidity. There are a few (4 out of 94) instances of pH measurements recorded outside the acceptable range of 6.5 to 8.5. However, these few measurements do not fall very far outside the acceptable range and could be due to sampling error. The recorded turbidity values are generally quite low, ranging from 0.47 to 14.3 NTU, compared to a threshold value of 50 NTU. Additional sampling during stormy periods would be needed to record the upper end of turbidity conditions that occur annually in Lost Creek.

The sampling results for dissolved oxygen are presented in table 6-9 below. The recorded values for dissolved oxygen indicate that minimum water quality standards for this parameter frequently are not met in Lost Creek.

Table 6-9. Dissolved Oxygen measured in Lost Creek 1999-2001.

Map ID	RM	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**
LC2	1.85	6/5/99	9.47			8/11/99	8.99	9/11/99	8.33	10/25/99	9.19		
LC3	2.85	6/5/99	8.63	7/4/99	9.61	8/11/99	8.67	9/11/99	8.45	10/25/99	9.39		
LC4	3.77	6/5/99	9.77	7/4/99	9.1	8/11/99	8.93	9/11/99	9.07	10/25/99	10.01		
LC7	4.97			7/4/99	9.02	8/11/99	8.75			10/25/99	9.88		
LCT18	0.7	6/5/99	7.25	7/4/99	9.6	8/11/99	8.57			10/25/99	9.56	12/9/99	10.17
LC9	7.82					8/12/99	9.0	9/11/99	9.35	10/25/99	10.58	12/9/99	10.71
LC10	8.97	6/5/99	7.7	7/22/99	8.45	8/12/99	9.37	9/10/99	8.9	10/25/99	10.58	12/9/99	10.16
LC13	11.71	6/5/99	9.25	7/22/99	8.97	8/12/99	9.05	9/10/99	9.08	10/20/99	10.03	12/9/99	10.88
LC15	14.68	6/5/99		7/22/99	9.07	8/12/99	9.12	9/10/99	9.08	10/20/99	9.93	12/9/99	10.81
Map ID	RM	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**
LC2	1.85	4/19/00	9.54			6/16/00		7/22/00	6.3	8/31/00	8	9/14/00	5.1
LC3	2.85	4/19/00	9.16			6/16/00		7/22/00	6.7	8/31/00	7.47	9/14/00	6.9
LC4	3.77	4/19/00	9.17			6/16/00		7/22/00	6.78	8/31/00	7.67	9/14/00	6.48
LC7	4.97					6/16/00		7/28/00	9	8/31/00	7.47	9/14/00	6.58
LCT18	0.7			5/31/00	8.81	6/22/00		7/22/00	6.02	8/31/00	8.16	9/21/00	6.8
LC9	7.82			5/31/00	10.47	6/22/00	9.56	7/28/00	12.36	8/24/00	7.63	9/21/00	7.32
LC10	8.97			5/31/00	8.92	6/22/00	8.57	7/28/00	7.8	8/24/00	8	9/21/00	7.79
LC13	11.71			5/31/00	10.62	6/22/00	9.52	7/28/00	14.98	8/24/00	8.39	9/21/00	7.73
LC15	14.68			5/31/00	7.77	6/22/00	9.5	7/28/00	7.85	8/24/00	9.73	9/21/00	7.22
Map ID	RM	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**						
LC2	1.85	10/28/00	6.89	11/29/00	9	12/30/00	11.33						
LC3	2.85	10/28/00	7.19	11/29/00	10	12/30/00	9.53						
LC4	3.77	10/28/00	9.29	11/29/00	10.96	12/30/00	11.96						
LC7	4.97	10/28/00	8.95	11/29/00	10.8	12/30/00	11.71						
LCT18	0.7	10/28/00	8.91	11/28/00	10.33	12/30/00	10.45						
LC9	7.82	10/28/00		11/28/00	8.28	12/30/00	9.24						
LC10	8.97	10/28/00	9	11/28/00	8.08	12/30/00	10.87						
LC13	11.71	10/28/00	7.53	11/28/00	11	12/30/00	10.36						
LC15	14.68	10/28/00	9.12	11/28/00	9.69	12/30/00	11.16						

Map ID	RM	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**	Date	**DO (mg/L)**
LC2	1.85	7/18/01	8.4	9/10/01	7.4	10/25/01	9.9	11/25/01	8.7
LC3	2.85	8/8/01	7.7	9/10/01	7.7	10/22/01	8.2	11/25/01	9.6
LC4	3.77	7/28/01	8.8	9/10/01	8.2	10/24/01	10.4	11/25/01	
LC7	4.97	8/8/01	9.1	9/14/01	8.3			11/25/01	10.7
LCT18	0.7	8/8/01	9	9/14/01	7.9	10/24/01	8.1	11/25/01	10.2
LC9	7.82	7/28/01	9.4	9/14/01	9.4			11/26/01	11.1
LC10	8.97	7/28/01	9.9	9/16/01	9.5			11/26/01	11.1
LC13	11.71	7/18/01	9.1	9/16/01	9			11/26/01	8
LC15	14.68	7/28/01	9.2	9/16/01	10.2			11/26/01	11.8

Of the 138 measurements of dissolved oxygen, 29 were below the minimum value of 8 mg/L (21% of all samples). Over the three-year sampling period, at least one measurement below the minimum level was recorded from May to October. Most of the low values were recorded in 2000. None of the sample sites met the minimum level for dissolved oxygen when measured in September 2000. In that month, the dissolved oxygen at the site nearest the mouth of Lost Creek was measured at 5.1 mg/L, which is below the threshold of acute salmonid mortality (OWEB, 1999).

A higher standard of 11mg/L applies in spawning waters in order to support embryo and larval development stages with no impairment (OWEB, 1999). In the Lost Creek watershed, spawning for resident cutthroat trout can occur from January to June, and from April through May for resident rainbow trout (Dan Van Dyke, ODFW, per. comm. 2002). Though data are limited, none of the samples recorded from April, May, or June met the minimum standard of 11mg/L for spawning waters. Spawning use by spring chinook, if it occurs in Lost Creek, would take place in September and October. As noted above, some of the lowest of all dissolved oxygen levels were recorded in September 2000. None of the September or October samples met the minimum spawning level of 11mg/L of dissolved oxygen.

6.3.4.2.2 Summary of Other Water Quality Data – Little Fall Creek

Additional water quality data for Little Fall Creek is limited to a few turbidity samples taken by Weyerhaeuser in 1996 and 1997. Samples were taken on six different days, with flow conditions being low to moderate on five out of the six days. During these low to moderate flow conditions, turbidity values ranged from 2 to 5 NTU for the six sample sites on Little Fall Creek and main tributaries. During high flow conditions, the turbidity ranged from 20 to 65 NTU at the same sample sites. The one measurement of 65 NTU, which is above the threshold value of 50 NTU, was taken on November 19, 1997 from Little Fall Creek about a mile above the mouth. See figure 6-9, Monitoring Sites for Additional Water Quality Parameters in section 6.3.4.2 above for locations of turbidity samples.

6.3.4.3 Summary of Water Quality Conditions

The OWEB manual provides guidelines for drawing inferences about water quality conditions from available data. The guidelines apply a fairly conservative assessment of the data because even short-term or periodic violations of water quality standards can have a "limiting factor" type of effect on aquatic organisms, especially during sensitive stages of development. For each sampling site, the degree of impairment is determined for each parameter by the percentage of total samples that violate the water quality criteria for that parameter. Table 6-9 presents the OWEB guidelines for water quality impairment.

Table 6-9: Level of impairment for water quality parameters based upon the percentage of data points that violate the criteria (OWEB, 1999).

Percent violating criterion	*Impairment level*	*Abbreviation*
< 15%	None (no or few exceeding the criteria)	N
15 – 50%	Moderate (points exceed criteria on a regular basis)	M
> 50%	Impaired (points exceed criteria most of the time)	I
Insufficient or no data	Unknown	U

The level of impairment determined according to these guidelines is somewhat of a subjective judgement call. This determination is intended primarily to guide future council actions regarding water quality monitoring and does not have the same regulatory implications as a formal "water quality limited" listing by DEQ. Based on these guidelines, and on available data, the water quality condition for key parameters is summarized by watershed in table 6-10. Data supporting these determinations are included in the appendix.

Table 6-10. Summary of current water quality conditions in the Assessment Area.

Little Fall Creek Watershed							
Site	**Location**	**Temp**	**pH**	**DO > 8mg/L**	**DO > 11mg/L**	**Turb. < 50**	**Bacteria**
LF1	Little Fall Creek near mouth	I	U	U	U	M	U
LF2	LF Creek rm. 3 elev. 700'	I	U	U	U	U	U
LF3	LF Creek rm. 5.5 near bridge	U	U	U	U	U	U
LF4	LF creek rm. 8.2 above Norton Cr.	M	U	U	U	N	U
LF5	LFC at fish ladder 1200'	N	U	U	U	N	U
LF6	LFC at upper FS boundary 1480'	N	U	U	U	U	U

Lower MFW watershed								
Site	**Location**	**Temp**	**pH**	**DO > 8mg/L**	**DO > 11mg/L**	**Turb. < 50**	**Turb. < 10**	**Bact.**
LMF1	MFW at millrace inlet	I	N	N	I	N	I	N
LMF2	MFW at Jasper Bridge	I	N	N	N	N	NA	N
LMF3	MFW at Jasper Park	I	U	U	U	U	NA	U
LMF4	MFW above Fall Cr.	I	U	U	U	U	NA	U
LMF5	MFW above Lost Cr.	I	U	U	U	U	NA	U
LMFT6	Wallace Cr. mouth	N/U	U	U	U	U	NA	U
LMFT7	Hills Cr. at Jasper road	I	U	U	U	M	NA	U
LMFT8	Hills Cr. at bridge rm. 2	I	U	U	U	U	NA	U
LMFT9	Hills Cr. at 3rd bridge, BLM 1030'	U	U	U	U	U	NA	U
LMFT10	Cedar Cr. mouth	I	U	U	U	M	NA	U
LMFT11	Rattlesnake Cr. near mouth	M	U	U	U	U	NA	U
LMFT12	Rattlesnake Cr at Hwy 58	M	U	U	U	U	NA	U
FC1	Fall Creek mouth	I	U	U	U	U	NA	U
FC2	Fall Cr. above Little Fall	I	U	U	U	U	NA	U

Lost Creek Watershed							
Site	**Location**	**Temp**	**pH**	**DO > 8mg/L**	**DO > 11mg/L**	**Turb. < 50**	**Bact**
LC1	Lost Cr. mouth	I	U	U	U	U	U
LC2	Lost Cr. at Elijah S.P	I	N	M	I	N	U
LC3	Lost Cr. At 38404 Dexter Rd. El. 625'	I	N	M	I	N	U
LC4	Lost Cr. At Barbre/Rogers road corner	I	N	M	I	N	U
LC5	Lost Cr. Below Wagner Cr. Elev. 700'	I	U	U	U	U	U
LC6	Lost Cr. Above Anthony Cr. Elev. 720'	I	U	U	U	U	U
LC7	Lost Cr. At 81894 LC rd.	I	N	M	I	N	U
LC8	Lost Cr. At Lost Creek road bridge, elev. 750'	I	U	U	U	U	U
LC9	Lost Cr. At 80933 LC rd, ab. Carr Cr. Elev. 820'	I	N	N	I	N	U
LC10	Lost Cr. At 80655 LC rd, bl. Guiley Cr. Elev. 860'	I	N	M	I	N	U
LC11	Lost Cr. Above Guiley Cr. Elev. 935'	N	U	U	U	U	U
LC12	Lost Cr. Below Eagle Cr. At quarry elev. 1000'	N	U	U	U	U	U
LC13	Lost Cr. At SE bend in road at rock outcrop elev. 1220'	N	N	N	U	N	U
LC14	Lost Cr. Headwaters NE 1/4 sec. 29 elev 2770'	N	U	U	U	U	U
LC15	Lost Cr. Headwaters road xing SE 1/4 sec. 26 easternmost stream in hairpin turn	N	N	M	U	N	U
Lost Creek Watershed - Tributaries							
Site	**Location**	**Temp**	**pH**	**DO > 8mg/L**	**DO > 11mg/L**	**Turb. < 50**	**Bact**
LCT16	Elijah Bristow S. P. pond	N	U	U	U	NA	U
LCT17	Anthony Cr. mouth	M	U	U	U	U	U
LCT18	Anthony Cr. bridge at rm. 0.4 L.V. Ed. Ctr.	U	N	I	I	N	U
LCT19	Anthony Cr. rm. 2.5 BLM sec 31 1020’	M	U	U	U	U	U
LCT20	Middle Cr rm. 0.5	N	U	U	U	U	U
LCT21	Carr Cr. at Lost Cr. rd. bridge	N	U	U	U	U	U
LCT22	Gosage Cr. at Lost Cr. rd. bridge	M	U	U	U	U	U
LCT23	Gosage Cr. at E/W fork confluence	N	U	U	U	U	U
LCT24	Guiley Cr. mouth	N	U	U	U	U	U
LCT25	Guiley Cr. rm. 1.0 BLM sec. 15	N	U	U	U	U	U

6.3.4.3.1 Water Quality Conditions Discussion

Temperature

Summer water temperature is impaired throughout much of the Assessment Area, especially in the lower mainstems of the major streams and rivers. Multiple factors may have interactive effects on stream temperatures. The amount of shade over the water surface directly affects the amount of solar radiation heating the water. Reduced riparian shade is likely a primary factor elevating temperatures in all impaired reaches except the Middle Fork Willamette (which is too wide to be well shaded). The other factors which are most likely affecting elevated temperatures in these reaches, except the Middle Fork Willamette, are water withdrawals, changes in channel geometry, and changes in bottom materials.

Since a smaller volume of water heats more rapidly than a larger one, reducing low summer flows further through withdrawals makes it easier for the sun to heat the stream. A wide shallow channel is harder to shade and easier to heat than a narrow deep one. Large areas of exposed bedrock can absorb heat directly from the sun and transfer it to the water, whereas thick cobble and gravel deposits can act like a cooling filter as water percolates through, particularly subsurface.

While most of the smaller tributaries in the Assessment Area currently appear to be near or below the summer temperature standard, they may still be a factor contributing to the cumulative effect of impaired temperature in lower reaches if those tributaries are not as cool as they could be.

For the Middle Fork Willamette River, the primary factor affecting stream temperature is the temperature of the water released from upstream dams. The temperature of the main tributaries is also a factor, and in the case of Fall Creek, is also directly affected by the reservoir releases. Changes in the river's channel geometry are opposite from those that have occurred in the tributaries (the river has become narrower and deeper since flooding has been controlled) and are probably not contributing to elevated water temperatures. Water withdrawals are also not a significant factor due to the increased summer flows resulting from reservoir storage.

Dissolved Oxygen

There appears to be some impairment of water quality in terms of dissolved oxygen, in Lost Creek and the Middle Fork Willamette River, particularly during spawning seasons. Dissolved oxygen levels are directly affected by stream temperature. Warmer water can hold less dissolved oxygen than colder water. Sources of oxygen in water include plant photosynthesis and the transfer of atmospheric oxygen to the water column through turbulence (reaeration). Plant respiration and decomposition of organic matter consumes oxygen. Dissolved oxygen levels typically have a daily pattern, similar to water temperature, with the lowest levels occurring in the early morning and the highest levels in the late afternoon. A study of factors controlling dissolved oxygen in the Upper Willamette Basin by the USGS found that photosynthesis and respiration of algae attached to the bottom of the streambed accounted for most of the variation in dissolved oxygen levels (USGS, 1994).

At present, there is no dissolved oxygen data for Little Fall, Hills, or Rattlesnake Creeks. Given the similarity of conditions (temperature, gradient, flow, land use) in the lower reaches of these streams compared to Lost Creek, there is some reason to suspect dissolved oxygen issues in these streams as well.

Turbidity

Meeting the more restrictive standard for drinking water filtration appears to be the main turbidity concern for the Middle Fork Willamette River. A very limited amount of data does seem to point to Hills Creek as a possible source of elevated storm-related turbidity to the river. The Weyerhaeuser watershed analysis found that, while turbidity during normal flows was related to natural sources of clay minerals in the headwaters of Cedar Creek, stormflow turbidity was caused primarily by sediment mobilized by surface runoff (Weyerhaeuser, 1997).

Little Fall Creek may also contribute to elevated turbidity in the Middle Fork Willamette River. Based on one sample, the lower reach probably occasionally produces turbidity above 50 NTU's. The main source of elevated turbidity here may be from directly in this reach rather than from upstream, given the lower NTU levels of the upstream sample sites.

There is no data to evaluate the contribution by either Fall Creek or Lost Creek to winter or storm-flow turbidity levels in the Middle Fork Willamette River.

6.4 RECOMMENDATIONS

In light of current monitoring results, a number of steps could be taken to refine the monitoring program in the Assessment Area in order to target key information needs.

- Continue to monitor summer stream temperatures throughout the Assessment Area. Current data indicates several additional stream reaches may be listed in the future as water quality limited for summer temperature. In particular, the lower 8 miles of both Lost Creek and Little Fall Creek, the lower 2 miles of Hills Creek, and the mouths of Cedar, Rattlesnake, and Fall Creeks should be monitored. A site on the Middle Fork Willamette just below Dexter dam should be added to the current 3 sites in order to more precisely delineate the complex reservoir-influenced temperature patterns in the Middle Fork Willamette. Data should be submitted to DEQ for the next round of updates to the 303(d) list.

- Monitor selected reaches for temperature during the spring season (April – June). Consult with a local fishery biologist to determine the best reaches to monitor for native salmonid spawning habitat.

- Increase the frequency of dissolved oxygen sampling from monthly to weekly at the current sites on Lost Creek. Sampling in the early morning is more likely to capture the daily minimum dissolved oxygen level. Expand the sampling season from April through October at all sites in order to include the spawning season of all salmonids potentially using Lost Creek.

- Given the similar temperature issues, there may also be concerns with dissolved oxygen in Hills, Rattlesnake, and Little Fall Creek. Add monthly or weekly dissolved oxygen sampling April - October at the mouths of these streams to provide baseline data and to compare with Lost Creek data. Sampling in the early morning is more likely to capture the daily minimum dissolved oxygen level.

- Collect turbidity samples during storms or during winter high flows in Lost Creek, lower Little Fall Creek, lower Fall Creek, and Hills Creek in order to more accurately determine the range of variability in turbidity. Compare turbidity in these tributaries to that in the Middle Fork Willamette at the Springfield millrace.

- Given that Lost Creek and Little Fall Creek are heavily used for recreational swimming, it would be prudent to collect baseline bacteria data in the lower reaches of these two creeks.

- Increase the amount and size of riparian vegetation along all streams in the agriculture/rural residential land use zones of the Assessment Area.

- Minimize the depletion of summer low flows.

7.0 SEDIMENT SOURCES

7.1 INTRODUCTION

This section of the report will provide an overview and brief analysis of the major sediment processes within the Lower Middle Fork Willamette Assessment Area. Existing information and reports were used to summarize what is known about known and potential sediment sources and delivery to streams.

7.2 METHODS AND KEY QUESTIONS

The assessment of sediment generating processes was based on existing reports, other information, and interviews with resource professionals.

In order to assess the major sediment sources within the Assessment Area, four key questions will be addressed:

1. What are the significant sources of surface erosion within the Assessment Area?

2. How does mass failure affect the Assessment Area?

3. How does sediment contribution from roads affect the Assessment Area?

4. How does channel erosion contribute to sedimentation in the Assessment Area?

7.3 RESULTS

The results of the sediment source assessment are organized by critical question.

7.3.1 What are the Significant Sources of Surface Erosion within the Assessment Area?

Surface erosion includes soil lost from the land surface through the physical weathering processes of wind and overland flow, and sheet and rill erosion. Surface erosion not only delivers sediment to streams, but also affects the long-term productivity and resiliency of soils through loss of soil and water nutrients. Surface erosion is most commonly observed on slopes with moderately detachable soils located on moderate to steep slopes, and in association with heavy rain and overland and/or surface flow (USDI, 1996). The most important factors considered in the assessment of surface erosion potential from hillslopes include soil characteristics, steepness, and vegetative cover percentage (WFPB, 1997).

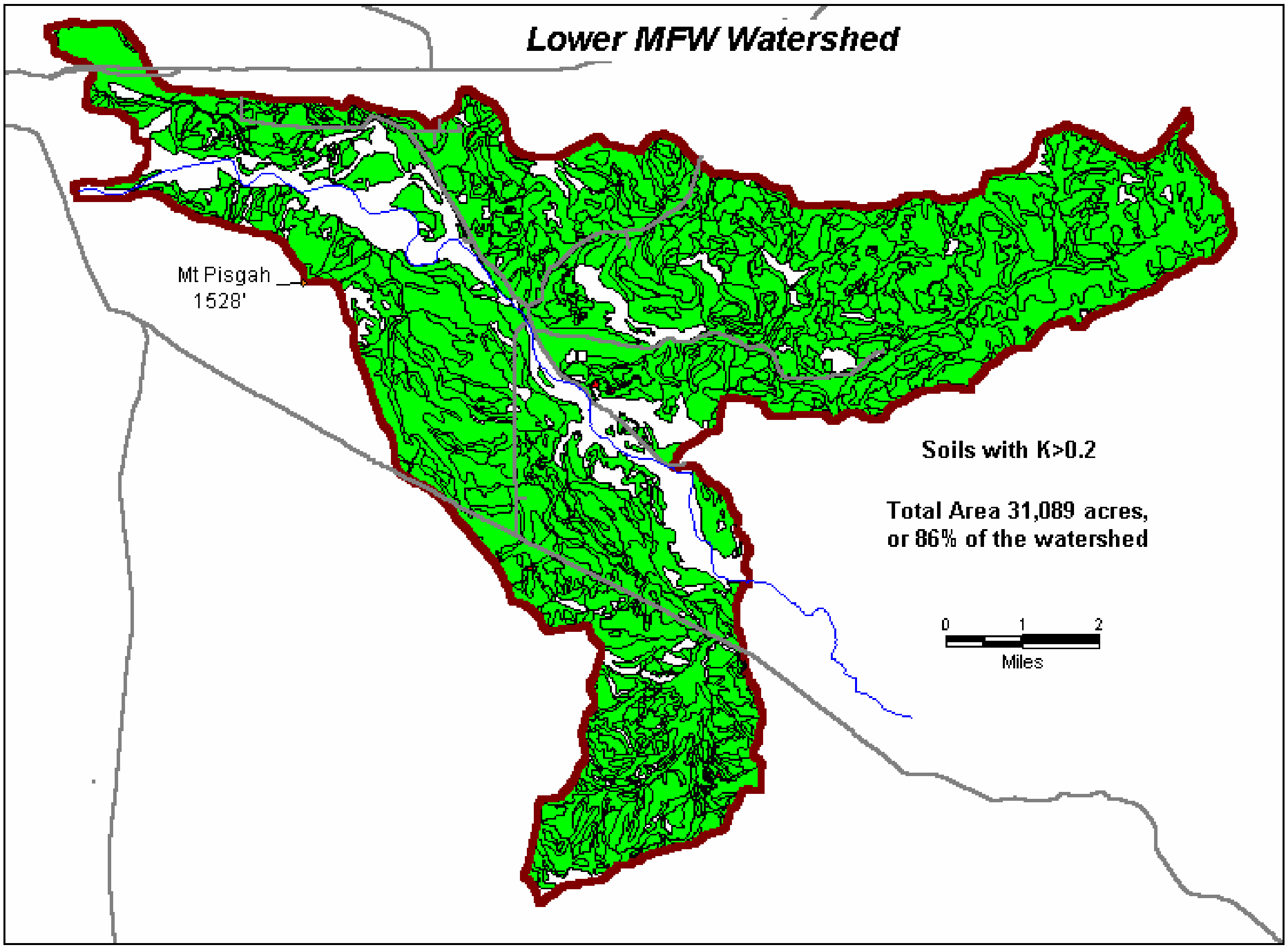
Under undisturbed forest conditions, surface erosion is quite low because enough material is on the forest floor to protect the soil surface. Soil permeability and strength are normally high, and little or no overland flow occurs. Any forest management activity that exposes and/or compacts the soil and reduces infiltration can concentrate surface runoff, thereby accelerating erosion. The type and magnitude of erosion depends on the amount of soil exposed, the soil type, steepness of slope, and treatments following disturbance, such as broadcast burning of slash after a timber harvest. Tree falling can cause increased erosion through soil compaction and surface gouging; while other timber harvest related activities such as road building, log skidding and stacking, and general site preparation can produce major soil surface disturbances that lead to significant increases in surface erosion.

Inherent erodibility of a soil is expressed in a figure known as the K factor. K gives an indication of the soil loss from a unit plot 22m (72 feet) long with a 9% slope and continuous fallow culture. The two most important and closely related soil characteristics affecting erosion are infiltration capacity and structural stability. Infiltration capacity is influenced greatly by structural stability, especially in the upper soil horizons. Other characteristics such as organic matter content, soil texture, the kind and amount of swelling clays, soil depth, tendency to crust, and the presence of impervious soil layers all influence the infiltration capacity. K factor normally varies from near zero to about 0.6. A low K factor of less than 0.2 is usually assigned for well-drained, sandy soils into which water readily infiltrates. Soils with intermediate infiltration capacities generally have a K factor of 0.2-0.3, while the more easily eroded soils with low infiltration capacities will have a K factor of 0.3 or higher (Brady, 1990).

7.3.1.1 Lower Middle Fork Willamette Watershed

Despite being the topographically lowest and flattest of the three watersheds of the Assessment Area, the Lower Middle Fork Willamette has high surface erosion potential. With 11,175 of its total 36,010 acres designated as agricultural land, the Lower Middle Fork Willamette has the highest percentage (31%) of agricultural usage of the Assessment Area. Of this area, only 20% (75 acres) has a slope of 10% or greater; with the remaining 94% (10,465 acres) being relatively flat with a slope of 10% or less. Nonetheless, 86.3% (31,089 acres) of the soils within the Lower Middle Fork Willamette have a K factor of 0.2 or higher. The following map (figure 7-2) reveals the distribution of these soils throughout Lower Middle Fork Willamette.

Figure 7-2. Moderately erodible soils within the Lower Middle Fork Willamette watershed.



This relatively high erodibility factor is linked to the sedimentation production increases that are commonly associated with lands managed for agricultural use (crop and livestock/grazing lands) which include soil compaction, stream bank damage and loss of bank vegetation, increased surface erosion, and increased fine sediment production and delivery to streams.

7.3.1.2 Little Fall Creek Watershed

Located in the western foothills of the Cascade Range within an area that was formed millions of years ago from the volcanism of the Cascade Mountains to the east; the Little Fall Creek watershed exhibits topographic features that are the result of the differential weathering of volcanically deposited waterlain tuff interbedded with flows of andesite and basalt. Ridges are capped by resistant basalt and basaltic andesite flows while the valleys and saddles in the watershed are the result of erosion in the relatively softer tuffaceous and breccia deposits.

The tuffaceous flows and highly weathered soils of the eastern edge of the watershed give way to a more competent andesitic basalt toward the headwaters of Little Fall Creek located in the watershed's eastern portion. These basalts are the source for very episodic and variable sized mass wasting which supplies a large proportion of fines, cobbles, and boulders to the stream channels of the steep upper reaches of the watershed. The soils in this area are shallow and not highly prone to surface erosion processes because of their cobbly loam texture and greater permeability (Weyerhaeuser, 1997). Soils with a stony or cobbly loam and clay texture are the dominant types in the watershed. Being three to five feet in depth and having clay contents of up to 60%, these soils produce a turbid runoff even during low flow events. During the entrainment process clay is not picked up as easily by turbulence as silt, but once entrained it remains in suspension longer. This fine sediment becomes part of the suspended sediment load, but appears not to be a dominant part of the Little Fall Creek watershed substrate. Steeply angled, unvegetated cutslopes in high clay content soils erode by process of sheetwash during periods of heavy rain and ultimately deliver fine sediment to road ditchlines during summer when the heat dries and cracks the soils, and they subsequently ravel into ditchlines.

In general, the soils of the Little Fall Creek watershed exhibit a low to moderate potential for soil erodibility, with K factors ranging from 0.1 to no higher than 0.32 and an average permeability rating of 0.6-2.0 inches per hour.

7.3.1.3 Lost Creek Watershed

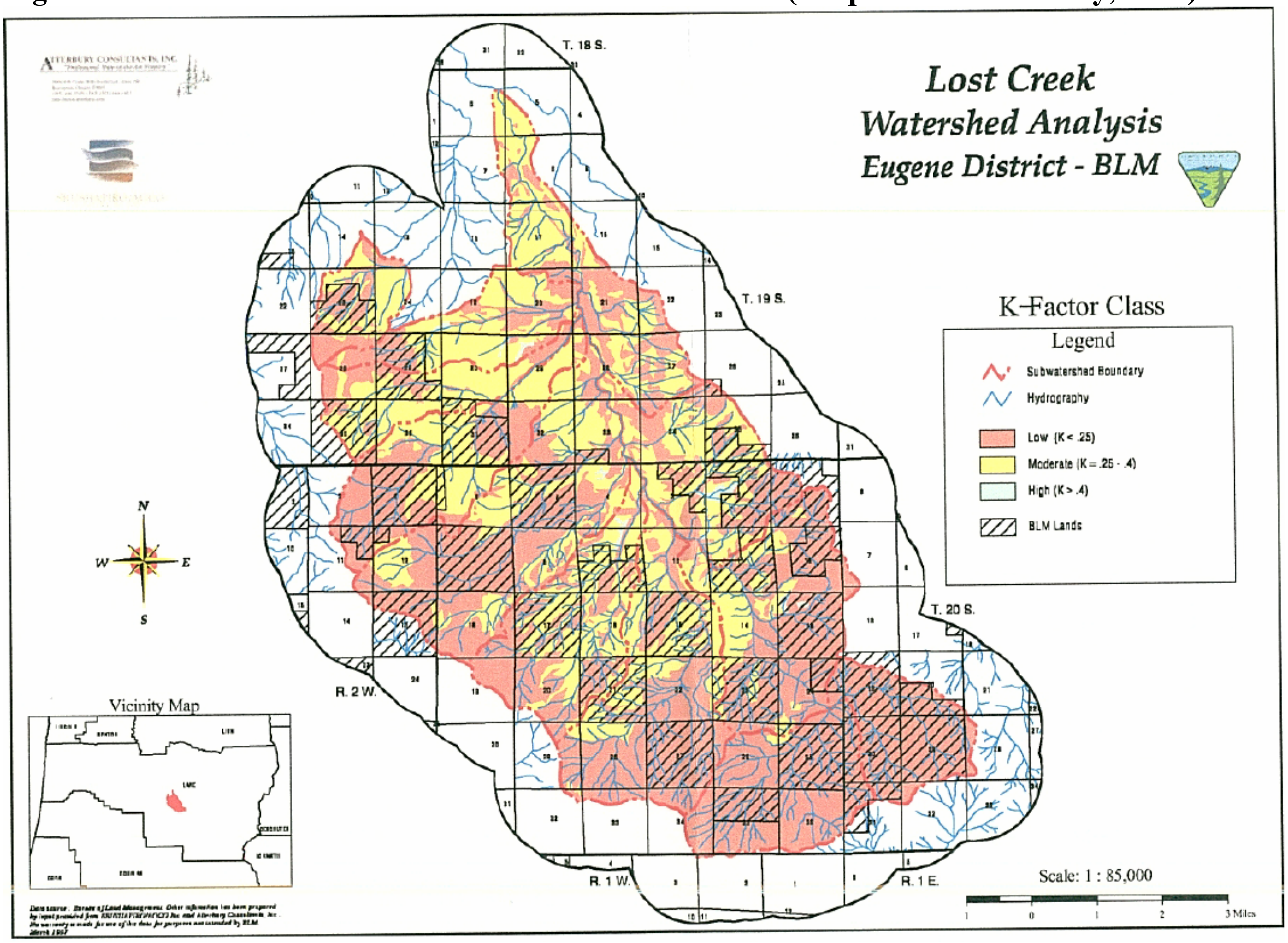
Surface erosion potential for the Lost Creek watershed was determined through application of the Department of Natural Resources manual for watershed analysis. Soil erodibility factors (K factors) were assembled from the Lane County Soil Survey. The survey lists the K factor with an erosion rating for each soil type. The ratings take into account information on vegetative cover, topography, climate and infiltration, permeability, and texture of the soil. The following table (table 7-2) summarizes potential erodibility ratings for the Lost Creek watershed.

Table 7-2. Erodibility Ratings Based on K factor and Slope (Shapiro and Atterbury, 1997).

Slope Class	K<0.25 (Not Easily Detached)	0.25<K>0.40 (Mod. Detachable)	K>0.40 (Easily Deatched)
Gently<30%	Low	Low	Moderate
Moderate 30-65%	Low	Moderate	High
Steep>65%	Moderate	High	High

As summarized in figure 7-3, approximately 17.6 acres (<1%) of the soils in the watershed exhibit high surface erosion potential. More than half of the watershed is dominated by highly productive and resilient soils that are generally deep with high levels of organic matter, nutrients, and plant-available moisture. Unless damaged, the surface organic layer and the high infiltration capacity of forested soils greatly minimize the potential for surface erosion. The majority of the soils exhibit moderate (approximately 2,652 acres (7.5%)) and low (approximately 32,685 acres (92%)) surface erosion potential (Shapiro and Atterbury, 1997).

Figure 7-3. K-Factor classes of the Lost Creek watershed (Shapiro and Atterbury, 1997).



7.3.2 How does Mass Failure Affect the Assessment Area?

Mass failure (synonymous with mass wasting or landslides) is a geomorphologic event that refers to the dislodgement and downslope transport of geologic material (soil and rock) under direct gravitational forces (Ritter, 1986). Mass failure is a naturally occurring geologic process that plays a significant role in shaping the habitat and water quality of all watersheds. However, natural resource practices involving forest management and agriculture can be a key contributor to mass failure which can have significant detrimental effects on water quality. Forest road building, timber harvesting, and recreational activity are important causal mechanisms of mass wasting which need to be addressed in the discussion of watershed health for each watershed within the Assessment Area. Mass failures, either naturally occurring or associated with land management activities, can deliver significant amounts of sediment to stream channels. Specific areas within the Assessment Area with the highest potential for mass failures will be identified later in this section. Slope gradient is one of the most influential factors affecting landslide initiation. In general, the steeper the slope, the more likely it is to fail, but the gradient at which different geologic materials and landform configurations fail varies considerably. Areas with the highest potential for mass failure are those with slopes in the 30-50% range and/or areas where loss of root strength associated with vegetation disturbance has occurred. Furthermore, stream sections classified as source reaches are strong candidates for mass wasting due to their steep slopes and channel gradients in excess of 20% (WPPB, 1997).

7.3.2.1 Lower Middle Fork Willamette Watershed

Due to its relatively flat topography and lower density of steep (>40%) slopes perched on unstable geologic materials, the Lower Middle Fork Willamette watershed contains the smallest area considered to be of high potential for mass wasting than any other watershed within the Assessment Area. According to data from the Oregon Department of Forestry (ODF), less than ten percent of the Lower Middle Fork Willamette poses a moderate or high debris flow hazard. The bedrock appears generally undeformed, except for minor folding and minor north-south faulting in the Hills Creek subwatershed on the steeper east side of the Lower Middle Fork Willamette.

7.3.2.2 Little Fall Creek Watershed

The bedrock geology of the Little Fall Creek watershed consists entirely of volcanic rocks with a wide variability in characteristics which range from igneous intrusions and nearly horizontal andesite and basalt flows that are erosion resistant and can support steep slopes; to tuffs, breccias and sediments that are poorly cemented and therefore much more prone to erosion and mass wasting. Except for some minor folding, the bedrock appears generally undeformed. West of Sturdy Creek, alteration and weathering of much of the bedrock has made it especially prone to continued deep-seated mass failure (landslides). Therefore, the subwatersheds of Sturdy Creek, Walker Point, and Upper Little Fall Creek exhibit the highest landslide per square kilometer density of all the subwatersheds within the Little Fall Creek watershed (Weyerhaeuser, 1997). The geologic units Tub and Tu represent 83% of the Little Fall Creek watershed and contribute 88% of the landslides that occur in the area. These failures frequently occur near the zone of contact between the two units. The geologic unit Qls (unstable ancient landslide deposits) comprises a very small portion of the watershed. The quantity of landslides and sediment delivered to streams is reflected in both the relative resistance of the geologic units to erosion and to the landforms within the watershed. Refer to the Assessment Area geology map for geologic unit distribution in the watershed.

Eighty-nine percent of the total sediment delivered from landslides within the Little Fall Creek watershed was initiated on slopes greater than 40% (Weyerhaeuser, 1997).

Road related landslides produced an estimated 82% of the total volume of sediment delivered to Little Fall Creek's streams by mass failure for the period of record. Nineteen road related landslides were triggered by undercutting and oversteepening of unstable slopes above the road prism. In some cases road drainage may have increased pore water pressure at the base of the cutbank, further reducing the slope stability. Only three failures were documented at stream crossings and may have been triggered by insufficient culvert size or by the blocking of culverts with debris.

A vast majority (81%) of Little Fall Creek's identified landslides occurred within eighteen years of timber harvest activities (Weyerhaeuser, 1997). This timing suggests that in the majority of cases the slope stability was reduced by harvest activities. A key factor in this process may be root strength reduction, as corroborated by research indicating that the root strength of the dominant watershed species (Douglas Fir) declines to a minimum between five and twenty years following harvest (as cited in Weyerhaeuser, 1997; Burroughs and Thomas 1977, Krogstad 1996, Ziemer 1981). In addition, shallow subsurface pore water pressure may be increased by reduction in water transpiration following removal of vegetation during harvest.

7.3.2.3 Lost Creek Watershed

Due to the bedrock geology and topography prevalent in the watershed, Lost Creek exhibits the highest potential for mass failures of the three watersheds that comprise the Assessment Area. Debris slides, small rotational failures, and loss of soils on steep areas of weathered rock are the main mass wasting processes. Loss of the protective organic layer and exposure of steep road cuts and fill slopes on unstable areas greatly increases the potential for mass wasting (Shapiro and Atterbury, 1997). Old evidence of small slumps and instability occur mainly in areas with weathered tuff and breccia bedrock. Small unstable areas with weathered sedimentary and igneous rock also occur within the watershed. Some small areas of past debris flows occur along stream channels. Recent evidence of debris flows and erosion, mainly associated with road crossings and undersized or plugged culverts, was observed along drainageways in the watershed. Several small areas of road cut and fill failures on steep slopes were also observed, mostly in areas with tuff and breccia or with weathered sedimentary bedrock. The majority of the watershed (60%) has a low mass wasting potential, due to the area's domination by competent igneous and sedimentary bedrock. However, 18% of the soils in Lost Creek have moderate potential, and the remaining 22% have high mass wasting potential (Shapiro and Atterbury, 1997). The locations of mass wasting events closely correspond to areas identified as exhibiting high mass wasting potential and are identified on the geologic map as Qls, areas of past landslide and debris flow deposits. A detailed geologic inventory or detailed mass wasting inventory may be needed in the future to determine precisely the extent and location of unstable landforms within the watershed. (Shapiro and Atterbury, 1997)

7.3.3 How does Sediment Contribution from Roads Affect the Assessment area?

In many watersheds, sediment delivery from roads can found at the top of the list of all major sediment contribution sources. Forest roads have been identified as a leading cause of increased sedimentation to stream systems. Roads are generally impervious surfaces with poor permeability rates that can cause accelerated runoff and bypass longer, slower subsurface routes. This impairs the natural filtration that the undisturbed forest floor otherwise provides the watershed system. The longevity of the alteration to the hydrologic process resulting from roads is as permanent as the road. Until the road is removed and natural drainage patterns restored, the road will continue to affect the routing of water through the watershed. The well developed and highly traveled road system of the Middle Fork Willamette Assessment Area contains a wide variety of road ages and types, many of which are unstable or in poor condition and in need of maintenance. Road sediment production and delivery involves many factors and processes including road surface, width, profile, maintenance practices and use level, ditch infeed lengths, and proximity to a stream channel. Determination of actual road sediment contribution requires the evaluation of each of these factors for each road segment. Since complete data for all three watersheds within the Assessment Area are not available, certain assumptions are made in order to estimate the relative importance of road sediment contribution within each of the watersheds.

The first assumption combines all paved and unpaved roads into a single "unpaved" category, negating the disparity of sediment contribution between paved, gravel and rocked roads which contribute considerably less sediment than an unimproved dirt or native road. In addition, it is assumed that trails, paved roads, and closed roads are not likely to be significant sediment contributors. Furthermore, it is assumed that the greatest amount of sediment would be delivered from road segments that fall within 200 feet of a stream. Despite the obvious sedimentation contribution variability that may occur between road segments that are 20 feet from a stream versus segments located 200 feet from a stream, this distance has been adopted as a logical break point to identify the road segments that have the potential for the bulk of sediment delivered to streams (OWEB, 1999). Verification through field inventories of road-generated sediment delivery as well as more detailed analyses using GIS is a possible way to address the limitations presented in this screening-level assessment.

7.3.3.1 Lower Middle Fork Willamette Watershed

The road system within the Lower Middle Fork Willamette watershed contains a high density of streamside roads, many of which are unpaved. This close proximity of roads to a stream channel creates situations where sediment from road drainage flows directly into the channel, even places where relief drainage structures have been installed. See figure 7-4 for map of roads within 200' of streams. The potential for roads within 200 feet of streams to deliver sediment is due to the limited forest floor surface area needed for adequate filtration of sediment discharge between the road segment and the stream channel. Furthermore, lack of vegetation in the ditchlines via regular ditch cleanings and brush removal allows erosion of the ditchline itself and unfettered transport of road sediment. In addition, there are 299 stream crossings by unpaved roads in the Lower Middle Fork Willamette. See figure 7-5 for the distribution of road-stream crossings in Lower Middle Fork Willamette. This is a significant source of sediment production because most, if not all, of the runoff and fine sediment generated on the road prism is delivered directly to the stream channel. Long tread flowpaths and ditch infeed lengths along the ditchline generate and deliver fine sediment from the cutslope and tread. In addition, grades frequently drain from both directions of the road to a live stream crossing, causing fine sediment to be delivered directly into a stream channel.

Figure 7-4. Roads within 200' of Streams for Lower Middle Fork Willamette watershed.

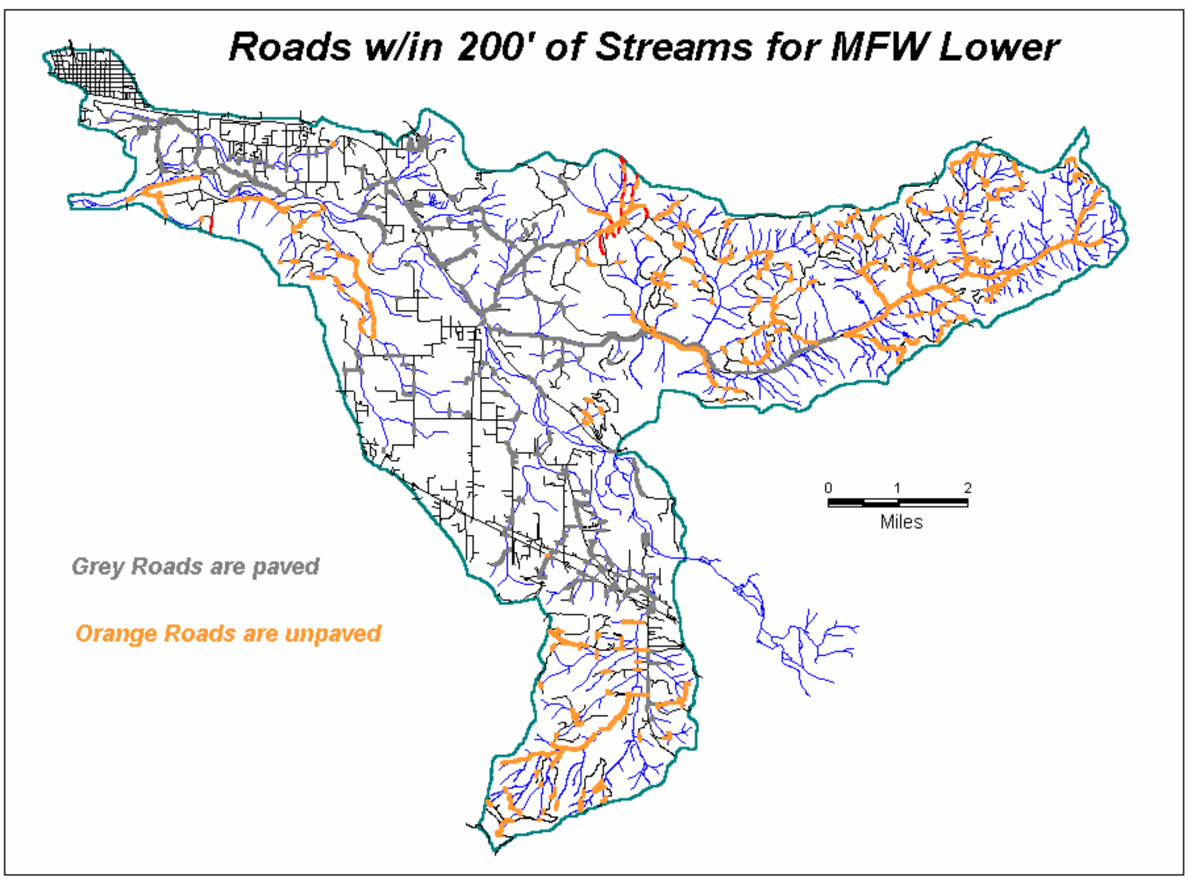
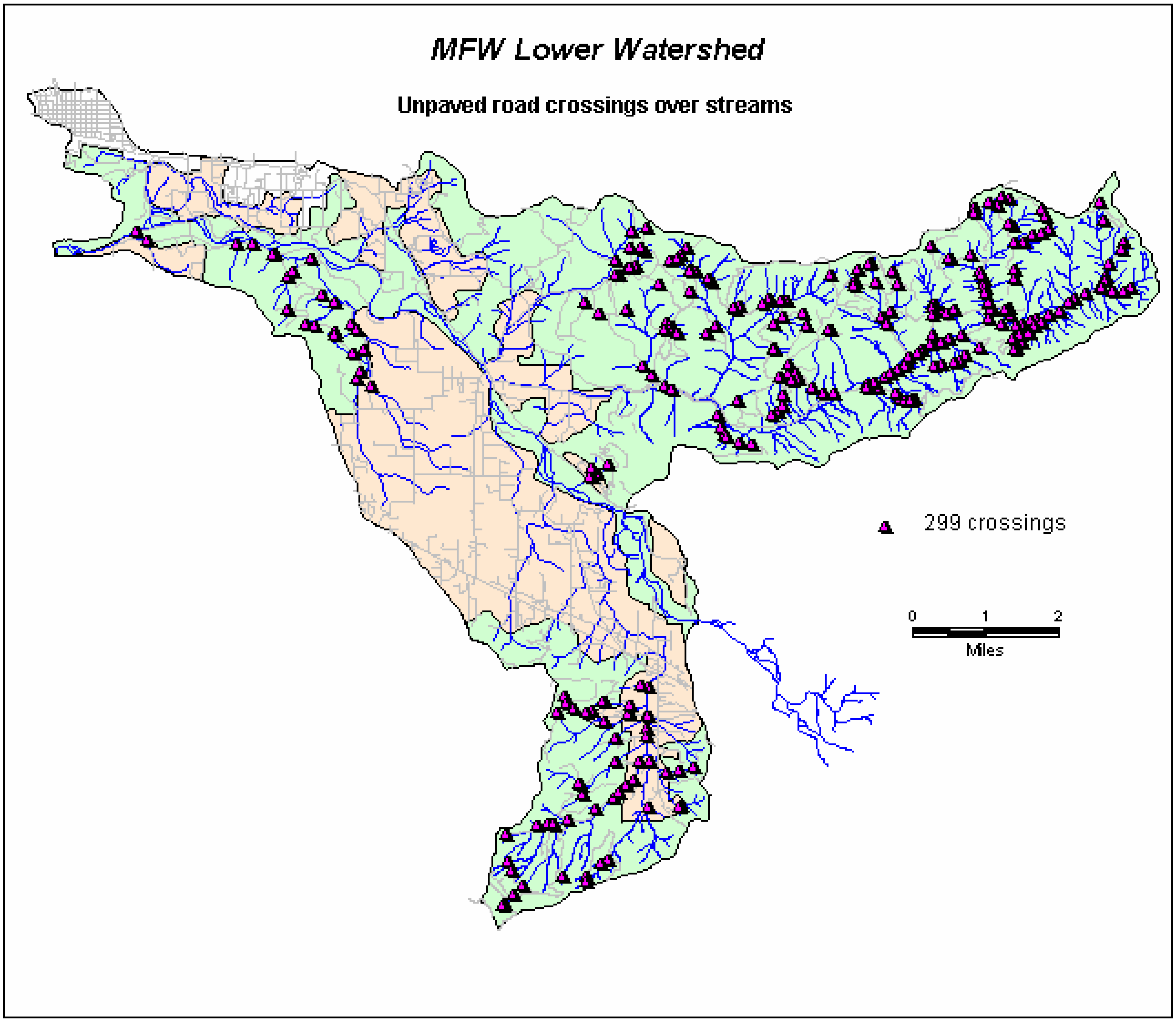


Figure 7-5. Unpaved road-stream crossings within Lower MFW watershed.



The heavy traffic on some of the gravel roads of the Lower Middle Fork Willamette greatly increases erosion through compaction of road tread. Erosion of the tread is compounded as ruts in the treadline develop which tend to channel and trap water instead of allowing it to infiltrate or exit the road prism through runoff.

7.3.3.2 Little Fall Creek Watershed

Sediment contribution from roads within the Little Fall Creek watershed is significant and is affected by a number of factors: current traffic conditions on each road segment (mainline-heavy, primary/secondary moderate, spur-light, abandoned/no use), slope positions of each road segment (streamside, midslope, ridgetop), and by road surfacing type (soft rock, crushed gravel, dirt, vegetated, paved). Abandoned dirt roads and ground based dirt logging roads have the potential to deliver fine sediment to a stream when bare soils are either compacted or in close proximity to stream channels or stream delivery points, such as road stream crossings. The Little Fall Creek watershed contains a total of 838 stream crossings, 816 of which are unpaved roads in forested areas. One hundred sixty-seven of these crossings are by abandoned roads. Refer to figure 7.6 to view the distribution of road-stream crossings within the Little Fall Creek watershed.

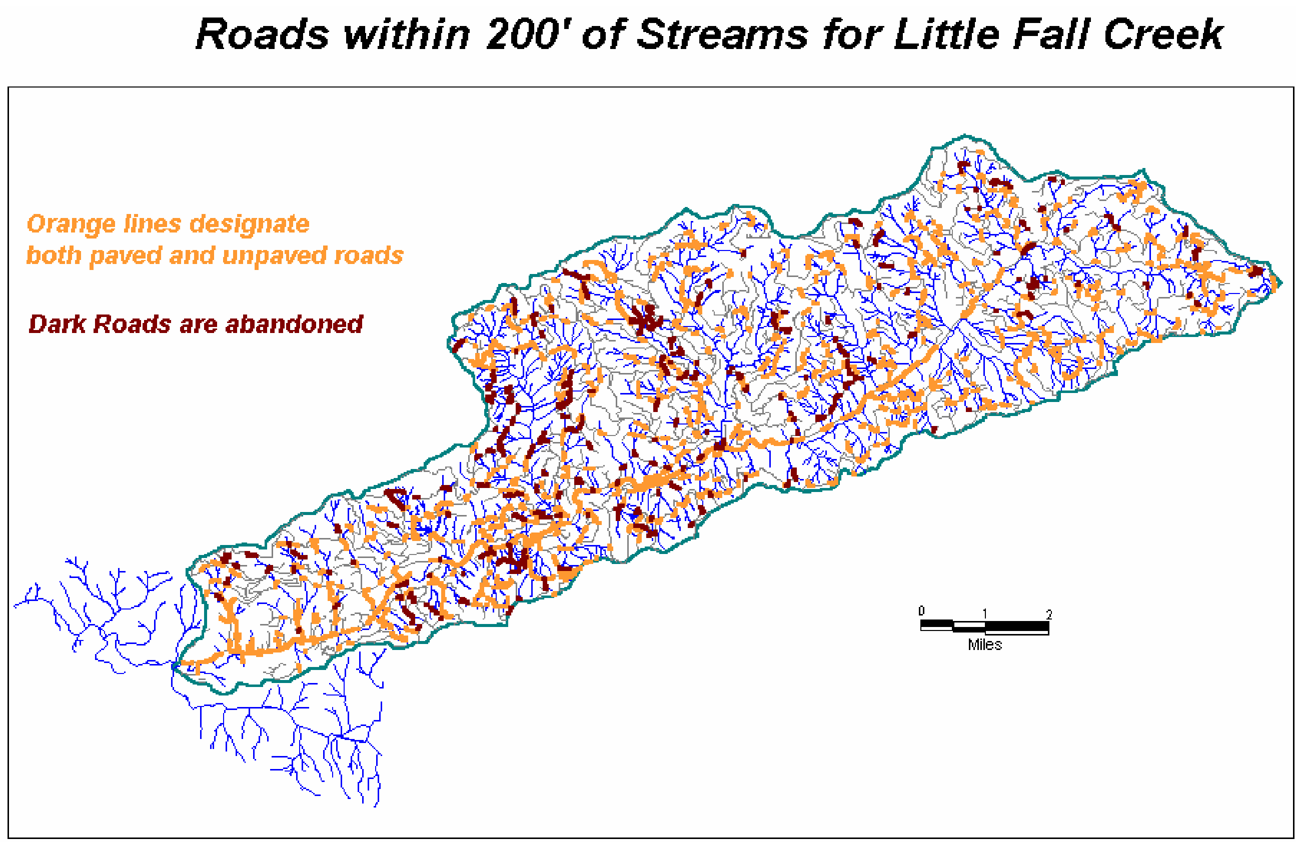
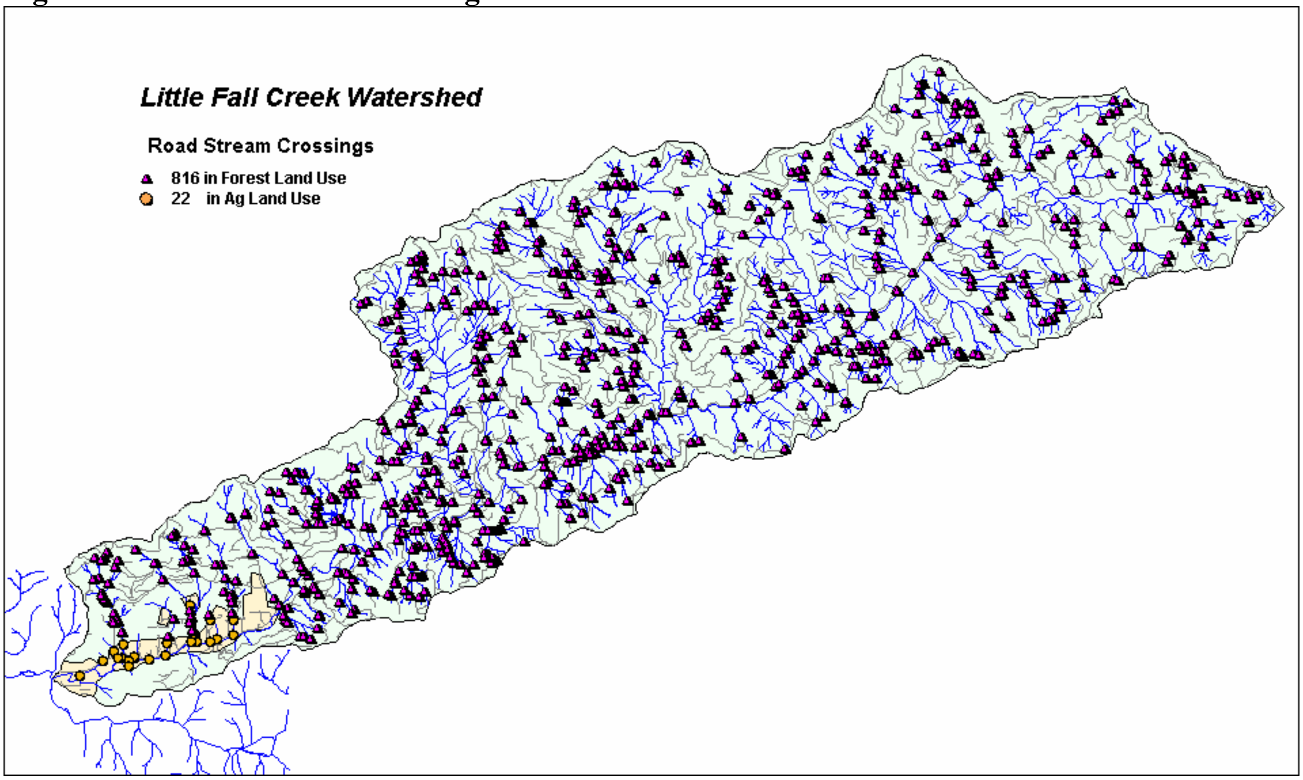


Figure 7-6. Roads within 200' of streams for Little Fall Creek watershed.

Compaction of the soils frequently occurs along the tread of dirt and gravel roads and has the potential to be a significant source of fine sediment. Field observations within the watershed have shown that during high flow, sediment is delivered to a road ditchline that carried the fine sediment to a stream channel. The Little Fall Creek watershed contains fewer than fifty miles of streamside road, yet these roads deliver significantly more sediment proportionately than all other miles of road within the watershed, especially during heavy haul (see figure 7-6). During periods of heavy haul, significant fine sediment yields from roads are produced. This is largely due to the fact that most mainlines are streamside roads. However, under most haul conditions, the largest total volume of sediment delivery is produced by midslope roads because of the higher number of miles of road in this position in the Fall Creek watershed (Weyerhaeuser, 1997).

Figure 7-7 Road-Stream crossings within the Little Fall Creek watershed.



7.3.3.3 Lost Creek Watershed

Sediment yield from mass wasting, debris torrents, and surface erosion are likely contributing to the overall sediment budget for the Lost Creek watershed. However, road-related sedimentation is probably the most significant source of human-caused sediment increases in the watershed as well as the source most readily addressed through management. Of these, gravel roads have been identified as the primary source of road-related sedimentation in the watershed (Shapiro and Atterbury, 1997). See figure 7-8 to view the distribution of roads within 200 feet of streams in Lost Creek watershed. Figure 7-9 illustrates the road-stream crossings for the watershed. Road segment groups, based on surface and type and use, were analyzed to produce rate estimates of sediment delivery for each road segment type. The rates were then applied to the segments of that type in each subwatershed. Road erosion potential was determined from several attributes: the relative areas of road in each prism component; the inherent erodibility of the parent material on which the road was constructed; the protection provided by cover materials such as vegetation and surfacing; and the level of traffic use. Table 7-3 summarizes the predicted sediment yields from roads within the watershed.

Figure 7-8. Roads within 200' of streams within the Lost Creek watershed.

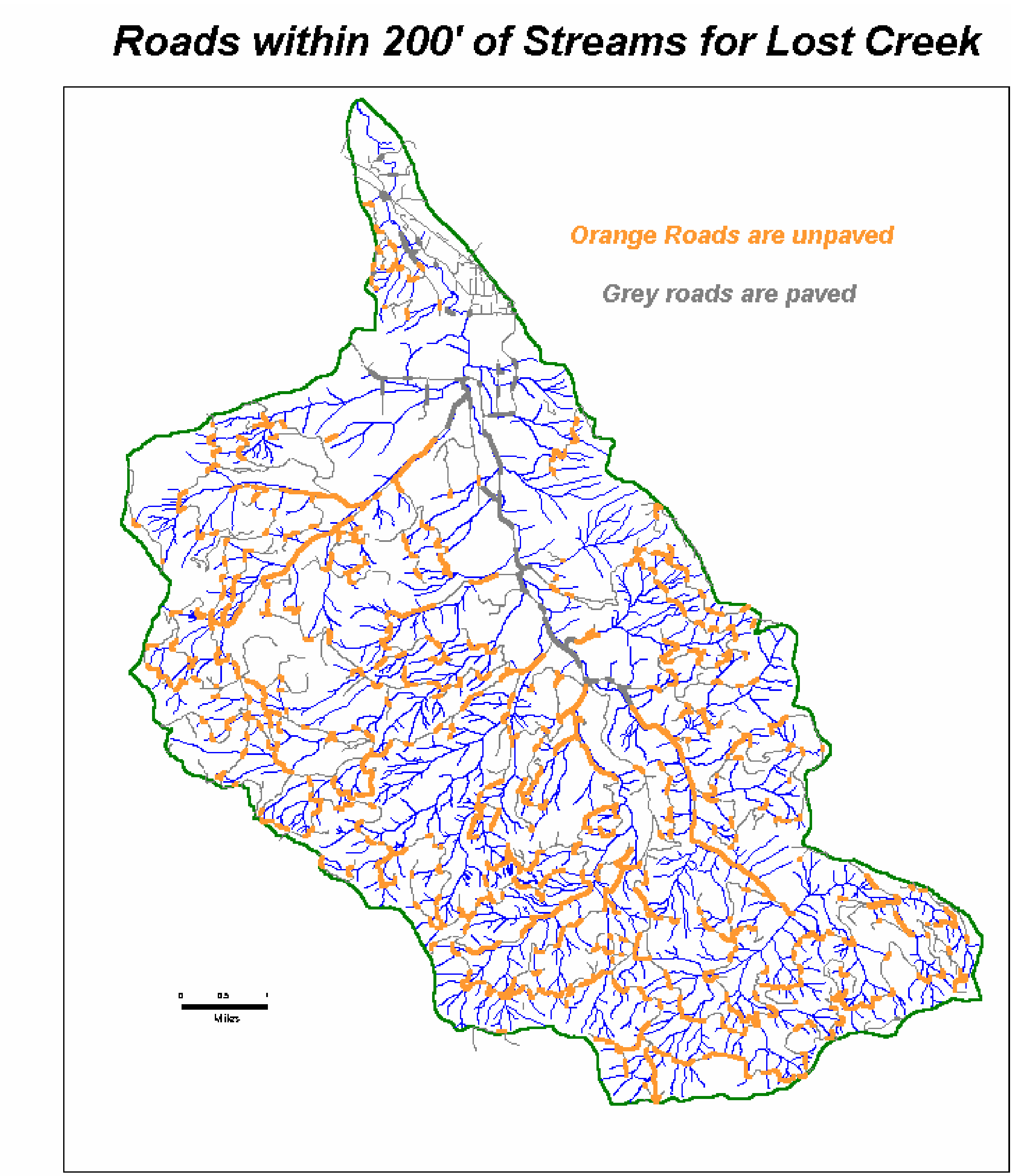


Figure 7-9. Road crossings over streams within Lost Creek watershed.

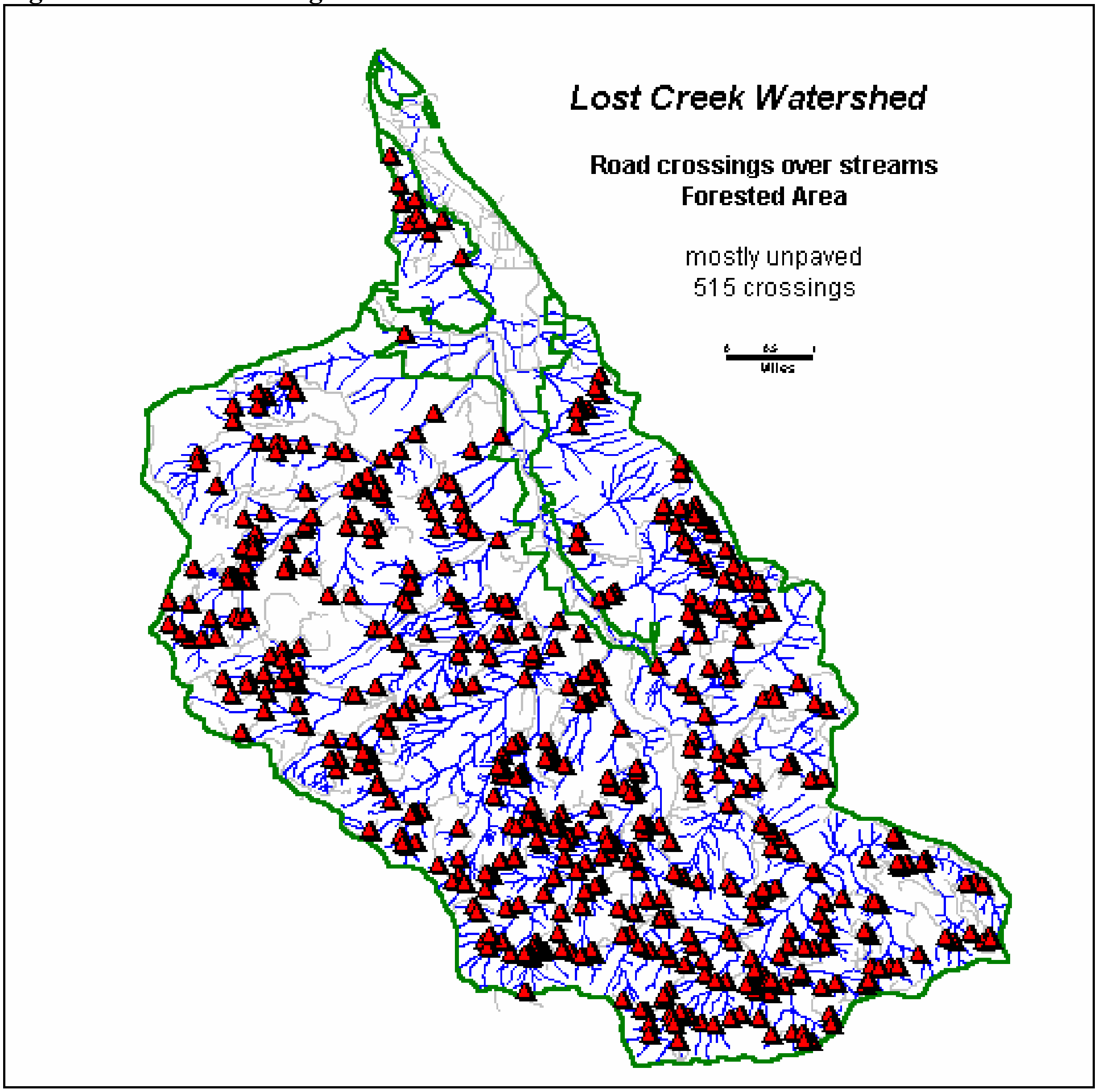


Table 7-3. Estimated background and road-related sediment yield in tons per year for subwatersheds in the Lost Creek Watershed (Source: Shapiro and Atterbury, 1997).

Subwatershed	Background Sediment Yield (tons/yr)*	Road Sediment Yield (tons/yr)*	Total Sediment Yield (tons/yr)*	Relative Increase Factor (Total/Background)
Buckhorn	343	210	533	1.6
E. Lost	158	114	272	1.73
Gosage	221	703	923	4.18
Guiley	334	908	1,242	3.71
Middle/Carr	254	958	1,212	4.77

Subwatershed	Background Sediment Yield (tons/yr)*	Road Sediment Yield (tons/yr)*	Total Sediment Yield (tons/yr)*	Relative Increase Factor (Total/Background)
Mt. June	156	103	259	1.66
N. Anthony	57	624	681	11.94
Rattlesnake	43	150	193	4.47
S. Anthony	110	1,041	1,150	10.45
S. Dexter	118	85	204	1.72
U. Lost	294	102	396	1.35
Wagner	55	126	181	3.3
Total/Average	**2,143**	**5,124**	**7,267**	**3.39**

*Based on methods described in Washington Forest Practices Board, 1995.
Standard Methodolody for Conducting Watershed Anaylsis-Version 3.0.
Department of Natural Resources, Forest Practices Division, Olympia, Washington.

Based on this analysis, potential increases in sedimentation due to roads could be significant within the Lost Creek watershed. It should be stated that, due to the assumptions and limitations inherent within the road sedimentation model, these numbers should not be viewed as hard and accurate figures but as relative values generated to help highlight possible problem areas. Relative increases range from 1.4 fold to 12 fold above naturally existing background sedimentation rates. However, based on the observations made by Giustina Resources and the personal knowledge of their road system, annual increases for Gosage, Carr, and Guiley Creeks appear to be overestimated (Personal Correspondence, June 2002, staff of Giustina Resources).

7.3.4 How does Channel Erosion Contribute to Sedimentation in the Assessment Area?

Channel erosion refers to sediment removed from the bed and banks of the channel as flows fluctuate and streams migrate laterally or incise vertically. Channel erosion is a natural process and can result in aquatic habitat improvement through the introduction of spawning gravels and the creation of refuge sites in the form of undercut banks. However, excessive channel erosion is extremely detrimental to the aquatic system and contributes to the deposition of excessive amounts of fine sediment to the channel bed which subsequently compromises the amount and quality of available spawning gravels. Human activities involving timber harvesting and agricultural practices have significant impacts on channel erosion throughout much of the Assessment Area. Forest practice guidelines require buffer zones of undisturbed habitat adjacent to streams of a certain order, but smaller headwater streams are commonly entirely consumed within clearcuts and left with no substantive vegetation on their banks, resulting in active channel erosion in many source streams throughout the Assessment Area. In the lower portions of the Assessment Area, especially in the

Lower Middle Fork Willamette where agricultural use comprises 31% of the watershed, livestock grazing is a significant source of sedimentation and channel erosion. Causal mechanisms linked to cattle such as soil compaction and the removal of streambank vegetation result in active erosion along unfenced stream segments as well large amounts of sediment introduced directly to the channel. The fish habitat inventory section of this report notes specific sections of active streambank erosion along sections of Little Fall Creek and Lost Creek (Ecosystems Northwest, 2001). Further investigation as to specific human-related causes of channel erosion may be warranted as part of the watershed restoration process within the Assessment Area.

7.4 RECOMMENDATIONS

In order to prioritize actions that would be most beneficial with respect to sediment reduction, it is first necessary to summarize the key sediment sources for each of the watersheds within the Assessment Area:

- Surface Erosion
- Mass Failure
- Sediment Contribution from Roads
- Channel Erosion

Management practices aimed at sediment reduction in Assessment Area include:

- Ensure continued training for appropriate field personnel in identifying topographical/geological features that accompany areas of high risk. Utilize a geologist or qualified slope stability specialist when risk is indeterminate.
- Consider alternative timber harvest plans when operating in high risk areas. These may include designation of partial, selective, or no cut areas, suspension logging, falling and yarding away from unstable areas, keeping a high density of leave trees in downslope draws from high landslide potential areas to help arrest a failure and/or provide large woody debris to the channel if failure does occur.
- Examine the possibilities of road upgrades. Road upgrades include additional culvert installation, ditch relief structures 150 to 200 feet prior to stream crossing when topography allows, road crowning, and cutslope revegetation between the last ditch relief culvert and the

stream crossing. Installation of sediment catch basins would help to capture runoff and/or direct flow to filter through the forest floor.

- While road related sediment contributions have likely declined over time due to road closures, culvert replacements, and better road maintenance efforts, the specific role of roads in the overall sediment picture is not known (WPN, 2002). Restriction of general public access to closed and/or dirt roads with signs, barriers, and gates will help to maintain drainage integrity and reduce damage during periods of wet weather.

- Stabalizing cut and fill slopes, increasing the number of ditch relief culverts to reduce delivery of sediment from cutslope ditchlines, and replacing or repairing culverts identified as erosion hazards are key steps in reducing road related sedimentation. Establishing a complete, current inventory of all culverts within the watershed and mapping identified problem areas would greatly facilitate this process.

- Priority should be given to roads when considering restoration opportunities. The Lost Creek Watershed Analysis includes a breakdown of erosion potential by road segments and should be used to prioritize and focus initial restoration efforts. Road decommissioning should be considered where cost-effective road erosion control measures have been exhausted, and especially in areas where roads bisect riparian reserves. Seasonal road closures during wet weather should be maintained and strictly enforced through implementation of signs, gates, barriers, and water bars.

- Due to its high percentage of land use designated as agricultural; erosion and sedimentation reduction actions for the Lower Middle Fork Willamette watershed should focus on finding effective methods of mitigating damage to stream channels and soils on farmland. Poor grazing practices have been shown to increase soil compaction, reduce streambank stabilization via removal of vegetation, and increase sediment delivery to streams. Encouraging landowners to fence off sensitive riparian areas and to plant vegetation along denuded, actively eroding banks are obvious but effective restorative methods.

- In order to most efficiently focus any future restoration activities, it may be useful to first conduct a thorough survey of the agricultural lands in the watershed to identify and map key areas of concern that exhibit high erosion potential and show signs of stream channel delivery of sediment. Working closely with farmers and landowners to develop voluntary conservation resource projects could be a beneficial means of gaining public cooperation and support.

8.0 REFERENCES

Altman B, C Benson, I Waite. 1997. Summary of information on aquatic biota and their habitats in the Willamette Basin, Oregon, through 1995. Water-Resources Investigations Report 97-4023. U.S. Geological Survey Portland, OR.

Andrus C, J Walsh. 2002 (draft). Aquatic and Riparian Habitat Assessment for the Eugene-Springfield Area. available at ftp://ftp.ris.lane.or.us/cedp/outgoing/MECT/Assessment/

Berry J, D Plawman, J Stark. 1993. US Forest Service Little Fall Creek survey notes. On file at Oregon Department of Fish and Wildlife Office, Springfield, OR.

BLM (Bureau of Land Mangement) 1997. Lost Creek watershed analysis. Contracted with SRI/Shapiro/AGCO, Inc, Portland, OR. Bureau of Land Management, Eugene, OR

Christry JA, E Alverson, M Dougherty, S Kolar, L Ashkenas, P Minear. 1999. Presettlement vegetation of the Willamette Valley, Oregon, compiled from records of the General Land Office, 1851-1909. Oregon Natural Heritage Program, Portland, OR.

City of Springfield. 1998. GIS layers on file at City of Springfield offices, Springfield, OR .

Connolly PJ, MG Wade, JM Hutchison, JS Ziller. 1992. Middle Fork Willamette subbasin fish management plan. Oregon Department of Fish and Wildlife.

Dykaar. 2000. A Hydrogeomorphic Index for River-Floodplain Habitat Assessment in the Willamette Basin. Report prepared for the Oregon Department of Fish and Wildlife.

Erickson DL. 1983. US Forest Service Little Fall Creek Survey Notes. On file at Oregon Department of Fish and Wildlife Office, Springfield, OR.

Foster SC, CH Stein, KK Jones (no date) A guide to interpreting stream survey reports. Aquatic Inventories Project, Oregon Department of Fish and Wildlife, Portland, OR

Hanavan, Morton, Parkhurst, Wilding. 1938. US Fish and Wildlife Service Lost Creek survey notes. On file at Oregon Department of Fish and Wildlife Office, Springfield, OR.

Hutchison, Hooten, Sims. 1984. ODFW Little Fall Creek survey notes. On file at Oregon Department of Fish and Wildlife Office, Springfield, OR.

Moore, KM, KK Jones, JM Dambacher. 1997. Methods for Stream Habitat Surveys. Information Report 97-4. Portland. Oregon Department of Fish & Wildlife.

ODFW no date. Little Fall Creek survey notes from 1936. Transcribed and on file at Oregon Department of Fish and Wildlife Office, Springfield, OR Ross B, D Moser. 1990. US Forest Service Little Fall Creek survey notes. On file at Oregon Department of Fish and Wildlife Office, Springfield, OR.

Orr, E.L., Orr, W.N., Baldwin, E.W. 1992. Geology of Oregon, 4th edition, Kendall/Junt Publishing Company.

OWEB(Oregon Watershed Enhancement Board), 1999, Oregon Watershed Assessment Manual.

Ritter, D.F., 1986, Process Geomorphology, 2nd edition, Southern Illinois University at Carbondale, Wm. C. Brown Publishers.

Ross B, D Moser. 1990. Little Fall Creek survey report. On file at Oregon Department of Fish and Wildlife Office, Springfield, OR.

SRI/Shapiro/AGCO Inc. and Atterbury Consultants Inc., 1997. Lost Creeek Watershed Analysis, McKenzie Resource Area, Eugene District, Bureau of Land Management.

Thompson KE, JM Hutchison, JD Fortune Jr, RW Phillips. 1966. Fish resources of the Willamette basin. Willamette Basin Review, App.D: Fish and Wildlife; Sect. II: Present Status. Oregon State Game Commission, Portland.

Thompson KE. 1964. A physical inventory of streams in the Upper Willamette watershed above the confluence of Middle and Coast Forks of Willamette River. Oregon State Game Commission, Portland, OR.

US Army Corps of Engineers. 2000. Biological assessement of the effects of the Willamette River Basin Flood Control Project on listed species under the Endangered Species Act. Final document, submitted to National Marine Fisheries Service, U.S. Fish and Wildlife Service. [Goodreview of dams and operations, fish species, habitat, and effects of dams in the Willamette basin. Good review of published literature. Large document, but available in PDF format on

internet. See especially chapter 5 for effects]
https://www.nwp.usace.army.mil/pm/e/WillametteBA/WillametteBA.htm

United States Geological Survey (USGS). 1964. Geologic Map of the Eugene-Springfield Area, Southern Willamette Valley.

USGS. 1969 and 1970. Water-Level Map of Eugene-Springfield Area Southern Willamette Valley, Oregon.

USGS. 1973. Groundwater in the Eugene-Springfield Area, Southern Willamette Valley, Oregon.

USDI, Bureau of Land Management. 1996b. Vida/McKenzie Watershed Analysis. Bureau of Land Management, Eugene, Oregon.

Walker, G.W., and MacCleod, N.S., 1991, Geologic Map of Oregon. USGS, scale 1:500,000.

Wevers M, D Nemeth, J Haxton, S Mamoyac. 1992. Coast Range Subbasin Fish Management Plan. Oregon Department of Fish and Wildlife, Northwest Region, Corvallis, OR.

Weyerhaeuser 1997. Little Fall Creek / Hills Creek watershed analysis. Weyerhaeuser, Springfield, OR. Copy of report on file at ODFW Springfield, OR.

WFPB. 1997. Standard Methodology for Conducting Watershed Analysis, version 4.0. Washington D.N.R., Olympia, Washington.

Willamette National Forest. 1984. Memo regarding Little Fall Creek stream enhancement, dated 12/27/94. On file at Oregon Department of Fish and Wildlife Office, Springfield, OR.

WPN (Watershed Professionals Network). 2002. Trout Creek Watershed Assessment. Report prepared for the Bonneville Power Administration, Portland, OR.

WPN. 1999. Oregon Watershed Assessment Manual. Pepared for the Oregon Watershed Enhancement Board, Salem, OR.

9.0 APPENDICES TO THE FISHERIES REPORT

9.1 HABITAT USE AND LIFE HISTORY OF NATIVE FISH WITHIN THE LOWER MIDDLE FORK WILLAMETTE

Appendix 9-1: Habitat use and life history of native fish in the Lower Middle Fork Willamette analysis area.

Common name	habitats used
cutthroat trout	Cutthroat trout occur at low to moderate densities throughout analysis area and use mainstem and headwater streams up to gradients of 15 %. Cutthroat seem to avoid the first three reaches of Lost Creek where water is either of slow velocity or too warm in summer. Cutthroat prefer pools. Depth can be shallow as long as there is overhead cover or woody debris for hiding. Stream velocities of 1 ft per second is preferred by adults, fry use slower margin areas or side channels. Large adults often are found in either the deepest parts of pools, in hiding areas along banks with overhead cover, or will feed at head of pools or in riffles. Juveniles may be pushed out of feeding slots by rainbow and may use the margins, and smaller tributaries. Adults (as small as 4 inches but commonly over 6 inches) spawn in clean, sorted, smaller gravels (e.g., ¼ inch diameter and up to 4 inches in diameter) in smaller streams. Small individuals in the headwaters may remain in the same pool for years; other larger individuals may migrate some distance to downstream larger habitats in the Middle Fork. Sources: authors pers. obs. but see also: http://www.orst.edu/Dept/ODFW/conference/cuthab.html
rainbow trout / winter steelhead	Rainbow trout occur naturally as a resident trout. Anadromous steelhead were first introduced by stocking in 1953 (as winter stocks and in 1981 as summer stocks). The winter steelhead are managed for natural and hatchery production. The summer steelhead are managed for recreational fishing. But not all summer fish are caught and some natural reproduction probably is occurring. During the 2001 snorkel surveys, adult steelhead were observed up through Reach 5 of Little Fall Creek and at least one adult was observed in Reach 5 of Lost Creek. Rainbow or steelhead juveniles were observed in mainstem of Little Fall and Lost to the end of the 2001 surveys and probably occur up to gradients of about 8 %. Like cutthroat, rainbow prefer pools but they will also make greater use pocket pools in riffles. They seem to use slightly faster waters and will be found at the locations where fast and slow waters meet. Like cutthroat, rainbow seem to avoid the first three reaches of Lost Creek where water is either slow velocity or warmer than 68 degree F. Rainbow will tend to outnumber cutthroat where they co-occur. (Larger adult cutthroat can out compete a rainbow, but rainbow of similar size seem to be more aggressive that cutthroat.) Adult rainbow use similar habitat as adult cutthroat, but typically will be more common in the lower reaches that have higher quality (e.g., larger and deeper) pools. Spawning habitat used by resident trout is probably similar to that used by larger cutthroat. Steelhead need larger habitats more similar to chinook, but seem to seek faster and somewhat shallower waters with very clean gravels of ½ inch diameter up to 4 inches in diameter. Source: authors pers. obs. but see also: Connolly et. al. 1992, and http://www.fish.ci.portland.or.us/fact3.htm or http://www.naparcd.org/steelheadtrout.htm
spring chinook salmon	Historically, large numbers of spring chinook spawned in the Middle Fork system, mainly upstream of the analysis area. But Dexter and Fall Creek dams now block 80 % of the available habitat. Chinook are trapped at the base of both dam systems and are transported to hatcheries or released in upstream areas. ODFW does not consider wild chinook reproduction to be successfully in the Middle Fork below the dams. Excessively warm water releases from dams (> 55 F) during incubation periods are cited and the use of tributaries is discounted as offering too small of

Common name	habitats used
	habitat for chinook (Connolly 1992, G. Taylor pers. comm.). It is noteworthy that a number of spawning adults and low densities of juveniles were observed in Little Fall Creek during the 2001 surveys. While 239 adult chinook that had been trapped at the dam had been released into the Little Fall during the spring of 2001, these would not be expected to have spawned until October. Therefore, the juveniles observed in 2001 may represent wild spawning in Little Fall Creek. Additional evidence of spawning in the Middle Fork below the dams are the redds and juveniles that were noted in a side channel in Reach 4 during the habitat survey of the Middle Fork in 2001. Spawning in Lost Creek may also occur but is likely infrequent as only one adult was observed in Lost Creek during the habitat survey and no juveniles were observed during snorkeling of Lost Creek. Only a few juvenile chinook were trapped in the screw trap in Lost Creek (but these may have been the test plants used to test trap efficiency). It is commonly assumed that chinook prefer to spawn in pool tails and riffles of larger rivers, such as the mainstem Middle Fork Willamette and do not normally enter the tributaries in large numbers. Chinook are generally thought to prefer larger sized gravel (e.g., 1 to 4 inches in diameter) that is not embedded with fine silts. Fry and small juveniles use pool margins or off-channel habitats early on and then migrate downstream to larger stream habitats before heading to the ocean. Some juveniles in habitats far from the ocean such as in the analysis area, choose to spend the summer in deeper pools either in the analysis area or in habitats down river before heading to the ocean. Source: authors pers. obs. and see also: Connolly et. al. 1992, Ecosystems Northwest 2001, and http://www.fish.ci.portland.or.us/fact4.htm - facts or http://danr.ucop.edu/uccelr/h26.htm
Pacific lamprey	No Pacific lamprey were observed in the analysis area, despite a number of surveys. Lamprey are known to occur in the upper Willamette system, but are rarely observed probably due to their secretive behavior. The lamprey, like salmon, are anadromous. They enter streams during the fall and spawning takes place the following spring. Spawning takes place in low gradient sections of water, with gravel and sandy bottoms. The adults die after spawning. The young hatch in 2-3 weeks and swim to backwater or eddy areas of low stream velocity where sediments are soft and rich in dead plant materials. They quickly burrow into the muddy bottom where they filter the mud and water, eating microscopic plants (mostly diatoms) and animals. The juvenile lamprey will stay burrowed in the mud for 4 to 6 years, moving only rarely to new areas. After a two-month metamorphosis, triggered by unknown factors, they emerge as adults averaging 4.5 inches long. Then during high water periods, in late winter or early spring the new adults migrate to the ocean. While in their 4-6 year larval stage lamprey occupy a special niche in the stream system, filtering microscopic plants and animals from the bottom sediments. They fall prey to a wide variety of species including trout, crayfish, and birds. Lamprey may be impacted by pollutants from urban and agricultural runoff that can concentrate in the sediments. Because this species depends on muddy bottoms, backwater areas, and low gradient areas during its juvenile life stage, it is susceptible to loss of wetlands, side channels, back eddies, and beaver ponds resulting from agricultural, forestry or urban development practices or channelization for flood control. High stream temperatures and lack of stream cover can also reduce the lampreys' food supply. Source: http://www.psmfc.org/habitat/edu_lamprey_fact.html
western brook lamprey	Six western brook lampreys were observed in a group in the upper portion of Reach 6 of Lost Creek during the snorkel surveys and were likely spawning. Western brook lampreys are non-parasitic and spend their lives in freshwater. They are smaller than Pacific lampreys, obtaining lengths of 160 mm. They spawn in the spring to early summer in nests of ½ inch to 4-inch diameter gravels. Nests may be used by up to 30 adults in several different groups. After hatching, blind larval ammocoetes move to low flow, high organic matter areas. Larval remain in the sediment for 3 to 6 years, feeding similarly as Pacific lamprey ammocoetes. Adults emerge in the fall and over winter without feeding. They become sexually mature by March and die after spawning. Little else is known about the brook lampreys—they seem to use smaller habitats, typically pools with moderate to lower stream velocities and appear to prefer cool, clean water. Source: authors pers. obs.; see also

Common name	habitats used
	http://www.r1.fws.gov/crfpo/lamprey/lamprey2000.pdf
dace	Dace were observed in very high densities along the edges of the thalweg and at the margins of pools of the lower reaches of Little Fall and Lost Creek. They would be expected to use similar habitats in the Middle Fork. Species were not identified but are mainly speckled dace *Rhinicthys osculus*, though some long-nosed dace *Rhinichthys cataractae,* probably occur. The dace are widespread over western United States, but their basic biology is not as well studied as salmonids. In general, dace prefer shallower waters with reduced velocities and warmer stream temperatures. When observed, they typically occur in large schools of up to hundreds. Spawning in dace is thought to be triggered by increasing temperature and lengthening photoperiod, and likely starts in the analysis area in June. Dace spawn on finer gravels (¼ inch to 2 inch diameter) and in shallow water (1 inch to 4 inches deep). Development is rapid and newly emerged fry are small (9 mm) and probably emerge in June and July as many were observed during the habitat surveys during July. Dace feed on aquatic insects and also on filamentous algae and diatoms. Sexual maturity is reached in two or three years. Source: authors pers. obs. and see: http://www.zoology.ubc.ca/~etaylor/nfrg/dace.pdf
northern pikeminnow	Northern pikeminnows were reportedly observed in the first three reaches of Lost Creek in 2001, but these could have been largescale sucker as no northern pikeminnow were caught in the screw trap in Lost Creek in 2001. Northern pikeminnow have been electroshocked in the Middle Fork during recent ODFW surveys. Northern pikeminnows typically usie slow-moving habitats and edge waters. They are known to be common in reservoirs in the Columbia River and can pose a serious threat as a predator to juvenile salmon during downstream migrations. In general, northern pikeminnow feed on a variety of organisms, but larger individuals are primarily piscivorus. Sexual maturity is achieved at around six years, once the fish reaches about 30 cm in length. Spawning occurs during late May to July when congregations form along lake shores or near tributary streams. Females may spawn many times in a season, and are usually accompanied by many males during breeding. http://livinglandscapes.bc.ca/peter_myles/nat_cyprinidae.html
largescale sucker	The snorkeler surveyors in 2001 reported one sighting of a sucker near the top of Reach 2 in Lost Creek and suckers were trapped in the Lost Creek screw trap. There are likely abundant numbers in the mainstem of the Middle Fork and were sighted during snorkel surveys in the mainstem near the mouth of Lost Creek. Suckers typically inhabit larger habitats and deeper pools and glides such as those found in the mainstem of the Middle Fork. They tolerate warmer temperatures and feed on plant and animal material, picking up much material from the bottom. In the spring they run up tributary streams to spawn, at which time the male takes on brighter colors. They may reach 2 to 2-1/2feet in length. Source: authors pers. obs. and see also http://www.dfw.state.or.us/springfield/McKFish.html
redside shiner	Red-side shiners were the most abundant fish counted in Reach 1 of Little Fall Creek and the most abundant in Reach 1 of Lost Creek during the 2001 surveys. No red-side shiners were counted upstream of Reach 1 in Little Fall and they disappeared by Reach 4 in Lost Creek. Redside Shiners are seldom found alone, often congregating in large schools. They are commonly found together with dace in slower velocity and in warmer waters. They are often seem at the margins of large pools. Though dace seem to prefer the bottom, shiners are often observed in mid-column or closer to the surface. Redside shiners spawn in groups of 30-40 during May to early August when males become brilliantly colored in crimson and gold. Sexual maturity is reached in their third year, and females deposit small, adhesive eggs in multiple lots throughout the breeding season over an unprepared substrate. Redside Shiners are known to hybridize with Northern pikeminnow, Longnose Dace, and peamouth chub. Redside Shiners are common throughout the Columbia Basin. Source: authors pers. obs. and see http://livinglandscapes.bc.ca/peter_myles/nat_cyprinidae.html#n_richardsonius_balteatus
sculpin	Low numbers of sculpins were widely distributed in the snorkel surveys of Little Fall and or Lost Creeks during 2001. But sculpins are difficult to see in snorkel surveys

Common name	habitats used
	directed toward salmonids, and as a result are always under-counted. In fact, some researches have estimated sculpins to be the most abundant fish in higher gradient streams in the Cascades. In general sculpins appear to be well distributed throughout the analysis area, occurring in most places trout are found. Sculpins may be of four or more species (e.g., reticulate, paiute, torrent, and shorthead are thought to occur in the nearby McKenzie basin). Each may use slightly different habitats. But sculpins are always found directly on the bottom among the cobbles and boulders of the stream, and typically in moving water. Sources: authors pers. obs. and see: http://www.nanfa.org/articles/acreticula.htm
Oregon chub	During the 2001 survey of the Middle Fork, surveyors thought they observed an Oregon chub in an isolated pool off of the mainstem in Reach 4 (unit 399) and also noted several area that appeared to be good chub habitat. A beaver pond habitat just below the Falls Creek Dam reportedly has a successfully introduced population of Oregon chub. They are also thought to occur in the backwater areas of the mainstem near Springfield. At one time, the Oregon chub occurred throughout lowland areas in shallow, slow moving water, such as sloughs, beaver ponds, oxbows and side channels. Historically, floods maintained Oregon chub habitat by scouring new side channels and backwaters and filling in other areas. Dam construction and flood controlled has altered this process and caused habitat loss. Habitat loss also results from dike construction, channelization of streams and draining and filling of wetlands. Additionally, non-native species like bass, bluegill and mosquito fish compete for the habitat preferred by Oregon chub or prey on the chub. In the late 1980s only four sites were known to be inhabited by Oregon chub. Additional populations have been discovered in the Upper Willamette and elsewhere in the Willamette basin bringing the total to 24. Additional undocumented populations probably inhabit the Middle Fork Willamette and Coast Fork Willamette basins. Source: http://www.orst.edu/Dept/ODFW/freshwater/inventory/chub.html http://www.dfw.state.or.us/springfield/Orchub~1.htm
sand roller or troutperch	A single sandroller was trapped in the screw trap in Lost Creek in 2001. Sandrollers are native only to the lower Columbia River and tributaries, including the Willamette. Little is know about this species, though they are thought to hide in daylight hours among submerged objects and feed at night over sandy substrates. Juveniles occur primarily in weed bays or waterways directly adjacent to the main river. Slightly older fish can be found in undercut banks hiding from the daylight. Adult fish are associated with eddies behind large boulders, logs, and bridge supports. Source: Wevers et. al. 1992 and see: http://www.nanfa.org/articles/acpercopsi.htm
whitefish	Two dead whitefish were observed in Reach 4 of the mainstem Middle Fork during the survey conducted in 2001. Whitefish have also been electroshocked in the mainstem during recent ODFW surveys. Whitefish occupy similar habitat as rainbow trout, particularly larger pools and deeper riffles. They feed largely among cobbles largely on benthic invertebrates, including aquatic insect larvae and molluscs, but will readily take terrestrial insects from the surface. Sexual maturity is reached by age 3-5. Spawning occurs in the fall in shallow areas over gravel substrates. Sources: authors pers. obs. and see: http://www.biology.ualberta.ca/jackson.hp/IWR/Taxa/Salmoniformes/Salmonidae/Prosopium/P_williamsoni/Alberta.php

Nice photos of many of these fish can be viewed at the Fish of the McKenzie River website: http://www.dfw.state.or.us/springfield/McKFish.html#DACE

Another good website for fish and fishing information of the South Willamette including the analysis area: http://www.dfw.state.or.us/South_Willamette/

9.2 SENSITIVE FISH SPECIES

Appendix F-2: Background on sensitive fish species in the analysis area.

Chinook Salmon

Spring chinook historically were able to negotiate Willamette Falls during high flows (Collins, 1968) and are a native anadromous fish to the upper Willamette River. Spring Chinook in the upper Willamette were listed as "Threatened" under the federal Endangered Species Act (ESA) in March 1999. It is thought that the only significant natural production of spring run chinook occurs in the McKenzie River Basin. Whereas the Middle Fork run of spring chinook were once considered to be equal or perhaps even larger than the McKenzie run, they are now considered to be mostly a hatchery stock. A decline in the abundance of the Middle Fork fish is attributed to habitat blockage and degradation of habitat below the dams. Dexter and Fall Creek dams block upstream migration. Agriculture and urban development have also been cited as the main activities that have adversely affected habitat (Bottom et al. 1985, Kostow 1995, cited in the Federal Register Vol. 64, No. 56, March 24, 1999).

But still, the Middle Fork is part of the Upper Willamette critical habitat (Federal Register Vol. 64, No. 56, March 24, 1999, page 14315). The decision to include the Middle Fork as critical habitat seems to be based on the acknowledgment that the Middle Fork stocks can contribute to the recovery of the Upper Willamette ESU. For example, some of the returning fish are released to upstream habitats above the dams and these released fish seem to reproduce and pass smolts over the dam. The releases of hatchery smolts below the dams are from returning adults that are an unknown mix of hatchery and stream-spawned fish. While it has been presumed that below-dam reproduction is minimal, the evidence from the 2001 habitat surveys suggest that some reproduction is occurring below the dams. All returning adults in 2002 should be fin clipped if reared in a hatchery. This will allow for the first time a quantitative measure of the size of naturally spawned fish in the returning run.

Oregon chub

Oregon chub was listed as endangered under the ESA by the US Fish and Wildlife Service in 1993. Oregon chub are listed as occurring in the back waters and side channels of the main stem of the Middle Fork Willamette River from ODFW surveys. An introduced population occurs in a beaver pond below Fall Creek. The preferred habitat of the Oregon chub is quiet water such as sloughs and overflow ponds at low elevations in the Willamette Valley (Dimick and Merryfield 1945). Much of the historic range of these fishes has disappeared in the Willamette River and its tributaries as a result of the construction of flood control dams, channelization of the river and channel cleaning for the purpose of navigation (Sheerer 1998). In addition to the loss of habitat, introduced species may inhibit the establishment of new populations of chub, which colonize during high-flow events. Non-native fish are present at approximately half of the known population sites of Oregon chub statewide and may pose a threat to Oregon chub in the Middle Fork.

Steelhead

In March 1999, winter steelhead were listed as "Threatened" under the (ESA) in the Upper Willamette River. Designations of critical habitat were made February 16, 2000 by the National Marine Fisheries Service (NMFS). The Upper Willamette was designated as part of the critical habitat for winter steelhead only as far upstream as the Calapooia River. Therefore the Middle Fork Willamette is not part of the critical habitat for winter steelhead. One issue may be the propagation of non-native steelhead in the Middle Fork, particularly summer steelhead. The natural reproduction of these fish may produce smolts that migrate downstream and compete with the native winter steelhead.

Cutthroat

Upper Willamette cutthroat trout were determined to be not warranted for listing by the National Marine Fisheries Service. However, they are currently being reconsidered for listing by the Fish and Wildlife Service and were considered as part of the biological assessment by the Corps (U.S. Army Corps of Engineers 2000). The life history of cutthroat appears to somewhat complex and less well known than that of other anadromous fish. Generally the Upper Willamette fish are considered to be residents that do not migrate to the ocean. There may be two types of fish: those that stay in smaller headwater habitats their entire lives or those that are called "fluvial" and migrate between larger rivers and headwater streams to spawn. The concern of cutthroat is mainly regarding the uncertainty of the status of the fluvial type. Population declines are generally attributed to over harvest and degraded habitat, though some evidence of population increased exist for Willamette reaches between Corvallis and Eugene (see U.S. Army Corps of Engineers 2000). Cutthroat have been sampled in periodic electrofishing surveys in the main stem of the Middle Fork since the mid 1970's. These spot checks seem to show a nearly even mix of cutthroat and rainbow in the 10 to 40 cm length classes. The 2001 snorkel survey data of Little Fall and Lost Creeks generally showed low densities of cutthroat when mixed with rainbow and increasing densities in upstream habitats where rainbow began dropping out.

Sandroller

Sandrollers (also known as trout perch) have been listed as a "stock of concern" by the Oregon Department of Fish and Wildlife (ODFW) due to suspected low populations. They are native only to the lower Columbia River and its tributaries, including the Willamette River. Sandrollers are thought to occur at least in Lost Creek as a single individual was trapped in the screw trap in 2001. Because of their secretive nature, sandroller populations may be underestimated. Sandrollers and Oregon chub are considered the two most endemic fish species of the western Cascades/Willamette River basin region, with little to no occurrence in other regions (Hughes et al. 1987). Much of the historic habitat of sandrollers has been lost to the draining of wetlands and channelization (Dunette 1997).

9.3 FISH AND HABITAT SURVEYS

Appendix 9-3: Summaries of fish and habitat surveys performed in the analysis area.

Fish surveys

1966 Fish Resources of the Willamette Basin (Thompson et al.1966). Oregon State Game Commission report on present status of fish and wildlife. This report was prepared shortly after the construction of the dams on the Middle Fork. Pages 37 through 44 contain comments on the Middle Fork Subbasin, which are summarized below.

· High summer water temperatures that range between 65 and 75 F were cited as limiting production of salmonids in the tributaries below the dams.

· Large numbers of non-game fish were cited as limitations to production of salmonids in the reservoirs.

· In 1966, over 400 winter steelhead and 6,100 spring chinook entered the Middle Fork; 100 steelhead and 60 % of the chinook entered Fall Creek. These numbers were thought to be typical run sizes. The report stated that considerable spawning takes place below the dams.

· Other non-salmonid species that were common in the Middle Fork included largescale suckers, squawfish, redside shiners, and chiselmouth plus low numbers of warm-water game fish extend up from the Willamette River.

1977-78 and 1990 electrofishing surveys (summarized from ODFW files at Springfield office). The files are field notes (1977-78) and computer data summaries (1990) that describe species by size class, sex, and sexual maturity. In the 1976-77 data, the mainstem Middle Fork was electrofished from a drift boat on three occasions in 1977 and on six occasions in 1978. Reaches surveyed were typically from Dexter Dam to Jasper or from Jasper to Springfield. In the 1990 data set, single pass shocking was performed in tributaries (Hills Creek, Lost Creek and two tributaries to Lost Creek). Some habitat data and habitat size was collected and notes indicate that densities are to be considered minimum as not block nets were used. During the 1978 surveys, cutthroat were tagged and recaptures in were noted. The main points are summarized below.

· In the main stem surveys from 7 to 90 trout were shocked in a drift. Cutthroat, rainbow both occurred in nearly even frequencies. Common size classes are 15 to 30 cm with some fish up to 40 cm. About 10 % of the rainbow were noted as planted or stocked hatchery fish.

· Chinook adults and smolts were noted in the main stem during June 1978. Whitefish up to 47 cm and squawfish up to 42 cm were shocked during March 1978.

· On July 27, 1978, on a drift from Dexter to Jasper, 34 cutthroat were shocked with 3 recaptures. As best as can be determined from the data, about 35 cutthroat had been tagged in the two months prior to this drift. Using a set of simple assumptions (e.g., all 35 tagged fish survived and stayed in the survey area, and all fish were randomly captured) one can calculate a population density approximately of 34/3 x 35 or 397 cutthroat in the 6 mile stretch of river. This population appears to be generally fish from 13 to 35 cm in length. The rainbow appear to be about equal in density. However, it is likely the smaller size class is under sampled as they do not respond to shocking as well as a larger fish. The larger fish may also be under sampled as they may be more wary to the boat.

· During electrofishing surveys in Lost Creek and two tributaries (Anthony Creek and Middle Creek) in 1990, the cutthroat were just slightly greater than rainbow in frequency of capture (though the two sites at Middle Creek had no rainbow). Densities of either species were generally from 1 to 6 fish per habitat. Cutthroat tended to the largest fish in the habitat with largest fish in the 9-12 inch size class.

· Sculpin were the most abundant fish shocked with commonly 20 to 30 individuals per habitat. Dace were shocked at about 1/3 the frequency of sculpin. Red-side shiners were shocked only occasionally. Three coho juveniles are listed as being shocked in Lost Creek near the mouth of Anthony Creek. Coho were stocked in the basin starting in 1953, but did not appear to have a establish a run by 1966 (Thompson et al. 1966). These salmonids may have been mis-identified and may likely have been chinook.

· Compared to the snorkel surveys of 2001, the 1990 shocking data show generally lower densities of most species, but much higher densities of sculpin due mainly to the differing methods. However, the 1990 data indicate that dace and red-sided shiners occurred much farther up into the watershed than the 2001data. In 1990, dace were shocked in Section 24, which is about 12 miles upstream of the mouth, and red-sided shiners were shocked in Section 10 at about 7 miles upstream. In 2001, dace and red-sided shiners dropped out at about mile 5. These fish species may have been effectively removed from upstream sections during the recent high flows of the mid to late 1990's and are now slowly recolonizing upstream. There is reportedly a moderate sized waterfalls at the top of Reach 4, at about 7 miles upstream, that may be an upstream migration barrier.

Habitat Surveys

Middle Fork Willamette 1964 (Thompson 1965). The report describes conditions over the first 16.8 miles (section below Dexter Dam) as 120 foot average width, little shade cover and mostly mixed broadleafs, abundant spawning gravels, and holding pools of 6 to 12 feet deep every 0.3 miles. 804 adult spawning chinook were counted over the section during the "peak of spawning season" 9/21-9/23/64. The majority of chinook were counted within one mile of Dexter Dam.

Middle Fork Willamette 2001 (Stein 2001). ODFW Aquatic Inventory Project survey starting at the confluence with the Coast Fork and ending at Dexter Dam. Four reaches are summarized and shown on Maps and tables in Appendix F-4.

Lower Middle Fork 1999-2000 (Andrus and Walsh 2002). Waterwork Consulting contracting with the City of Eugene performed an assessment of the rivers and associated channels in the Eugene-Springfield area. The study area included the portions of the McKenzie, the Willamette and the lower 7 miles of the Middle Fork Willamette rivers. The assessment was an evaluation of channel types, aquatic and riparian habitat, water quality, hydrology aquatic organisms, and restoration opportunities. The channel and habitat measurements were made off the aerial photographs from the year 1944 (pre-dam) and the year 2000 for each of 27 reaches. Overall, the reaches showed loss various measures of complexity including sinuosity, side channel lengths, alcove habitat, and gravel bars.

Two of the three reaches of the Middle Fork were scored in the top seven reaches (out of a total of 27 reaches) showing the greatest loss of complexity. Losses of habitat complexity were related to construction of riprap, reduced flood flows, gravel mining, and channel engineering.

Vegetation types evaluated for 500 feet each side of the river using the 1944 and 2000 aerial photos showed that there were sharp declines in the area of hardwoods greater than 40 years old, bare substrate, and grass. The reports cited reduced peak flows that had allowed vegetation to encroach upon the river edges, and harvests of older trees for timber and development. Rural residential and urban development was only 0.3% of the area in 1944 because of the flood hazard but increased to 7.3% by 2000.

Lost Creek 1938 (Hanavan et al 1938). This survey covered about 8 miles of Lost Creek starting at the mouth. High amounts of mud and sand (20 to 26 %) were noted. An impassable dam that was part of the Lewis Lumber mill existed at river mile 7.5. Most of the flow was diverted from the river and on other occasions, sawdust was flushed into the stream. The report also noted that residents reported that salmon had not been in the stream for the past 20 years though salmon and steelhead were seen and caught 20 to 30 years ago. Whitefish, suckers, and chub were abundant, and cutthroat were reportedly in the upper part of the stream. The banks were covered with a dense jungle of swamp maple, alder, willow, a few conifers and blackberry. Water temperatures were 66 F during June 9-10. A much higher abundance of deep pools was noted (20 pools > 3 feet deep per mile) that the 2001 survey (4.5 per mile).

Lost Creek 1959 (Thompson 1965). Water temperature was recorded at 70 F on August 28. An 8-foot falls was noted at mile 8.5. Fish species noted were cottids, cutthroat, dace, and redside shiners. The first 10 miles had 10 % good spawning area; the last four miles had 3 % good spawning area.

Lost Creek 1990-95 (ODFW) Report was not obtained. A summary sheet indicates that the first 4.5 miles were surveyed. This summary indicates that pools > 3 feet deep were 11.5 per mile. This represents a 50 % decline since 1938. The same measure in 2001 was 4.5 pools per mile.

Lost Creek 2001 (Ecosystems Northwest 2002). ODFW Aquatic Inventory Project survey starting at the confluence with the Middle Fork and ending about 14 miles upstream at a fork in the stream. Seven reaches are summarized and shown on Map x-_ and table x-4. The first nine miles of survey, corresponding to the first four reaches, contrasted with the upper five miles in several ways. The lower section had uniformly low gradient, the valley was wide and composed of alluvial deposits, and most of the riparian area was in small rural residences. The lower section also showed greater entrenchment, higher bank erosion, greater abundance of fine sediments and less shade. Long, deep pools and glides were common. In the next five miles of stream (Reaches 5 – 7), gradient increased, land ownership was mainly industrial forest or federal land holdings, the substrate was larger, and the shade greater. Long shallow riffles and rapids among boulders were common.

Pools were relatively abundant in the lower four reaches but they were not particularly deep (figure x-2). As noted earlier, frequency of deep pools has decreased since the earlier surveys of the 1930's and may reflect large amounts of sediment being transported from higher in the basin. Bed load appears to have been recently mobilized and the surveyors noted that pools appeared to be recently filled (see figure x-3). Woody debris counts were very low in the first four reaches but moderate elsewhere. Large trees in the riparian are uncommon as are conifers. Nine native fish and no introduced species were noted during the surveys. Dace and red-side shiners were the most common species in Reaches 1 and 2. Cutthroat and rainbow occurred to the end of the survey. One adult chinook and one adult steelhead were observed.

Little Fall Creek 1936 (no cite available but probably US Fish and Wildlife Service). The first 8 miles were surveyed. Mud and silt was about 9 % of the stream bottom. Three small dams were noted as constructed of either rocks or old logs. Five natural falls of 4 feet to 12 feet were also noted. All were passable with difficulty. The 12 foot falls was likely a falls over a log jam. No fish were observed, but the survey was conducted during February. The report noted that a few coho were reported in earlier years and they questioned whether salmon would use the stream due to its high gradient and obstructions.

Little Fall Creek 1959 (Fish Commission of Oregon 1960). Pool area was 50 to 60 %, banks were gravel and bedrock, and shading was fair to marginal. Good spawning gravel ranged from 1 % to 10 %. Fish passage barriers included a 15-foot falls at 12 miles above the mouth (actually two falls: a 8 foot cascade and a 7 foot vertical drop), plus a series of six log jams above the falls. Temperature was 65 F at the mouth and 54 F at 19 miles upstream (measured during June or July of 1959). It had been reported that both silver and chinook salmon had used the stream many years ago, but no salmon had been reported in recent years.

Little Fall Creek 1981 (Erickson 1983). This survey was conducted only on Forest Service lands in the upper portion of the watershed. Cutthroat and rainbow trout were listed as species occurring and that chinook and steelhead were prevented access by a falls downstream. Little logging had occurred at stream side but shading over stream was low due to low amounts of old-growth, a wide channel (30 feet) and extensive harvests on tributary side slopes. Pools were deep at 3 to 4 feet. Snorkel surveys observed 15 cutthroat per 100 feet of pool length and 42 torrent sculpin and 4 shorthead sculpin per 100 feet of riffle. The report suggests that that Oregon Department of Fish and Game install a fish ladder downstream at the falls.

Little Fall Creek 1984 (Hutchison et al 1984). This survey continue another 4 ½ miles starting where the 1981 survey ended (at the northern boundary of Forest Service lands). Pools were about 30 % of stream and were shallow and short. The report mentions a two falls that were tentatively scheduled for “laddering” one at river mile 16.4 (on Weyerhaeuser lands above the Forest Service) and another at river mile 11.8 below the Forest Service lands. (The ladder at river mile 11.8 was noted during the 2001 surveys). The report also mentions large log jams at river mile 17.8 that have been planned to be breached. Only cutthroat were observed in the upper section of this survey.

Little Fall Creek 1990 (Ross and Moser 1990). This survey covered the Forest Service lands in the upper portion of the watershed, similar to the 1981 survey. Average residual pool depth was 3.4 to 3.1 feet. Predominant substrate was mixtures of sand, gravel and cobble. Electrofishing produced cutthroat trout but three steelhead were also observed. Woody debris counts were about 140 pieces per mile, counting pieces of at least 12 inches in diameter at the large end and at least 25 feet in length. The riparian was mostly hardwoods less than 21 inches in diameter. Stream shade was generally low.

Little Fall Creek 1993 (Berry et al 1993). Combined Forest Service and ODFW style survey that starts at river mile 8.3 and ends at river mile 18.1. The report is narrative in form and describes the various projects performed on Little Fall Creek. In 1964 the 100-year flood event occurred. In 1979, the Forest Service removed woody debris between river miles 12.5 and 15.6. Between 1985 and 1988, the Forest Service installed habitat structures and constructed side channels. During this same time, the falls at river mile 12.2 was laddered (formerly referred to as river mile 11.8) and the upper falls at river mile 16.3 had jump pools blasted into it. Finally during the same period, ODFW and Weyerhaeuser removed a large debris jam at river mile 17.1 and gabions were installed to catch gravel released by the breaching.

This report also mentions sighting of an 18 inch long lamprey plus freshwater clams at about river mile 8.5. Electrofishing produced rainbow trout, cutthroat trout, speckled dace, long-nosed dace, torrent sculpin, other unidentified sculpin and lamprey. The section up to the fish ladder is noted mainly as low in wood and a poor developed riparian zone. Above the fish ladder, on the Forest Service lands, the report notes the abundant spawning gravels and deep pools. Also noted are the habitat structures that appear to be enhancing habitat. At river mile16, the gradient increased and habitat for fish diminished. The surveyors noted smaller trout and lamprey. On the Weyerhaeuser lands above the Forest Service lands, the surveyors noted the gabions that had been placed below the breached log jam had indeed increased the gravel content of the substrate from 1 % to 20 %. They also noted that these structures would likely fail in the near future. Pools were becoming low in area (10 %) and continued to decrease upstream. Woody debris also appeared to be scarce. Rainbow trout, cutthroat and sculpin occurred to the end of the survey.

Little Fall Creek memo 12/27/94 (Willamette National Forest 1994). This is not a survey but a summary of activities and restoration work (log placements) during 1994. Following the 1993 survey and report, log placements were performed on lands managed by Bureau of Land Management, Forest Service and Weyerhaeuser. Log structures totaled 17 on Forest Service lands, 43 on Bureau of Land Management lands, and 28 on Weyerhaeuser lands. The memo also mentions the results of a smolt trap set from March 7 to April 26,1994 at an unspecified location on Little Fall Creek. The trap estimated 800 steelhead smolts outmigrating and also trapped spring chinook. In another project, spawning surveys for winter steelhead on Forest Service lands counted 167 redds during the spring of 1994.

Little Fall Creek 2001 (Ecosystems Northwest 2002). ODFW Aquatic Inventory Project survey starting at the confluence with Fall Creek and ending about 18 miles upstream at the northern Forest

Service boundary. Six reaches are summarized and shown on Map x-_ and table x-4. The data are compared to ODFW benchmarks in Table x-5. The 2001 report noted that the pools were relatively abundant and deep (Figure x-1). But the habitats appeared to be lacking in complexity in the first four reaches. Low complexity was due to low off channel habitat and low wood counts. The abundance of sand in the pools combined with the high frequency of bedrock and cobble deposits suggested recent bed load movement. It is likely the stream is still sorting out the bed load from the 1996 floods. Shade and riparian cover appeared to be good (75 %), though most cover was from hardwoods and small conifers. Low numbers of woody debris will likely be a persistent problem given the low numbers of large conifers in the riparian zone.

Adult and juvenile steelhead, chinook, and native cutthroat were observed along with dace, red-side shiners and sculpin. Salmon and steelhead were observed upstream of the recently installed fish ladder.

9.4 AQUATIC INVENTORY SUMMARIES FROM 2001 SEASON.

Appendix 9-4: Aquatic inventory summaries performed in 2001.

Reach	Surv date mo/yr	Gradient %	Length m	land use 1	land use 2	Rip veg 1	Rip veg 2	Valley width index	Valley type	Channel type	Wet width m	Act ch width m	Floodprone width m	Floodprone ht m
Middle Fork Willamette														
1	9/01	0.2	12,038	AG	RR	D30	G	16	mult terraces	terrace	33	78	166	3.0
2	9/01	0.2	4,400	RR	AG	D15	G	15	mult terraces	terrace	24	87	219	3.1
3	9/01	0.6	3,426	AG	RR	D15	G	15	mult terraces	single channel	26	158	253	2.9
4	9/01	0.3	5,714	GN	--	D15	S	17	mult terraces	single channel	22	70	246	2.9
Lost Creek														
1	7/01	0.20	3,097	RR	LG	D15	S	10	constraining terrace	landuse	13	15	22	0.8
2	7/01	0.31	4,458	RR	LG	D15	S	10	constraining terrace	terrace	8.5	12	18	0.7
3	7/01	0.64	4,810	RR	ST	M30	S	15	constraining terrace	terrace	7.4	13	19	0.6
4	7/01	1.19	3,551	RR	ST	M30	S	10	constraining terrace	terrace	8.3	10	13	0.7
5	7/01	1.21	2,530	RR	ST	M30	S	15	constraining terrace	terrace	5.4	8.4	18	0.7
6	7/01	2.57	2,704	ST	TH	M30	S	9	constraining terrace	terrace	4.6	8.4	15	0.8
7	7/01	1.69	2,583	ST	TH	M30	S	6	constraining terrace	alt terrace hillslope	4.1	7.8	13	0.9
Little Fall Creek														
1	7/01	0.71	7,757	RR	RR	P	P	10	constraining terrace	terrace	15	18	22	1.1
2	7/01	1.05	1,158	LT	RR	M15	S1	7.5	moderate V	hillslope	15	16	18	1.4
3	7/01	0.86	4,972	ST	YT	M15	S1	2.0	moderate V	hillslope	14	16	20	1.4
4	7/01	0.95	6,437	ST	YT	M15	S1	3.0	moderate V	hillslope	10	13	18	1.4
5	7/01	1.95	2,510	ST	YT	M15	S1	4.0	open V	hillslope	8.3	10	14	1.3
6	7/01	0.92	6,952	ST	YT	M15	S1	5.0	mult terraces	terrace	6.7	11	16	1.0

Reach	Act ch ht m	Sand total %	Gravel total %	Bedrock total %	pools ≥ 1m deep #/km	Pool area %	Pool resid depth m	Stream shade %	Bank erosion %	LWD #/100 m	Max temp C	Conifer > 20” #/1000 ft	Conifer > 35” #/1000 ft	Riparian canopy closure w/in 30m %
Middle Fork Willamette														
1	1.6	11	39	2	2.0	47	2.35	31	7	2.0	19	0	0	38
2	1.6	8	41	3	3.4	26	1.12	41	2	5.7	18	0	0	59
3	1.5	11	47	0	4.8	37	1.23	32	4	7.9	18	0	0	38
4	1.4	13	35	2	5.7	34	1.37	41	9	4.7	17	37	0	78
Lost Creek														
1	0.4	11	33	1	3.6	37	0.83	31	9.0	2.4	17	0	0	43
2	0.4	13	30	7	4.9	55	0.81	47	8.4	1.4	17	15	0	35
3	0.4	13	34	23	3.1	48	0.66	57	4.1	0.8	21	24	0	43
4	0.3	11	32	28	1.4	40	0.64	70	3.2	0.3	16	0	0	44
5	0.4	16	28	17	3.2	31	0.55	76	2.8	5.0	13	30	0	51
6	0.4	16	28	18	2.6	23	0.55	79	3.4	4.5	12	46	0	49
7	0.5	14	25	21	0.8	17	0.47	88	4.3	2.3	12	20	0	63
Little Fall Creek														
1	0.6	25	21	10	5.2	40	1.30	68	2.6	1.2	15	0	0	34
2	0.7	20	26	7	2.5	13	1.03	73	3.8	1.6	15	61	0	70
3	0.7	22	16	19	4.9	27	0.86	73	0	1.8	14	41	0	38
4	0.7	27	15	14	5.6	32	0.93	77	2.4	4.0	14	35	0	66
5	0.7	32	19	18	8.5	43	0.99	82	1.9	6.5	14	0	0	72
6	0.5	34	25	4	6.0	31	0.96	73	1.5	10	14	0	0	67

Aquatic Inventory surveys, or variations thereof, have been performed on portions of Lost Creek and in all named tributaries during the 1990s (see Appendix E of the BLM’s Lost Creek watershed analysis (BLM 1997). Similar style surveys were performed in portions of Little Fall Creek duirng the same period (most files are availble in files at the ODFW Office in Springfield, OR). Weyerhaeuser performed some additional fish sampling as part of their Little Fall Creek watershed analysis (Weyerhaeuser 1997). The results are in turn presented along with the 2001 survey findings in the attached maps of this appendix.