REFERENCE & CURRENT CONDITIONS

CHAPTER III

REFERENCE / CURRENT CONDITIONS

PHYSICAL

GEOLOGY AND SOILS

The following discussion of soils found in the watershed requires the reader to have a working knowledge of the nomenclature of the Willamette National Forest Soil Resource Inventory (SRI). The original SRI was produced in 1973 and the maps revised in 1990 (USDA, 1994b). The map revision has not been field verified. To simplify analysis of the 1990 SRI soil mapping units within the watershed, they have been grouped into five categories based on similar soil properties and expected behavioral response to management activities.

Table 1: SRI Mapping Units by Soil Category

Soil Category	Definition of SRI Soil Category	SRI Mapping Units
Category 1	Nearly 100% clayey soils	25, 35
Category 2	At least 50% clayey soils	235, 335, 336
Category 3	Steep terrain and shallow soils	1, 2, 201, 203, 21, 3, 301, 310, 310U, 6, 601, 602, 61, 610, 610U, 8, 91, 910
Category 4	at least 50% steep terrain and shallow soils	212, 311, 313, 614, 615, 616, 714, 9, 914, 920, 941
Category 5	all others	

Category 1 consists of 1990 SRI mapping units 25, 35 and mapping unit complexes comprised of units 25 and 35, i.e. 255. Typically, these soils are on gentle to moderately hummocky sideslopes (5 to 40 percent), deep (from 6 to 12 feet), have a high clay content, and are occasionally associated with earthflow geomorphology.

Although this landform includes past large scale earth movements, it is usually stable in its current slope geometry, with the exception of localized areas such as road cuts and stream channels. In-place shear stress can be low to high depending on the moisture content, but the remolded strength (such as in road fills and subgrades) tends to be low. During construction, this requires that controlled compaction techniques are used and that the material is not allowed to become saturated. It is often necessary to exclude the surface and subsurface water from these soils to maintain a stable road prism. Due to the low permeability of the soils, these areas typically support hydrophitic vegetation and habitat for animals adapted to riparian and aquatic habitats.

Category 2 consists of SRI complexes which include at least 50 percent of the mapping units in Soil Category 1. The behavior of this category is similar to that outlined for Category 1 and are frequently associated with draws and swales on midslopes.

Category 3 is 100 percent of SRI mapping units and complexes characterized by steep terrain with shallow rocky soils. This category is more likely to have high surface and subsurface erosion potential and the highest number of road and harvest related slope failures. The sediments produced are typically coarse grained. The harvest related slope failures tend to be due to the loss of root strength after timber harvest or stand replacement wildfires. These slope failures most often occur where water is concentrated.

Category 4 consists of SRI complexes which include at least 50 percent of the mapping units described in Category 3. The behavior of these soil types is similar to those outlined in Category 3, but at a lower frequency.

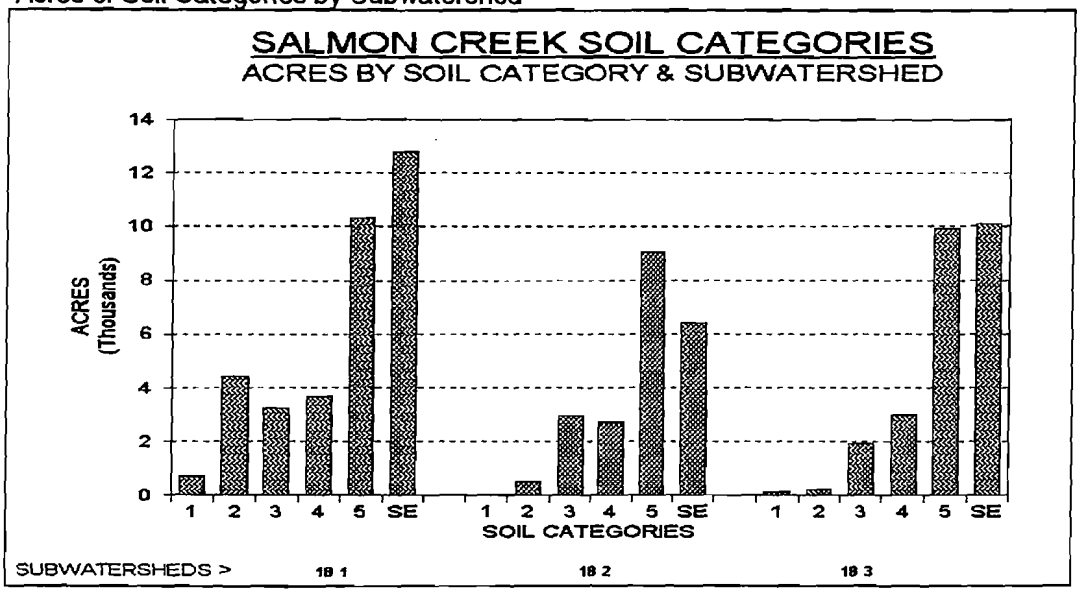
Category 5 consists of the rest of the SRI units and complexes. This category represents a wide rage of geomorphic settings which tend to be more stable.

Figure 1 displays the location of the various soil categories mapped in the watershed. Figure 2 displays the relative area by subwatershed.

Figure 1: Salmon Creek Watershed Analysis

SRI Soil Categories

Figure 2: Acres of Soil Categories by Subwatershed



Mass Soil Movement

REFERENCE AND CURRENT CONDITION

Prior to logging and road building, slope failures were typically localized slope movements in steeper portions of areas with deeper soils, i.e., stream banks, and debris slides on steep slopes with thinner soils over shallow bedrock. The current age of these failures is unknown, but presumably the majority are hundreds of years old, judged by the age of the trees growing on top of these slope movements.

The erosion potential for each soil category was determined by averaging the surface and subsurface erosion potential of those SRI soils comprising the soil categories. Category 3 had the highest, followed by categories 4, 1, 2, with 5 having the least erosion potential. Based on the gradation of the SRI soils comprising the soil categories, 1 and 2 can be expected to yield the greatest volume of fine grained sediments (see Figure 3); categories 3 and 4 can be expected to yield the greatest volume of coarse grained sediments (see Figure 4), while category 5 produces a mixture of both at a relatively low rate. Figure 2 displays the area within each soil category by subwatershed.

In addition to the potential sediment source areas associated with the various soil categories, data from the Watershed Improvement Needs Inventory (WIN) was used to locate existing mass failures. Fifty-eight mass wasting sites were identified, the majority of these sites are associated with roads and to a smaller extent with timber harvest units. The highest concentration of these sites occur in subwatershed 18 1 (see Figure 5).

SURFACE EROSION

REFERENCE AND CURRENT CONDITION

Naturally occurring stand replacement wildfires are probably the closest comparison that can be made relating timber harvest (particularly clearcut harvesting) with pre-historic conditions. The variation in the recurrence interval of stand replacement fires within the watershed is discussed in the Vegetation/ Fire History section.

Loss of canopy closure and duff layers due to high and some medium intensity fires would allow relatively unimpeded rainfall upon bare soil. This can result in down slope movement of soil particles detached by raindrop impact and possibly by overland flow.

High intensity fires remove under brush and kill mature trees, creating abundant snags. Soil surface erosion can be high immediately after a fire and decreases as the vegetation recovers. Over time, as trees killed by the fire fall, they serve as energy dissipaters limiting the down slope movement of soil. Results from a study in the Oregon Coast Range can be used as an example of what could occur after a fire where a large portion of the organic material is burned (Brown and Krygier, 1971). After clearcutting and broadcast burning, there was a five fold increase in suspended sediment production. After a period of four years, suspended sediment production returned to near pretreatment levels.

Figure 3:

Landflows and Potential High Risk Sources of Fine Grain Sediments

Salmon Creek Watershed Analysis

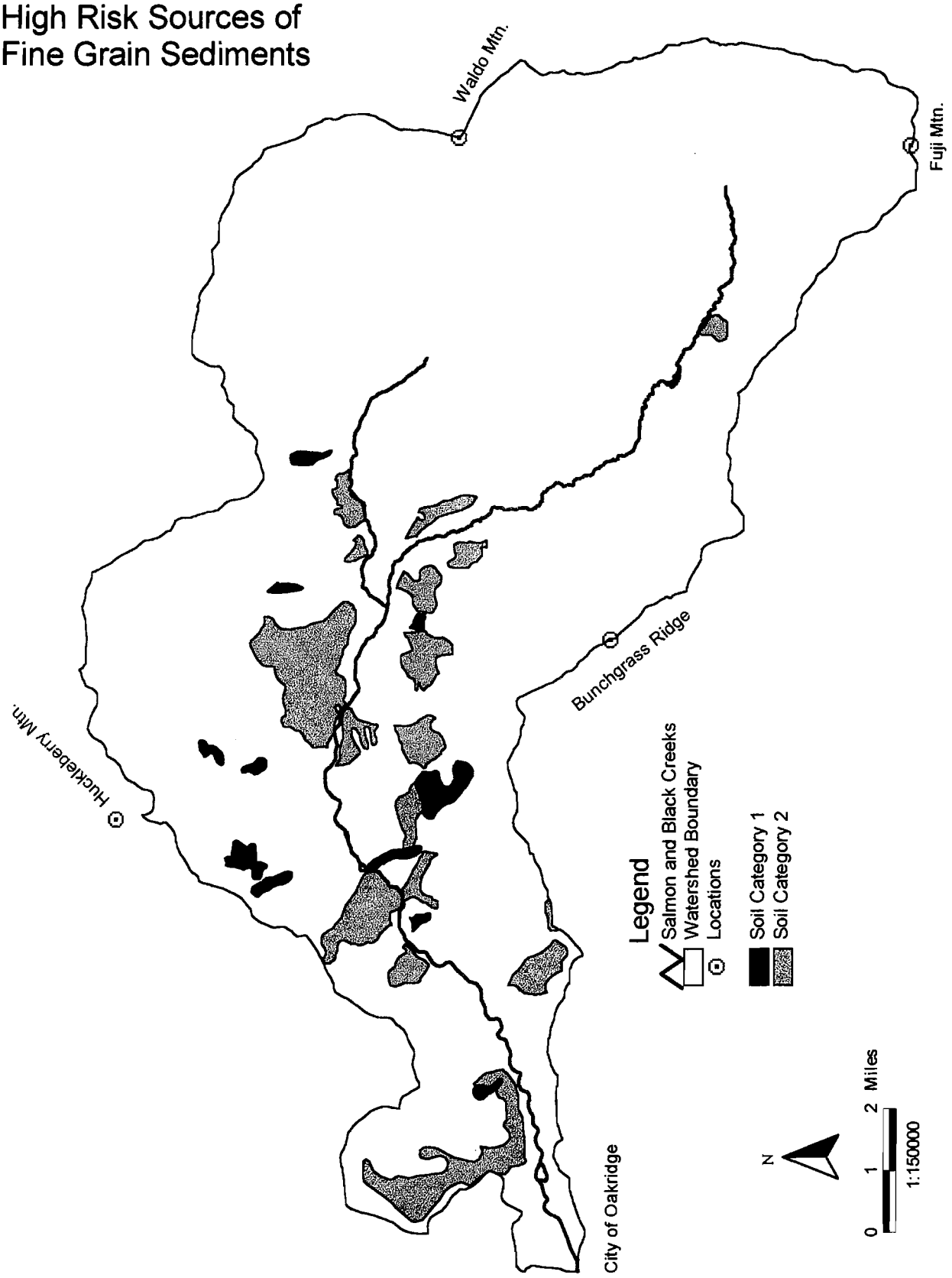


Figure 4:

Highest Risk Areas of Debris Failure and Potential Source of Coarse Grain Sediments

Salmon Creek Watershed Analysis

The Salmon Creek watershed contains approximately 8,600 acres that have been managed by stand replacement harvest on severely erosive soils as defined by SRI Landtype . Ninety-one percent of this harvest occurred on slopes greater than 30 percent. These severely erosive soils on relatively steep slopes would have the highest potential of contributing sediment to streams. Table 2 displays the acres of harvest on severely erosive soils on slopes greater than 30 percent by decade. Impacts to severely erosive soils were greatest during the time period from 1960 to 1989.

Table 2: Acres of Harvest on Severely Erosive Soils Greater Than Thirty Percent Slope

	Acres by Subwatershed			
Decade	18 1	18 2	18 3	Total
1900 - 1929	211	0	0	211
1930 - 1939	4	0	0	4
1940 - 1949	10	0	0	10
1950 - 1959	388	1	66	455
1960 - 1969	1278	221	662	2161
1970 - 1979	1499	267	474	2240
1980 - 1989	1065	461	1077	2603
1990 - 1995	32	8	135	175

Total = 7859 acres

Management practices relative to the retention of large woody material (LWM) have varied with time. Areas harvested during the period when most LWM was removed from harvest units (mid 1960's to mid 1980's) have the greatest potential for down slope movement of soil. As mentioned previously, the presence of LWM tends to reduce the down slope movement of soil. The greatest potential impact would be in the areas of severely erosive soils on steep slopes adjacent to stream channels.

SOIL COMPACTION

REFERENCE CONDITION

There was very little compaction of soil prior to the beginning of timber harvest and road building in the 1920's. There was a small amount of very localized compaction caused by trails used by humans, wildlife, and livestock.

CURRENT CONDITION

Tractor yarding was used extensively prior to 1980 on gentle slopes (usually less than 35 percent). Data is currently not available to determine how many acres have been impacted by tractor yarding within the watershed. The majority of the known tractor yarded areas are located on slopes less than 40 percent in subwatershed 18 1.

Soils with a high clay content (Category 1 and 2) would be the most susceptible to compaction regardless of the harvest method. Approximately 3,200 acres have been impacted by stand replacement timber harvest on soils with a relatively high clay content. Eighty-five percent of this harvest is located in subwatershed 18 1. Although tractor yarding generally results in the greatest amount of compaction per unit area compared with other harvest methods, even with partial suspension cable logging systems, these areas would be prone to moderate to high impacts whether it be gouging or compaction.

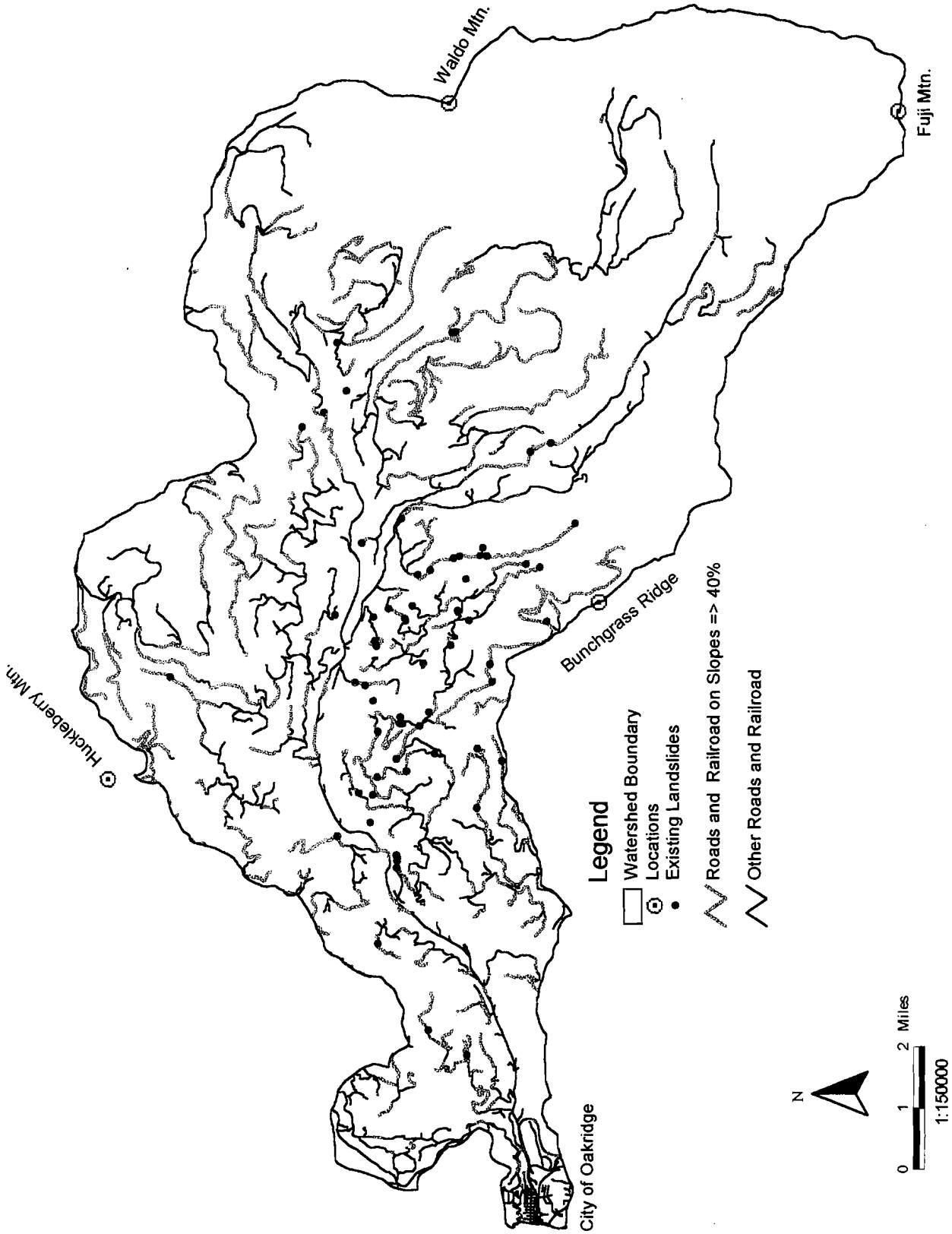
SEDIMENT ASSOCIATED WITH ROADS

Studies have shown that roads with vehicle traffic produce up to six times the amount of sediment as roads where traffic is eliminated. Research has also shown that sediment can be reduced by 50 percent when using central tire inflation during commercial log hauling (Foltz 1991). Further, these studies show that as rutting occurred during use, sediment production increased 2.9 to 13.3 times. This effect can be reduced by timely maintenance, but maintenance can also produce increased levels of sediment.

Roads can contribute sediment to streams through runoff routed directly to streams from roadside ditches or by the formation of gullies below relief culverts, particularly on mid-slope roads. As the drainage area of each culvert and the culvert spacing increases, there is a greater potential of gully formation below the culvert outlet. As the volume of water discharged from the culvert increases, so does its erosive force on hill slopes below the culvert. In some situations these gullies may create surface flow paths for water and sediment directly to streams. In a study conducted in the western Cascades of Oregon (Wemple 1994), statistical analysis of gullying below culvert outlets indicated that the probability of gully formation below a

Figure 5:
Potential Management Related Sediment Sources

Salmon Creek Watershed Analysis



relief culvert was significantly related to culvert spacing and hill slope steepness but not road grade.

The District Watershed Improvement Needs (WIN) database was used to determine the range of culvert spacing within the watershed. An analysis of WIN data from 25 sections of mid-slope roads indicates a range of culvert spacing of 361 feet to 1,056 feet and an averaging spacing of 605 feet. The culvert spacing above which gully formation is likely to occur will vary depending on factors such as slope steepness and drainage area. Many of the culverts within the Salmon Creek watershed have gullies below their outlets. There is a high probability that a portion of the existing gullies are linked to streams and are capable of routing sediment to stream channels particularly during high runoff events.

Gully formation is most likely to occur on slopes greater than 40 percent (Wemple 1994). Figure 5 displays a map of roads on slopes greater than 40 percent slope and existing management related mass wasting sites primarily associated with roads. These road segments and existing mass wasting sites are likely source areas of management related sediment.

The effect of both use and maintenance on the production of fine sediment can be reduced by the closure of roads when not in use for commercial, administrative or motorized recreation usage. Other factors that can reduce the amount of sediment from roads include the installation of additional relief culverts, out-sloping of roads, more frequent road maintenance, aggregate quality, and road surfacing type.

ROAD / STREAM CROSSINGS

There are 12 bridges within this watershed, all of which cross Class I perennial, fish bearing streams. Approximately 576 culverts have been installed within the analysis area where roads cross Class II through Class IV streams as currently identified. At least five times that amount exists when ditch relief culverts are considered. If any of the culverts were designed for fish passage many of them have lost that ability due to outlet scour or different velocity and distance design requirements than are currently used. In addition, most pipes were originally designed to carry a 50-year storm event. Others had no designed criteria. Inventory and analysis of 25 culverts within the analysis area indicates that 40 percent will overtop the fill during a 100-year flood event. This value is consistent with findings for 153 culverts analyzed on timber sale haul routes on Oakridge and Rigdon Ranger Districts.

Table 3: Stream Crossings by Stream Class

Subwatershed	Class I Stream	Class II Stream	Class III Stream	Class IV Stream
18 1 (roads)	7	47	64	259
(railroad)	2	1	0	3
18 2 (roads)	3	5	40	60
18 3 (roads)	0	15	36	52
Totals	12	68	140	374

Note: Class I crossings are all bridges

Table 4: Culvert Information from the WIN Database

	Number of Culverts			
Subwatershed	Totally Blocked	Partially Blocked	With other Problems	OK
18 1	36	298	89	454
18 2	12	117	16	175
18 3	20	169	27	240
Totals	68	584	132	869

AQUATIC

Streams

STREAM CLASSIFICATION AND DISTRIBUTION

REFERENCE AND CURRENT CONDITION

The distribution of streams vary across the watershed due to changes in site specific characteristics including soil properties and geology. Table 5 displays the number of mapped stream miles by class and stream density by subwatershed. Detailed mapping of all perennial and intermittent streams within the watershed has not been completed. The stream mileages appearing in Figure 5 under represent the true values for class III and IV streams.

Table 5: Length of Streams by Class and Subwatershed

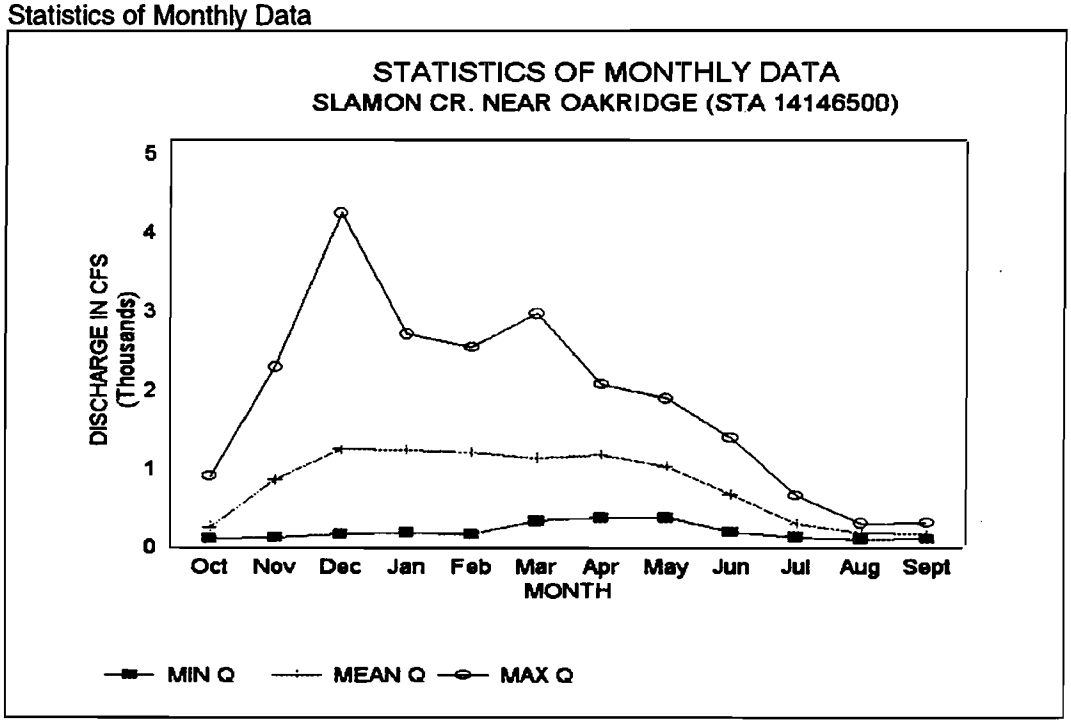
Stream Class	Miles by Subwatershed		
	18 1	18 2	18 3
I	14	12	5
II	35	4	20
III	40	34	23
IV	137	48	35
Total Miles	226	99	84
Stream Density (mi/sq mi)	4.1	2.9	2.1

STREAMFLOW

Stream discharge is a result of a combination of climatic and geologic conditions and can be influenced by natural events and management activities. Stand replacement wildfires and timber harvest can result in a temporary decrease in evapotranspiration resulting in higher stream flow and within the transient snow zone can increase the magnitude of peak flows under some conditions.

Flow measurement records from the US Geological Survey are available for a stream gauging station located near Salmon Creek Falls (station 14146500) at river mile 5.84. The period of record includes from October to November 1909, February 1913 to October 1919, October 1933 to September 1985, and October 1986 until it was discontinued in June of 1994. Statistics of mean monthly flow data is displayed in Figure 6 and a summary of data observations is presented below.

Figure 6: Statistics of Monthly Data



Data Summary for period of Record:

1. Annual mean discharge - 423 cfs
2. Highest annual mean discharge - 681 cfs in water year 1974
3. Lowest annual mean discharge - 217 cfs in water year 1941
4. Lowest average seven day minimum flow - 91 cfs in August of 1940

The variation in streamflow generally follows the pattern of precipitation. The lowest flow period during the year is typically August and September. The majority of the runoff occurs from November through May. High flow events during this time period often coincide with high rainfall events and may be associated with rapid snow melt. During the spring season, melting of the seasonal snow pack at high elevations in the watershed contributes a significant portion of the runoff.

A recurrence interval is the probability a certain magnitude flood event will occur over a given period of time. The following summarizes the results of two different methodologies for determination of a recurrence interval and corresponding flood magnitude utilizing Salmon Creek flow data. The first is an instantaneous peak flow recurrence interval, and the second is a Log-Pearson Type III Duration-Frequency Analysis for mean daily maximum flows. Instantaneous peak flow recurrence intervals were developed from data for this gauging station by Harris et al., 1979, and values are displayed in Table 6a.

Table 6a: Instantaneous Peak Flow Recurrence Intervals, USGS Station 14146500

Recurrence Interval	Discharge (cfs)
2 Year	3,150
5 Year	5,300
10 Year	7,020
25 Year	9,520
50 Year	11,600
100 Year	14,000

Table 6b: Mean Daily Maximum Flow Recurrence Intervals, USGS Station 14146500

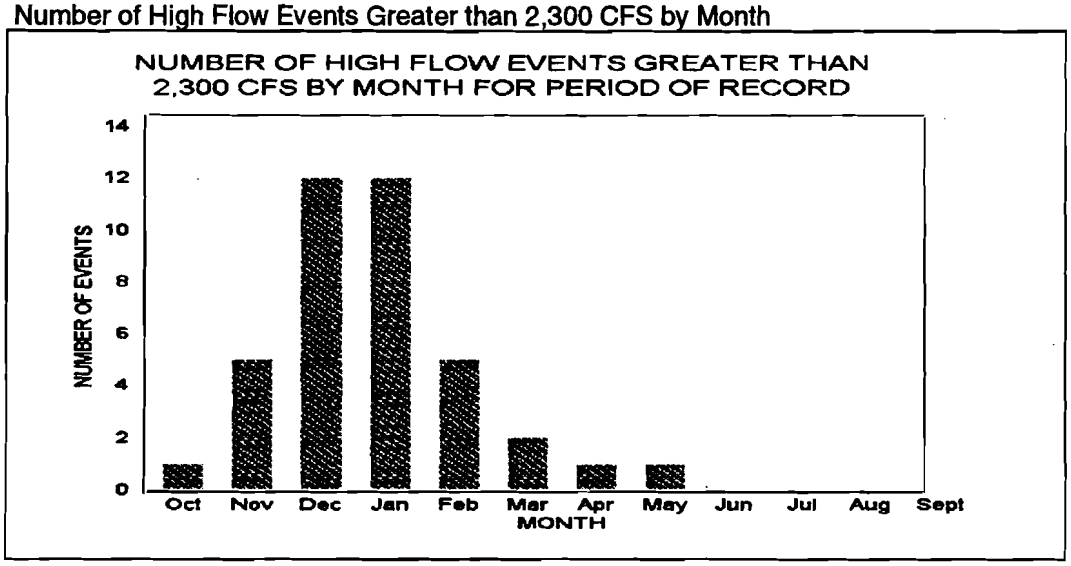
Recurrence Interval	Discharge (cfs)
2 Year	2,719
5 Year	4,278
10 Year	5,387
25 Year	6,855
50 Year	7,989
100 Year	9,153

A Log-Pearson Type III Duration-Frequency Analysis for the period of record up to year 1986 was completed based on USGS gauging station records (Welcher et al. 1991). This analysis provides a recurrence interval for mean daily maximum flows rather than instantaneous peak flows. These recurrence intervals are displayed in Table 6b.

Notable flood events within the Willamette River Basin prior to the period of record occurred in calendar years 1861 and 1890. The maximum discharge for the period of record was 11,700 cfs on December 22, 1964. Floods of smaller magnitude exceeding the 10 year recurrence interval but less than a 25 year event as displayed in Table 6b, occurred in December of 1942, 1945, and 1955. Floods of this magnitude also occurred in January of 1971 and February of 1986. A flood slightly greater than the magnitude of a twenty-five year event as displayed in Table 6b occurred in December of 1956.

The greatest frequency of high flow events occurs during the months of December and January. Figure 7 displays the number of recorded events with a mean daily discharge exceeding 2,300 cfs by month. This flow corresponds to an event with approximately a 1.5 year return interval under the Log-Pearson Type III Duration Frequency analysis for mean daily maximum flows.

Figure 7: Number of High Flow Events Greater than 2,300 CFS by Month



Hydrologic Recovery

REFERENCE AND CURRENT CONDITION

Variations in stream flow are influenced by the intensity, duration and type of precipitation, and the capacity of the watershed to store runoff. Peak stream flows are most likely to occur during storms delivering large quantities of precipitation in a short time. Some studies have linked increases in peak stream flow with timber harvest and attributed this change to an altered rate of snow accumulation and melt. Warm wind and

rain storms on saturated snow packs have been shown to contribute runoff to flood events. Christner and Harr (1982) studied the effects of timber harvest and roading on peak flows for three paired basins. They attributed increases in peak flows to increased rate of soil water input during rain-on-snow events. The latter type of event is most common in the transient snow zone between the months of October and March. Increases in peak stream flow may result in an increase in stream bed and bank erosion and a corresponding increase in sediment production.

The vegetative condition of an area as it relates to snow accumulation and melt within the transient snow zone is termed hydrologic recovery. Prior to forest management, hydrologic recovery values probably varied widely through time due to stand replacement wildfires. The Salmon Creek watershed likely experienced long periods of relatively high hydrologic recovery punctuated with relatively short periods (depending on the rate of reforestation) of very low recovery levels (similar to the effects of clearcut harvesting) after infrequent, landscape level fire events mentioned in the Vegetation/Fire History discussion contained in Chapter II.

The Willamette National Forest Land and Resource Management Plan (USDA, 1990) states that an assessment of potential for cumulative effects of operating and scheduling practices on beneficial uses should considered the effects of management practices on hydrologic recovery (FW-093).

Hydrologic recovery can be quantified by the Aggregate Recovery Percent (ARP) method. Calculated ARP values were used as a measure of the risk of increased peak streamflow related to management activities. For a further discussion of ARP, see Willamette national Forest Land and Resource Management Plan FEIS Chapter IV, Section: Water and Appendix B of that document.

For planning purposes, the Willamette National Forest Land and Resource Management Plan (Forest Plan) describes the sensitivity of planning subdrainages based on overall slope of the drainage and the percent in the transient snow zone. Each planning subdrainage was assigned a midpoint ARP value as a reference point for assessment purposes. The mid-point ARP values provide a relative measure of drainage sensitivity (see Forest Plan Appendix E). These may be viewed as threshold values below which a more detailed assessment should be conducted to determine the potential for adverse effects associated with increases in peak stream flow. Current and mid-point ARP values by planning subdrainage are displayed in Appendix C. Mapped locations of planning subdrainages can be found in Appendix B. Table 7 displays the current calculated ARP values and a weighted mid-point ARP by subwatershed. Subwatershed 18 3 is currently the lowest, 18 2 is intermediate, and 18 1 has the highest current value.

All subwatersheds are currently above a weighted mid-point ARP value calculated from Forest Plan values assigned to planning subdrainages. The weight assigned to each planning subdrainage was based on the area it contributes to the total subwatershed area.

Table 7: Aggregate Recovery Percentages by Subwatershed

Subwatershed	ARP Value	Weighted Mid-Point ARP Value
18 1	88	72
18 2	86	66
18 3	81	68

Roads contribute to an increase in peak flows above the change in vegetative condition primarily due to the reduced permeability of the road surface, more rapid routing of water to streams in roadside ditches, interception and conversion of sub-surface flow to more rapid surface flow, and in some circumstances through the formation of gullies below relief culverts (see discussion in Geology Sediment Associated With Roads). A study utilizing a stream network simulated for Lookout Creek and Blue River drainage's (Wemple 1994) indicated drainage density may increase by as much as 36 percent to more than 60 percent due to the road network. Appendix D lists the current road densities by subwatershed, planning subdrainage and streamsheds.

Jones and Grant (1996) studied the same basin pairs as Christner and Harr (1982) using 150 to 200 paired storms with a period of record greater than 55 years. The results of this study indicate a significant increase in peak discharge associated with cumulative percent of the basin harvested in all three basin pairs. The results of this study indicate no difference in the peak flow response for rain verses rain-on-snow events. They speculated that the trend of increasing peak flows could be several interacting mechanisms including changes in water routing by roads. The regression model used by Jones and Grant (1996) in the North

Fork of the Middle Fork of the Willamette and Salmon Creek pair, indicated that on the average, the basin with an additional five percent of its area harvested increased peak flows by an amount equivalent to 25 to 34 percent of an event with a one year recurrence interval.

Water Yield

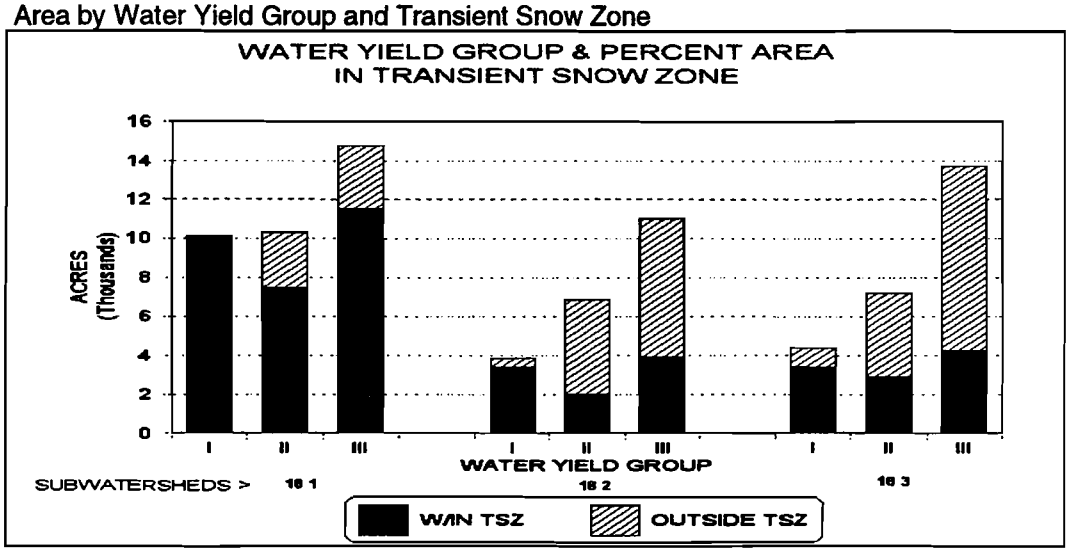
The water yield of an area is a product of the amount of precipitation it receives, combined with the soil and landform properties. The vegetative condition of an area also affects water yield due to changes in the rate of evapotranspiration. Water yield increases have been observed following stand replacement wildfires (Potts et. al., 1989) and after clearcut harvesting (Moring 1975, Harr 1983).

Groundwater storage capacity is directly related to the type of soil and its depth. Relatively shallow soils have a lower ability to store water and have the potential to be the greatest contributors to increased stream flow during high runoff events. Deep soil areas have the ability to store more water and release this water at a slower rate and contribute to baseflow. Soil water yield classification from the Willamette National Forest Soils Resource Inventory (USDA, 1994b) was used as an indicator of the water storage capacity of the soil and the rate at which water would be transmitted through the soil contributing to streamflow. Soil water yield class definitions used in this analysis are as follows:

I. Soils with a low runoff rate and high water detention capacity, given that the soils are not saturated or frozen. Important in sustaining high base flows.
II. Soils with a moderate runoff rate and moderate water detention capacity. Water contributes to both peak flow and base flow.
III. Soils with a high runoff rate and low water retention capacity. The storage capacity is low and easily exceeded with most of the water contributing to peak stream flow.

Landtypes identified in the Soils Resource Inventory were aggregated into high, moderate of low water yield classifications. Figure 8 displays the relative area of each water yield class by subwatershed and the relative proportion of each subwatershed within the transient snow zone. Those subwatersheds that have a high proportion of their area in water yield class III and a high proportion of their area in the transient snow zone would be most susceptible to increases in peak stream flow during rain on snow events. Subwatershed 18 1 would likely contribute the largest volume of runoff during peak flow events due to the large proportion in water yield class III and a high proportion within the transient snow zone.

Figure 8: Area by Water Yield Group and Transient Snow Zone



Water Quality

BENEFICIAL USES

The Oregon Department of Environmental Quality has identified beneficial uses in Oregon Administrative Rules 340-41-442. Beneficial uses for Salmon Creek include resident fish and aquatic life, water contact recreation and aesthetic quality. The Salmon Creek watershed is a secondary municipal water supply for the City of Oakridge and is a source of water for the Oakridge Fish Hatchery operated by the Oregon Department of Fish and Wildlife. Water quality parameters of concern include stream water temperature and sediment.

WATER TEMPERATURE

REFERENCE CONDITION

The water quality within the Salmon Creek watershed during prehistoric times would have been considered high quality by today's standards the majority of the time. Stand replacement wildfires would have had the potential to significantly affect stream temperatures by removing stream side vegetation. After large scale fires or large magnitude flood events, stream temperatures would likely be elevated for a period of time as the stream side vegetation recovers. This recovery period would vary depending on site specific factors. The recovery period could extend to twenty years or more before shading reached pre-disturbance levels.

Limited stream temperature data is available to indicate the range of stream temperatures within the watershed before extensive timber harvesting and road building occurred within the watershed. Table 8 displays the known stream temperature data during this time period. In the summer of 1917 water temperatures were found to be six to eight degrees Fahrenheit colder in Salmon Creek near the mouth when compared to temperatures in the Middle Fork Willamette near the mouth of Salmon Creek.

Table 8: Historic Salmon Creek Temperatures: Year 1917 (from Johnson D.R. 1917)

Location	Month	Maximum Temp. (°F)	Minimum Temp. (°F)
Salmon Creek:	July	56.0	46.0
near mouth at	August	57.0	46.0
river mile 1	September	58.0	46.0

Table 9: Historic Stream Temperatures (from McIntosh et al. 1996)

Location	River Mile	Date	Time	Temperature (°F)
Salmon Creek:				
near mouth		9/1/37	5:15 p.m.	56
bridge at ranger station	1.6	9/1/37	5:00 p.m.	55
Salmon Creek Falls	5.4	9/1/37	4:00 p.m.	52
Mouth of Wall Creek	10.0	7/12/38	1:45 p.m.	56
Mouth of Black Creek	13.5	7/12/38		56
Mouth of Furnish Creek	17.7	7/17/38	4:30 p.m.	49
Black Creek:				
4.0 miles from confluence with Salmon Creek	4.0	7/17/38	2:00 p.m.	50

CURRENT CONDITION

Oregon State water quality temperature standard (OAR Chapter 340):

Seven day moving average of the daily maximum shall not exceed the following values unless specifically allowed under a Department of Environmental Quality approved basin surface water management plan-

- 64 degrees F (17.8 degrees C)
- 55 degrees F (12.8 degrees C) during times and in waters that support salmon spawning, incubation and fry emergence from the egg and from the gravel.
  [except when the air temperature exceeds the 90th percentile of the 7-day average daily maximum air temperature for the warmest 7-day period of the year]

Water quality limited criteria:

Rolling seven day average of the daily maximum exceeds the standard listed above. In cases where data was not collected in a manner to calculate the rolling seven day average of the daily maximum, greater than 25 percent (and a minimum of at least two excedences) of the samples exceed the standard based on multi-year monitoring programs that collect representative samples on separate days for the season of concern (typically summer) and time of day of concern (typically mid to late afternoon).

Time period:

Rearing > June 1 through September 30

Spawning through fry emergence > October 1 to May 31

Stream temperatures within the Salmon Creek watershed vary greatly by season of the year. The highest daily maximum temperature for a given year can occur any time between June through September. The highest average of the daily maximum temperatures occurs during the month of July and the lowest temperatures in December and January .

MAINSTEM SALMON CREEK

Stream temperature data for lower Salmon Creek is available for the critical summer months from the Oakridge fish hatchery located at river mile 1.0. A nearly continuous data record of daily maximum and minimum stream temperatures exists for years 1955 through the present. Figure 9 displays a monthly average of the daily maximum and daily minimum stream temperature at this location for the period of record. For this analysis, recorded daily maximum stream temperatures during the months of June, July and August were used to determine compliance with current standards and determine if any trends are apparent. Figure 10 shows the maximum stream temperature recorded for each summer season and the maximum of the seven day rolling average for this time period.

Figure 9: Average Monthly Stream Temperatures for Salmon Creek Near Mouth

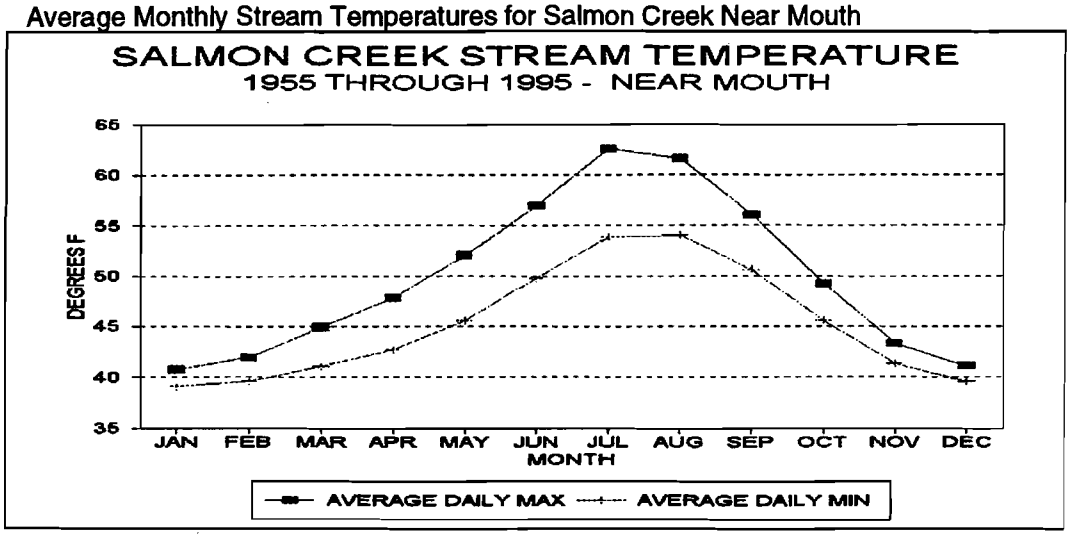
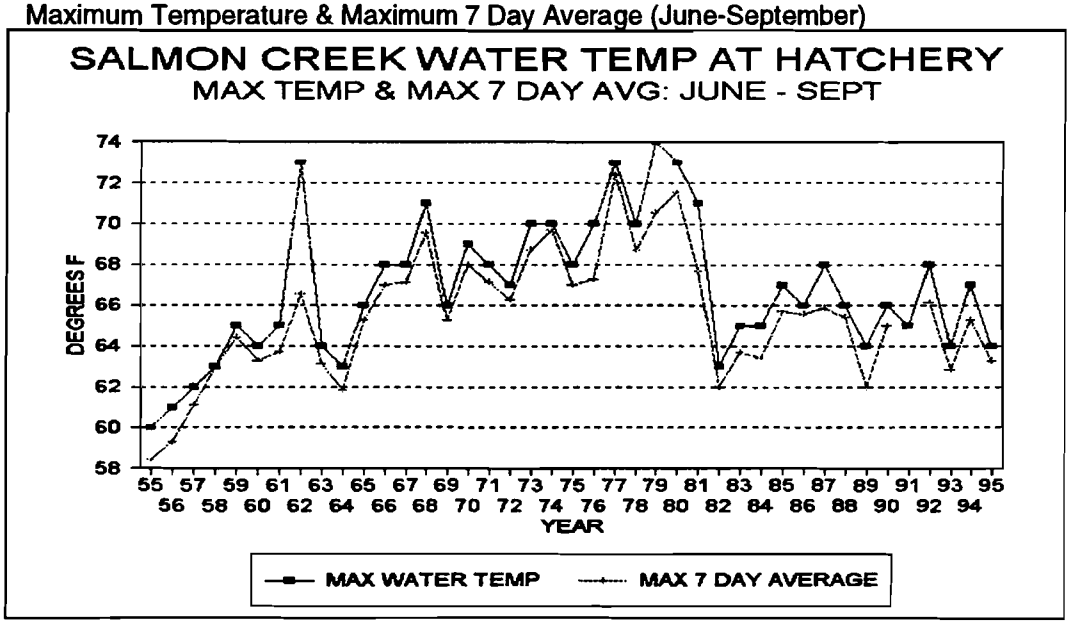


Figure 10: Salmon Creek Water Temperature at Hatchery;
Maximum Temperature & Maximum 7 Day Average (June-September)

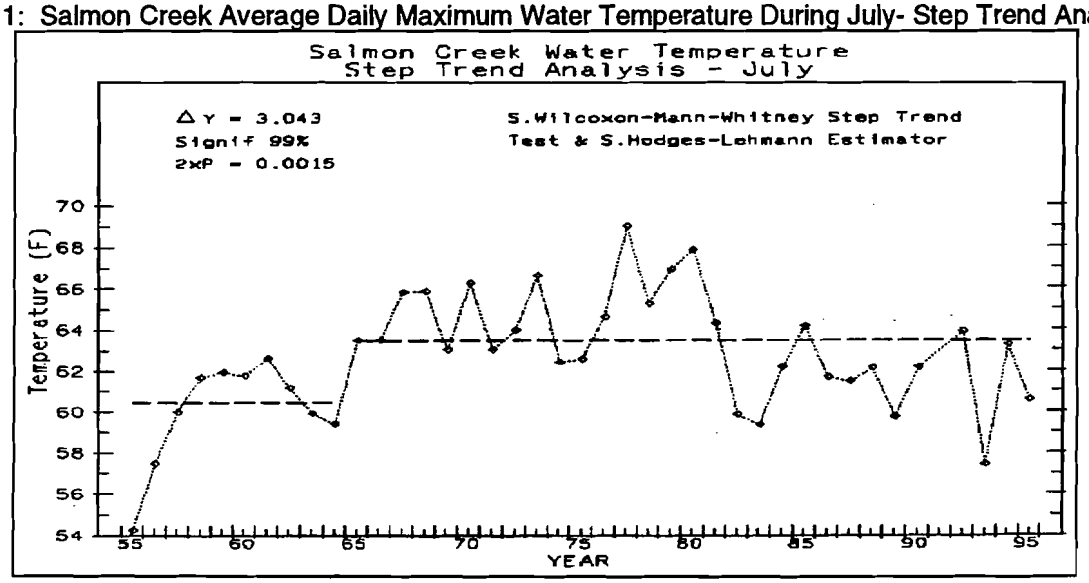


For the period from the beginning of the record through 1981, the maximum stream temperature and the maximum of the seven day rolling average tends to increase. After 1981, the temperatures tend to be lower. However , they do not reach the cooler temperatures measured during the summer season at the beginning of the period of record (1955-1957) or the lower temperatures indicated during the reference period.

The increase in stream temperature coincides with the time period when stand replacement timber harvest and road building was occurring at a faster rate within the watershed. Logging practices implemented during the 1960's and 1970s typically would remove the majority of stream side vegetation and frequently included

the removal of in-channel large woody material. Studies have demonstrated these practices can result in increased temperatures in streams (Moring 1975). Another factor which could have contributed to the apparent increase in stream temperatures is damage to stream side vegetation during high flow events such as the flood of December 1964. Figure 11 displays an analysis of the average daily maximum stream temperatures for the month of July before and after this flood event. Analysis of the average daily maximum stream temperature during July indicated a significant increase in the mean of the maximum stream temperatures from the period before the 1964 flood to the period after the flood ($p<0.01$).

Figure 11: Salmon Creek Average Daily Maximum Water Temperature During July- Step Trend Analysis



A study completed by Beschta and Taylor (1988), reported a highly significant ($p<0.01$) correlation between a cumulative index of timber harvest and maximum stream temperatures. They also noted that stream temperatures tend to increase following damage to streamside vegetation from large magnitude peak flow events and associated mass movements. Their study utilized a forward step wise multiple regression to confirm the occurrence of a highly significant ($p<0.01$) time trend in maximum stream temperatures in Salmon Creek over the study period of 1955 to 1984. Regression analysis for this study indicated the effect of streamflow upon stream temperature was considerably less than the time trend effects. They found that the majority of the explained variance was associated with "year". Only eight percent of the variance was accounted for by "streamflow". Analysis of air temperature data for the 30 year period of record covered by the study indicated a slight decrease in air temperatures during the same time period that stream temperatures were increasing.

The data record studied by Beschta and Taylor (1988) included relatively large magnitude peak flow events in the Salmon Creek watershed in years 1956, 1964, and 1971. They noted that increased water temperatures would be expected to decrease as streamside vegetation recovers. In the Salmon Creek watershed however, summer water temperatures continued to increase after the 1964 flood (the highest on record) for several years after this event. During the 1960's and 1970's, extensive salvage and "stream cleaning" operations were conducted throughout much of the watershed. These activities could have damaged streamside vegetation and contributed to a reduce rate of recovery. Beschta and Taylor speculated that the lower stream temperatures observed after 1981 could be due to several factors including (1) a reduction in timber harvest and road building after 1972, (2) the absence of a large peak flow event since 1971, which would allow for streamside vegetation to recover, and (3) changes in forest management practices. Data displayed in Figure 14 suggests that the lower stream temperatures after 1981 may be more closely associated with the latter two factors listed above.

LONGITUDINAL VARIATION IN TEMPERATURE

During the summer of 1976, the Oakridge Ranger District placed recording thermometers in Salmon Creek at various locations that measured maximum and minimum stream temperatures. Temperature was recorded on approximately a weekly basis. This data indicates a decreasing trend in stream temperature from the mouth to headwater reaches. Maximum water temperatures in the lower reaches of Salmon Creek are likely lower in the current decade when compared to those displayed in Figure 12.

Figure 12: Salmon Creek July through August 1976; Average of Maximum Weekly Stream Temperatures

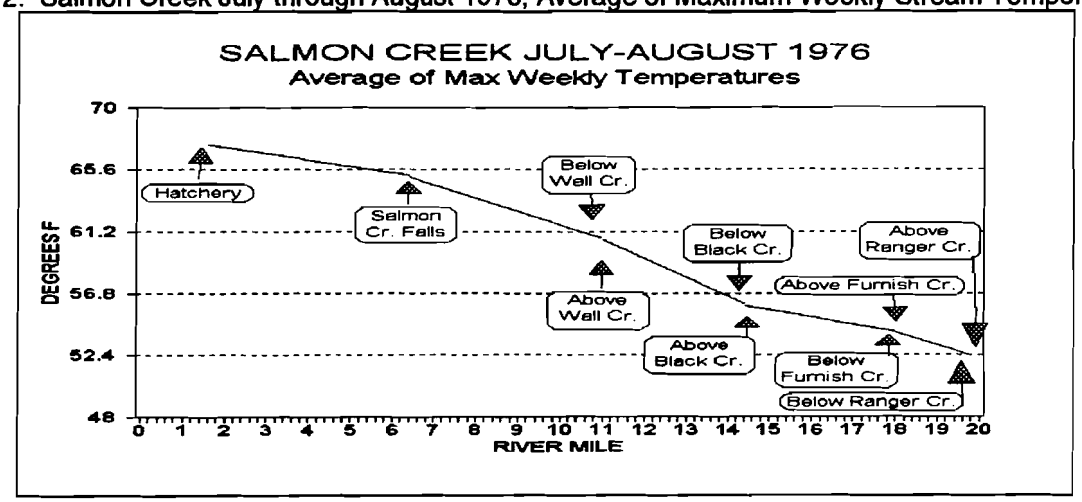


Table 10 below summarizes additional information on temperatures at various locations along the mainstem of Salmon Creek from the 1960's to the present.

Table 10: Salmon Creek Maximum Summer Water Temperatures

Date	Location	Temperature(s)	Data Source
June - October 1964	Near mouth	44.0 - 52.0	1964 survey
September 1965	Near mouth	56.0	1965 survey
Summer 1992 & 1993	Near mouth	59.9 - 67.1	Data recorder
July 1995	Near mouth	60.0	USFS stream survey
July 1995	Fish Hatchery Rd Bridge	55.0	USFS stream survey
July 1995	Near Diversion Dam for Hatchery	58.0	USFS stream survey
July 1995	Near Salmon Creek Falls	55.0	USFS stream survey
July 1995	Near Pollalie Creek	50.0	USFS stream survey
July 1995	Approximately river mile 12.5	51.0	USFS stream survey
July 1995	Between Black Creek and Furnish Creek (river miles 14.2 and 17.8)	52.0	USFS stream survey

TEMPERATURES OF STREAMS TRIBUTARY TO SALMON CREEK

Some small streams tributary to Salmon Creek have likely experienced increases in stream temperatures from the 1960's to the present due to stand replacement timber harvest and other management activities such as the removal of large wood from channels. The effect of the warmer water from these small streams would be partially offset by mixing with cooler water from ground water and other tributary sources. The available data indicates that streams tributary to Salmon Creek are generally relatively cool. Table 11 below summarizes stream temperature information of several tributaries of Salmon Creek.

Table 11: Temperatures of Streams Tributary to Salmon Creek

Stream Name	Date	Location	Maximum Temperature	Data Source
Wall Creek	June-October, 1964	Near mouth	43 - 56	1964 survey
	June - Sept., 1976	Near mouth	55 - 61	USFS data
	Sept., 1995	Above warm springs	48	USFS stream survey
Kelsey Creek	July 1992	Mouth to Headwaters	50 - 54	USFS stream survey
	Oct. - Sept. 1994	Near mouth	34 - 63	USFS data recorder
	Oct. - Sept. 1995	Near Mouth	35 - 60	USFS data recorder
Black Creek	June - Oct., 1964	Near Mouth	43 - 50	1964 survey
	Sept. 8, 1965	Near Mouth	49	1965 survey
	July 19, 1992	Near Mouth	51	USFS stream survey
	June - Sept., 1992-94	Near Mouth	52 - 57	USFS data recorder
	August 1995	Near river mile 10 (reach 12)	47 - 49	USFS stream survey
	August 1995	Near river mile 11 (reach 13)	45	USFS stream survey
Mule Creek	Sept., 1995	Reach 3	43	USFS stream survey
Furnish Creek	June - Sept. 1991	Near mouth	55 - 47	USFS data recorder
	August, 1990	Mouth to headwaters	45 - 52	USFS stream survey
	June - Sept. 1991,92,94,95	Road crossing 2417-266	49 - 57	USFS data recorder
Ranger Creek	July, 1995	Reach 2	54	USFS stream survey
	July, 1995	Reach 4	62	USFS stream survey

COMPLIANCE WITH CURRENT STATE WATER QUALITY STANDARDS FOR TEMPERATURE

The mainstem of Salmon Creek has exceeded the state water quality standard for temperature at the mouth of the watershed for at least a portion of the summer season (June 1 through September 30) in the majority of years data is available. Although stream water temperatures near the mouth of Salmon Creek have been lower since 1981 when compared to the time period of the mid-sixties through the seventies, the water temperature currently is above the state standard in some years during the critical summer season. The limited amount of data available indicates that water temperatures in the mainstem of Salmon Creek are likely maintained below the maximum allowed by state standards above river mile 10 (down stream of the confluence of Wall Creek). The majority of streams tributary to Salmon Creek are relatively cool and within state water temperature standards. However, it is likely some tributary streams that are recovering from stand replacement timber harvest within the riparian reserves are currently above the state standard.

STREAM SEDIMENT AND TURBIDITY

REFERENCE CONDITION

Prior to management activities in the Salmon Creek watershed, elevated turbidity was probably associated with high runoff events, particularly after large and infrequent wildfires, or disturbance such as a debris torrent. The majority of the time, Salmon Creek and its tributaries would have been clear with low levels of suspended sediment and turbidity.

CURRENT CONDITION

Studies indicate the ability of salmonids to find and capture food may be impaired at turbidity values in the range of 25-70 NTUs, growth reduced and gill tissues damaged after 5-10 days of exposure to turbidity of 25 NTUs, and some species may be displaced at 50 NTUs (MacDonald et al. 1991). Salmon Creek generally has low turbidity values (typically less than 5 NTUs) except during winter high flow conditions.

Shallow rapid mass movements in the form of debris torrents can result in dramatic short-term changes in turbidity. Chronic sources of fine sediment contributing to increases in turbidity include road and hill slope surface erosion, and stream bank cutting where banks are composed of unconsolidated material and vegetation has been disturbed.

The degree to which specific drainages contribute chronic sources of sediment varies by management history combined with soil type and geologic structure. See Physical/ Geology and Soils section, this chapter for a related discussion and identified management related sediment source areas.

Bank instability was noted during stream surveys in Warble Creek, Kelsey Creek, Wall Creek, and Mule Creek in subwatershed 18 1. Wall Creek, Mule Creek, and Kelsey Creek had the highest number of mass wasting and bank cutting sites in this subwatershed (18, 9, and 10 sites respectively). Subwatershed 18 2, consisting primarily of Black Creek, had 21 sites of bank cutting and mass wasting, with some of the mass wasting sites being quite large (100 feet long by 50 feet high). Subwatershed 18 3 containing Furnish Creek and Ranger Creek had relatively few sites of bank instability. Subwatersheds 18 1 and 18 2 which have numerous areas of bank instability are likely to be source areas of sediment for stream channels as well as potential sediment sources for the mainstem of Salmon Creek. The mainstem of Salmon Creek itself also had reaches with evidence of bank instability. Reaches 4, 5, 7 and 9 had the highest frequency of unstable areas (see Figure 15).

GROUNDWATER

REFERENCE AND CURRENT CONDITION

The Safe Drinking Water Act requires the Oregon Health Division to identify community water supply systems utilizing groundwater sources under direct influence from surface waters. To meet this requirement, the city of Oakridge contracted with a consulting engineering firm to conduct a hydrogeologic assessment to evaluate whether surface water has a direct hydrologic connection with the wellfield groundwater from which the City extracts its water. The following information was taken from the consulting engineers report prepared for the City of Oakridge (Barry 1993).

The available geologic information indicates no laterally continuous low permeability zone that would isolate surface water (Salmon Creek) from the aquifer that supplies the City's wellfield. In addition, it appears there is a hydrologic connection between the wellfield and Salmon Creek and that there is a potential for surface water to influence the wellfield. The estimated surface water contribution to the Oakridge wellfield over a six month time period is approximately 60 percent. The travel time of ground water from Salmon Creek to

the wellfield is estimated to range from less than three months to more than one year. Actual travel time of the water is probably greater however because the preceding estimates do not include the time required for the surface water to infiltrate vertically downward from Salmon Creek to the open interval of the wells.

Large Woody Material

Large Woody Material (LWM) is an important component on most stream reaches within the Salmon Creek watershed. This material influences the form and structure of stream channels by affecting stream profile, pool formation, and channel pattern and position. The rate at which sediment and organic matter are transported downstream is controlled in part by LWM. The features formed by LWM affect the formation and distribution of in-stream habitat, provide cover and complexity, and act as a substrate for biological activity.

REFERENCE CONDITION

Due to the affects of floods and debris torrents, LWM would have been distributed non-uniformly, existing in large debris jams in and adjacent to stream channels and as isolated logs or trees. Amounts of LWM in stream channels likely varied across the watershed. Some areas that experience repeated fire (see discussion of re-burning in the Vegetation/Fire History Section) may have had low amounts of in-stream LWM.

CURRENT CONDITION

Past management activities such as salvage logging and stream cleaning projects have reduced the current amount of LWM present in and adjacent to stream channels when compared to pre-management conditions. The 1964 flood event combined with extensive timber salvage within the riparian area of Salmon Creek likely had significant impacts to the stability of gravel and cobble bars, stream banks, and riparian vegetation. The loss of LWM is likely in part responsible for reduced channel complexity including a reduction in the number of pools and the number and length of side channels (see the channel condition discussion later in this chapter).

Large woody material for streams originates directly from the adjacent riparian area, from tributaries, and from hill slopes. Past timber management activities have significantly affected this source area of LWM within the riparian areas. Stand replacement timber harvest and salvage logging has reduced the amount of LWM currently available and the potential recruitment of LWM in the future (Figures 13 and 14). Many decades will be required for riparian areas to recover and provide LWM of similar sizes and amounts as would have been available under pre- management conditions.

Riparian Reserves

CURRENT CONDITION

Approximately 31 percent of the total area of the Salmon Creek watershed is within areas identified as riparian reserves. The proportion of the watershed in riparian reserves will likely increase as more detailed stream mapping is completed. Figure 13 of this chapter displays the acres of mapped riparian reserves by subwatershed and the area by harvest category within these reserves. Subwatershed 18 1 has had the highest percentage of harvest in riparian reserves.

The area impacted by management activities within riparian reserves has varied over time. Harvest impacts within riparian reserves increased during the decade beginning in 1960 and remained relatively high through the decade ending in 1990. Figure 14 and Table 12 of this chapter display the acres of riparian reserves harvested by decade and subwatershed.

Table 12: Acres Harvested in Riparian Reserves

	Decade of Harvest								Total Acres by Subwatershed
Subwatershed	< 29	30-39	40-49	50-59	60-69	70-79	80-89	90-95	
18 1	195	0	152	413	1388	1438	831	36	4453
18 2	0	0	0	45	337	431	303	64	1180
18 3	0	0	1.5	137	527	361	511	40	1577.5
Total Acres by Decade >>	195	0	153.5	595	2252	2230	1645	140	Total = 7210.5

Figure 13: Acres of Riparian Reserves and Amount Impacted by Harvest

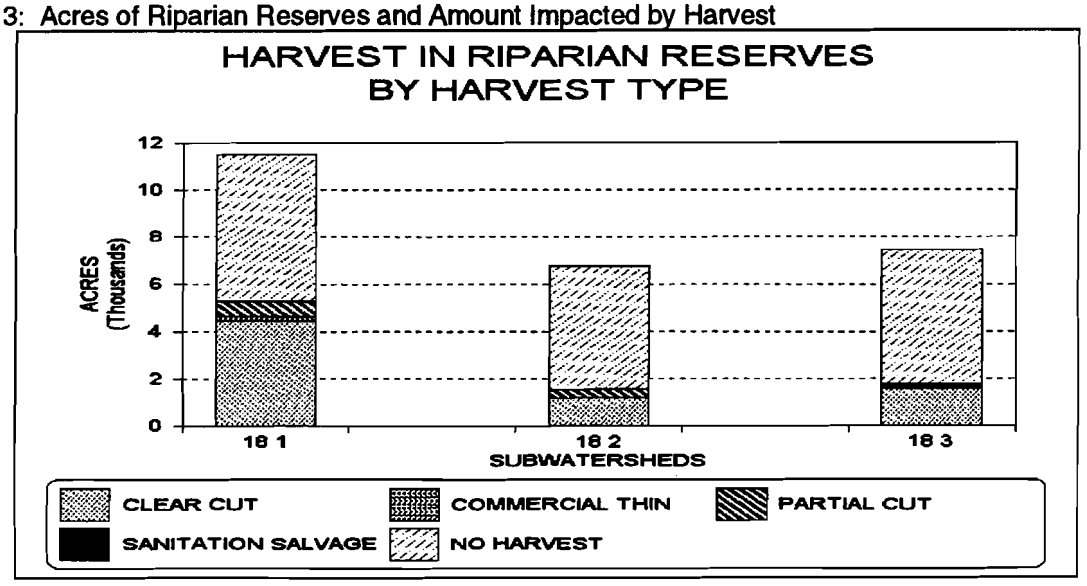
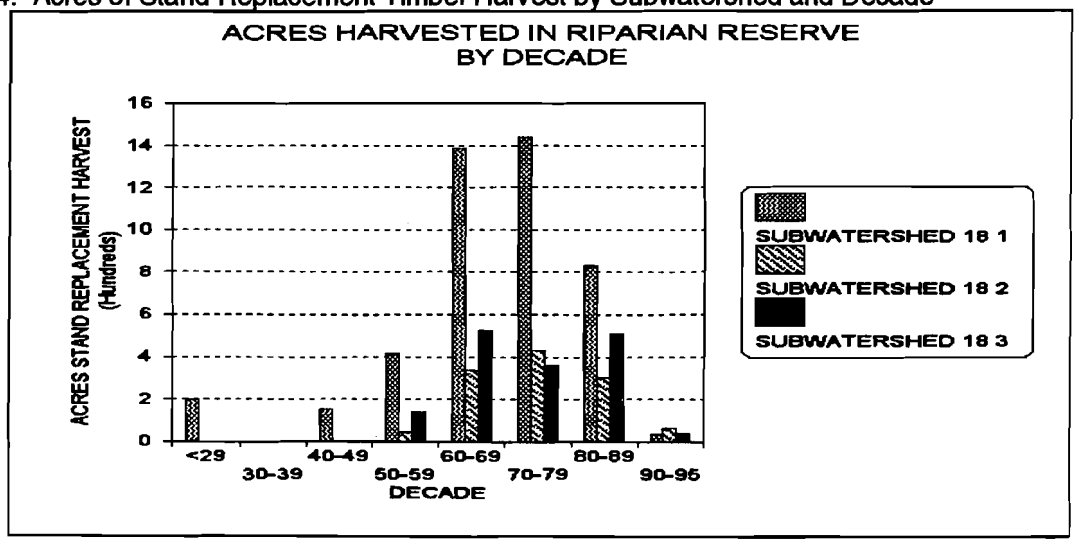


Figure 14: Acres of Stand Replacement Timber Harvest by Subwatershed and Decade



Channel Condition

REFERENCE CONDITION

Channel conditions in general are heavily influenced by the presence and distribution of large woody material (see above section on large woody material). Overall channel conditions prior to management probably varied substantially by stream type and due to the influence of varying amounts of large woody material. It is likely that most stream reaches had relatively high amounts of large woody material before management impacts occurred, as historic stream survey data indicates. Streams located in areas of high fire frequency and high elevation areas may exhibit a natural condition of low amounts of large woody material.

CURRENT CONDITION

Channel conditions were analyzed by subwatershed, except for the main stem of Salmon Creek which was analyzed separately because it flows through more than one subwatershed. Physical and biological characteristics of each subwatershed, as well as the main stem of Salmon Creek, were determined from stream survey data. Many of these characteristics can be compared to objective values to aid in determining the current condition of the watershed (Table 13). A total of 64.1 miles of streams have been surveyed in the Salmon Creek watershed (Table 14).

Assessing channel condition and predicting channel response requires identification of functionally similar portions of the channel network. On the Willamette National Forest, the identification of Valley Segment Types has been incorporated into the stream survey methodology to stratify stream segments based on

similar drainage morphology. Tables 16 and 17 of this chapter outline the valley segment types delineated within the Salmon Creek watershed.

Table 13: Objectives for Aquatic Variables

Habitat Variable	Definition or Range	Objective	Source
Large Pools	<2% Gradient	1 pool/5-7 channel widths	Willamette NF Plan
Large Pools	2-8% Gradient	1 pool/3-5 channel widths	Willamette NF Plan
Large Pools	Channel Width	See below (*)	PACFISH
Large Wood	Undefined	80 pieces over 24" dbh & 50' length per mile	PACFISH
Large Wood	Low Gradient Streams	105 pieces longer than stream width w/pieces >25' per mile	Willamette NF Plan (Appendix E)
Large Wood	High Gradient Streams	50% of channel length should be influenced	Willamette NF Plan (Appendix E)
Width:Depth Ratio	All Streams	<10	PACFISH
Temperature	Streams (salmonids)	Meet state standards (58 degrees F)	State Standards

(*) PACFISH Objective for Pools per Mile by Wetted Stream Width in feet (USDA, USDI, 1994c)

Wetted Stream Width	10	15	20	25	50	75	100	125	150	175	200
Pools/Mile	96	70	56	47	26	23	18	14	12	10	9

Table 14: Streams Surveyed in the Salmon Creek Watershed

Stream	Subwatershed	PSUB	Miles Surveyed	Year Surveyed	Method*
Salmon	NA	NA	12.3, 21.8	1990, 1995	GP, Reg
Warble	Lower Salmon (18 1)	182	.9	1990	GP
Salmon Trib	Lower Salmon (18 1)	183	.34	1990	GP
Wall	Lower Salmon (18 1)	18E	5.36, 7.01	1991, 1995	GP, Reg
-Tributaries		18E & F	3.08	1991	GP
Mule	Lower Salmon (18 1)	18I	3.49	1995	Reg
Kelsey	Lower Salmon (18 1)	18Z	5.73	1992	Reg
-Tributaries		18Z	1.5	1992	Reg
Black	Black Creek (18 2)	18X	8.99, 3.25	1992, 1995	Reg
Ranger	Upper Salmon (18 3)	18T	3.28	1995	Reg
Furnish	Upper Salmon (18 3)	18K	4.68	1990	GP

*GP - Gifford Pinchot, Reg - USFS Region 6

Relatively high gradient streams associated with Steeply Incised Valley/Steep and Moderate Channel Gradients (types 2, 3, V1, V2, V3, H1, H2, and H3) are generally high debris transport streams with channel features including frequent vertical drop scour pools and infrequent log jams. Lower gradient streams associated with valley segment types such as U-Shaped Glacial Trough and alluviated mountain valleys (types 7, 10, M2, V4, U2, and U3) will have depositional features such as point bars, and under natural conditions would be expected to have abundant log jams. Channel stability ratings are an indication of sediment source areas often from stream bank and stream bed erosion. Areas indicated as having a poor stability rating may be particularly susceptible to adverse impacts during high flow events. It should be noted that valley\headwall tributaries are probably under represented since many of these are Class IV streams which are not surveyed under current stream survey methodology. The following is a synopsis of the stream surveys conducted in the Salmon Creek watershed.

Main Stem of Salmon Creek

VALLEY SEGMENT TYPES

The main stem of Salmon Creek is composed of several different valley segment types and Rosgen types (Table 17 and Figure 15 of this chapter). The first reach of Salmon Creek flows through an alluvial/colluvial fan area. The reaches just above this area flow through alluviated slope bound valleys and alluviated mountain valleys before entering a bedrock canyon about 8.8 miles upstream from the confluence with the Middle Fork of the Willamette River. Above this bedrock canyon Salmon Creek again flows through an alluviated mountain valley until the confluence with Black Creek. Above this point, the valley changes to a v-shaped valley with a moderate gradient bottom until the confluence with Ranger Creek, when the gradient of the V-shaped valley gets steeper. The total number of miles for each valley segment type is shown in Table 18 of this chapter.

Figure 15:
Valley Segment Types and Rosgen Types

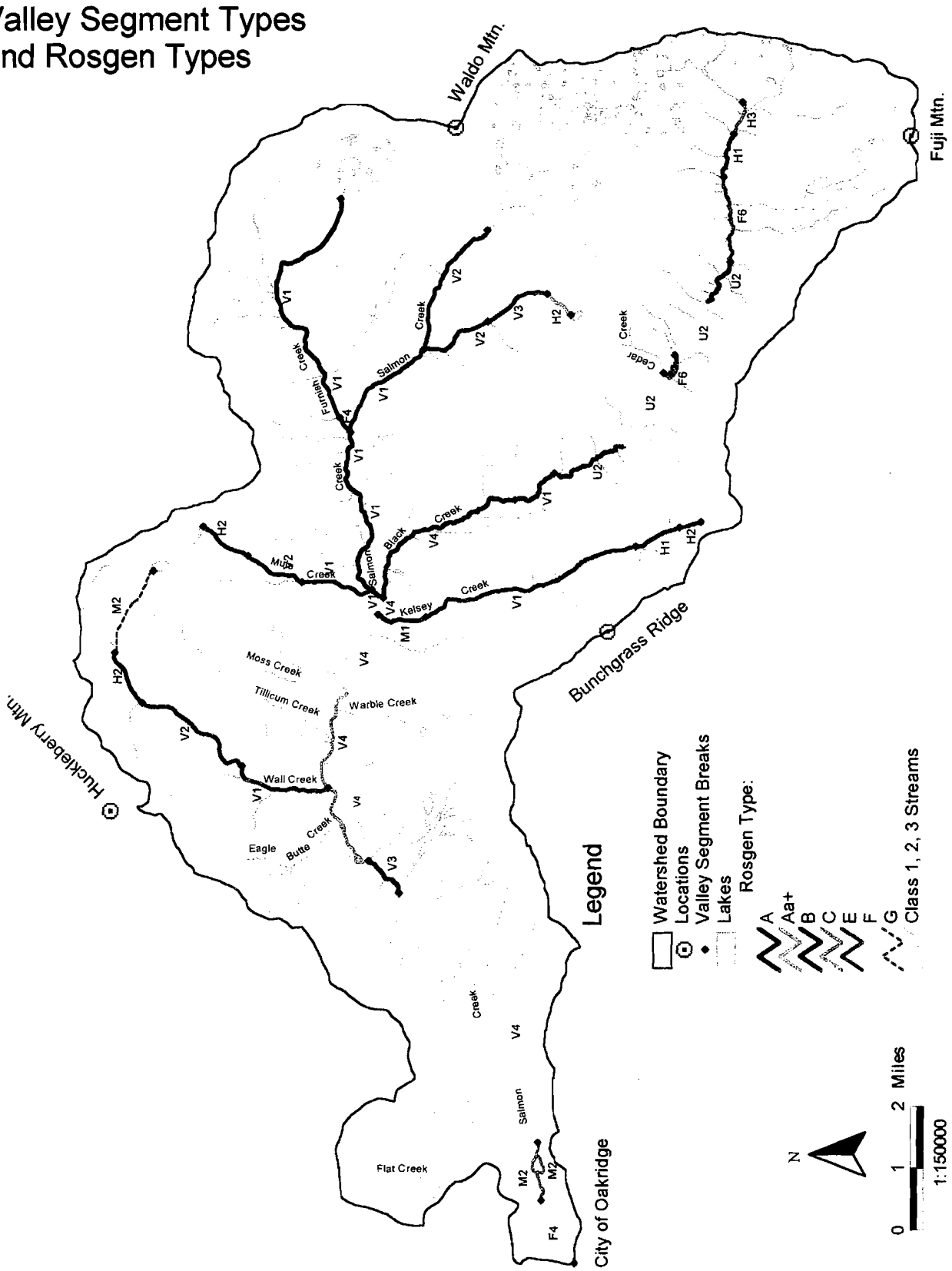


Table 15: Valley Segment Types in the Salmon Creek Watershed

Valley Segment Type	Valley Bottom Gradient	Side Slope Gradient	Valley Bottom Width	Channel Pattern	Stream Order	Landform & Geographic Features
F4- Alluvial / Colluvial Fan	1-3%	<=10%	>3X	Variable;generally unconstrained	1-4	Occurring where tributary streams enter low gradient valley floor; alluvial /colluvial fan deposition overlaying floodplains of larger, low grade stream; may actively downcut through alluvial fan deposition
F6-Palustrine Spring fed Meandering Flats	<2%	<5%	75X	Unconstrained; high sinuosity	>=2	Associated w/lakes, wetland outlets; often high elevation; fine sediment storage; grass/forb riparian communities
M1-Moderate Slope Bound	2-5%	10-30%	<2X	Constrained; infrequent meanders	1-4	Constrained, narrow floodplain bounded by mod. gradient sideslope; typically found in lowlands/foothills, may occur on broken mountain slopes and volcano flanks
M2-Alluviated Moderate Slope Bound	<=2%	<5% gradually increase to 30%	2X-4X	Unconstrained; moderate to high sinuosity	1-4	Active floodplain & alluvial terraces bounded by moderate grade hillslopes; typically found in lowlands & foothills, may occur on broken mountain slopes and volcano flanks
V1-V-Shaped Moderate Gradient Bottom	2-6%	30-70%	<2X	Constrained	>=2	Incised drainage w/steep competent sideslopes; very common in uplifted mountainous topography; also glacial outwash terraces in lowlands
V2-V-Shaped High Gradient Bottom	6-11%	30-70%	<2X	Constrained	>=2	Same as V1, but valley bottom longitudinal profile steep with pronounced stairstep characteristics
V3-Bedrock Canyon	3-11%	>=70%	<2X	Highly constrained	>=2	Canyonlike stream corridors with frequent bedrock outcrops, stairstepped profile; associated with faulted or volcanic landforms
V4-Alluviated Mountain Valley	1-4%	Channel adjacent slopes <10%; increases to 30%	2X-4X	Unconstrained; high sinuosity; with side channels and braids common	2-5	Deeply incised drainage with relatively wide floodplains; distinguished as "alluvial flats" in otherwise steeply dissected mountainous terrain
U2-Incised U-Shaped Valley, Moderate Gradient Bottom	2-5%	Steep channel adjacent slopes, decreases <30% then increases to >30%	2X	Moderately constrained by unconsolidated material; infrequent short flats w/braids and meanders	2-5	Downcuts through deep valley bottom glacial till, colluvium glaciofluvial deposits; cross sectional profile variable, but generally weakly U-shaped w/active channel vertically incised into valley fill deposits; immediate sideslopes composed of unconsolidated & often unsorted coarse grained deposits
U3-Incised U-Shaped Valley, high Gradient Bottom	6-11%	Same as U2	<2X	Same as U2	2-5	Same as U2
H1-Moderate Gradient Valley Wall / Headwater	3-6%	>30%	<2x, may be >2X in headwater cirques	Constrained	1-2	Small Drainage w/channels slightly to moderately entrenched into mountain toeslopes or headwater basins
H2-High Gradient Valley Wall / Headwater	6-11%	>30%	<2X	Constrained; stairstepped	1-2	Small drainage w/channels moderately entrenched into high gradient mountain slopes or headwater basins; bedrock exposures & outcrops common; localized alluvial/ colluvial terrace deposition
H3-Very High Gradient Valley wall / Headwater	>11%	>60%	<2X	Constrained; stairstepped	1-2	Small drainage w/channels moderately entrenched into very steep mountain slopes or headwater basins; bedrock exposures & outcrops frequent

Table 16: Valley Segment Types- Gifford Pinchot Stream Survey Methodology

Valley Segment Type	Stream Order	Sideslope	Channel Pattern	Land Form Features	Channel Type	Channel Gradient	Large Woody Material
Lower Alluvial Valley (1)	Any	0-10%	unconstrained, highly sinuous	on lower large river floodplain/ lacustrine terrace, elevated glacial valleys	alluvial	0-5%	abundant large jams on channel margins
Alluvial Fan (2)	2-4	flat-moderate	sinuous, generally unconstrained	occurs where tributaries enter low gradient streams	alluvial	1-6%	frequent large jams and individual pieces
Steeply Incised Valley Moderate Channel Gradient (3)	2-4	steep	constrained, slightly sinuous	downcutting steep hillsides, often vertical canyon walls	bedrock, alluvial in short reaches	3-6%	infrequent large jams
Steeply Incised Valley /Steep Channel Gradient (4)	2-4	steep, often vertical	constrained, slightly sinuous	downcutting steep hillsides, often vertical canyon walls	bedrock, big boulder	>6%	infrequent large jams
Incised Glacial Till/Incised Colluvium Deposits (5)	2-4	steep w\ flat to steep upper slopes	straight-slightly sinuous	downcutting through glacial deposits or colluvium substrate - high potential bank failure	boulder / rubble	2-5%	abundant single pieces and occasional jams
Moderate-Slope Bound Valley (6)	1-3	flat - moderate	straight-slightly sinuous	lower foothill sand minor fault block areas as well as upper drainage areas	alluvial, short sections of bedrock	1-5%	small debris jams & single stems common
U-Shaped Glacial Trough (7)	1-3	flat	moderate-high meanders	located in bottoms and lower side slopes of U-shaped glacial valleys	alluvial	0-3%	abundant small jams and single pieces
Valleywall/Headwall Tributary (8)	1-2	moderate-steep	straight; stairstep profile	small tributaries flowing over moderate/steep hillsides	bedrock or boulder	1-5 %	variable, creates stairsteps
Lava Flow/Spring Fed Meadow (9)	1-2	0-10%	slight meander	low gradient slopes and slight downcutting	alluvial or boulders	0-3%	infrequent large jams, beaver important
Alluviated Mountain Valley (10)	2-4	flat w\ steep upper slopes	high meanders and braiding	wide annual floodplain, continual alluvial deposits	alluvial	0-3%	frequent jams and single pieces create pools
Moderately Incised Valley (11)	2-3	steep w\ flat upper slope	straight - slightly sinuous	steep, bedrock banks with broad flat upslope areas	bedrock, boulder and rubble	3-5%	infrequent channel width jams, few single pieces

Table 17: Valley Segment Types for Salmon Creek

Reach Number	Reach Length (miles)	Cumulative Miles	Valley Segment Type	Reference Point for Start of Reach
1	1	1	Alluvial/Colluvial Fan (F4)	Confluence with Middle Fork
2	1.1	2.1	Alluviated Moderate Slope Bound (M2)	Fish Hatchery Road bridge
3	1.5	3.6	Alluviated Mountain Valley (V4)	Diversion Dam for Fish Hatchery
4	2.2	5.8	Alluviated Mountain Valley (V4)	
5	2.3	8.1	Alluviated Mountain Valley (V4)	Salmon Creek Falls
6	.7	8.8	Bedrock Canyon (V3)	Bedrock Canyon
7	3.9	12.7	Alluviated Mountain Valley (V4)	Top of Bedrock Canyon
8	1.7	14.4	Alluviated Mountain Valley (V4)	Moss creek
9	3.6	18.0	V-Shaped Moderate Gradient Bottom (V1)	Black Creek
10	1.8	19.8	V-Shaped Moderate Gradient Bottom (V1)	Furnish Creek
11	1	20.8	V-Shaped High Gradient Bottom (V2)	Ranger Creek

Table 18: Total Miles for Valley Segment Types for Salmon Creek

Valley Segment Type	Miles	%
Alluvial/Colluvial Fan (F4)	1	5
Alluviated Moderate Slope Bound (M2)	1.1	5
Alluviated Mountain Valley (V4)	11.6	56
Bedrock Canyon (V3)	.7	3
V-Shaped Moderate Gradient Bottom (V1)	5.4	26
V-Shaped High Gradient Bottom (V2)	1	5

LARGE WOODY MATERIAL

Given the valley segment types present in the main stem of Salmon Creek, large woody material would be expected to be present in the form of frequent jams and single pieces in the alluvial reaches, such as the alluviated mountain valleys. Steeper gradient reaches, such as those flowing through V-shaped valleys, would be expected to have less frequent, large debris jams. Figure 16 of this chapter shows the current levels of large woody material along the longitudinal profile of the main stem of Salmon Creek. All reaches of the main stem of Salmon Creek, including those in which large wood would be expected to be abundant, are below large woody material objective values (Figure 17). Large wood is most abundant in the upper reaches of Salmon Creek, although current levels of wood are lower than objective and historic values. During the 1995 survey, a total of 22 log jams were noted with the majority occurring in reach 9 (above the confluence with Mule Creek. Notes from a 1938 stream survey (McIntosh et al., 1992) reported that Salmon Creek "was full of log jams above the falls, a number of which" were thought to "present impassable barriers to salmon." The highest levels of large wood were located above the confluence with Black Creek according to the same 1938 survey.

Figure 16: Longitudinal Profile for Mainstem Salmon Creek (1995)

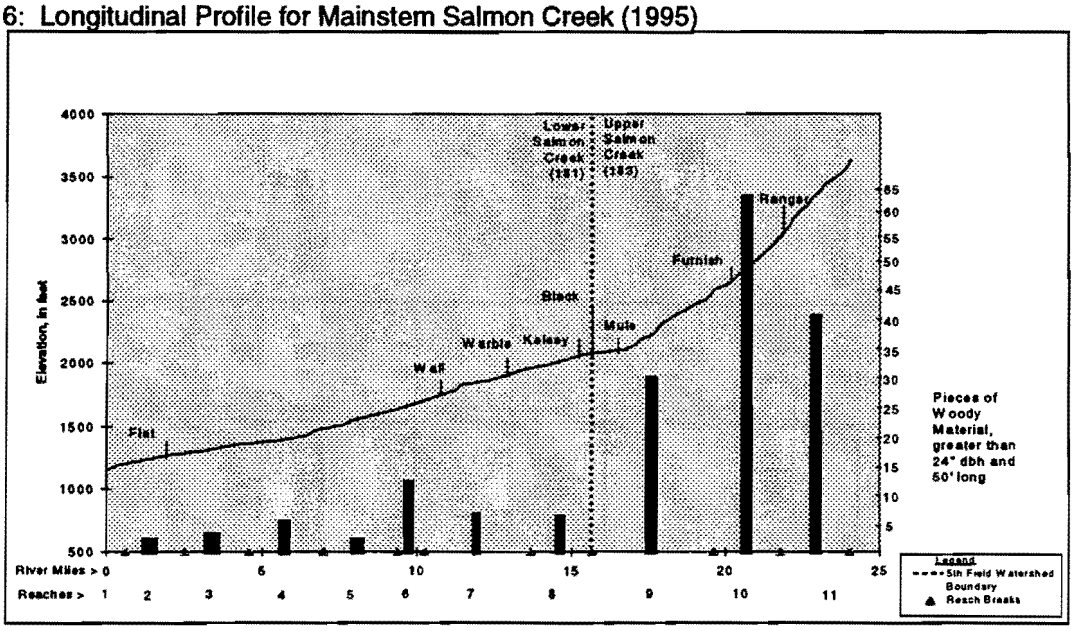
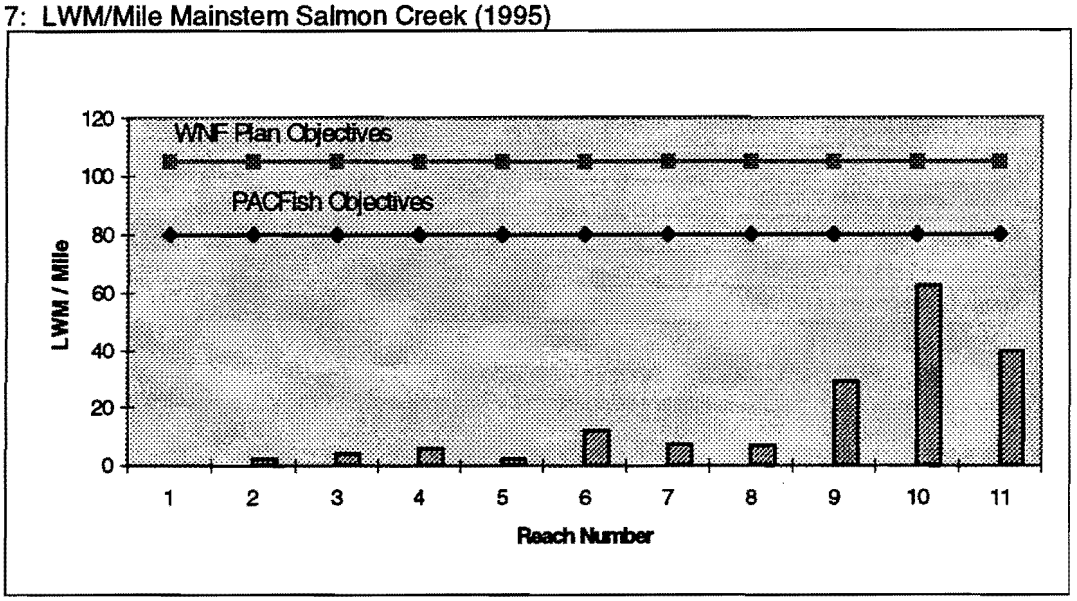


Figure 17: LWM/Mile Mainstem Salmon Creek (1995)



LARGE POOLS AND SIDE CHANNELS

In alluvial reaches, large woody material and scour at meander bends are major components in the formation of large pools. In higher gradient, boulder dominated reaches, pools are typically associated with large log jams or occur as pocket pools associated with large boulders. Figure 18 shows the riffle and pool percentages for the mainstem of Salmon Creek. Pools make up a larger percentage of the total habitat in the lower reaches of Salmon Creek and are less common in the upper reaches. The number of large pools/mile nears or exceeds the Forest Plan objective values, but not PACFISH objective values, in the lower reaches of the mainstem of Salmon Creek (reaches 1-7) (Appendix E). Since there is very little large woody material in this section of Salmon Creek, the majority of pools are probably scour pools at meander bends with very little cover. Although there are higher amounts of large woody material in the upper reaches of Salmon Creek (reaches 9-11) the number of large pools per mile is lower than both Forest Plan and PACFISH objective values.

Figure 18: Mainstem Salmon Creek Riffle/Pool Percentages (1995)

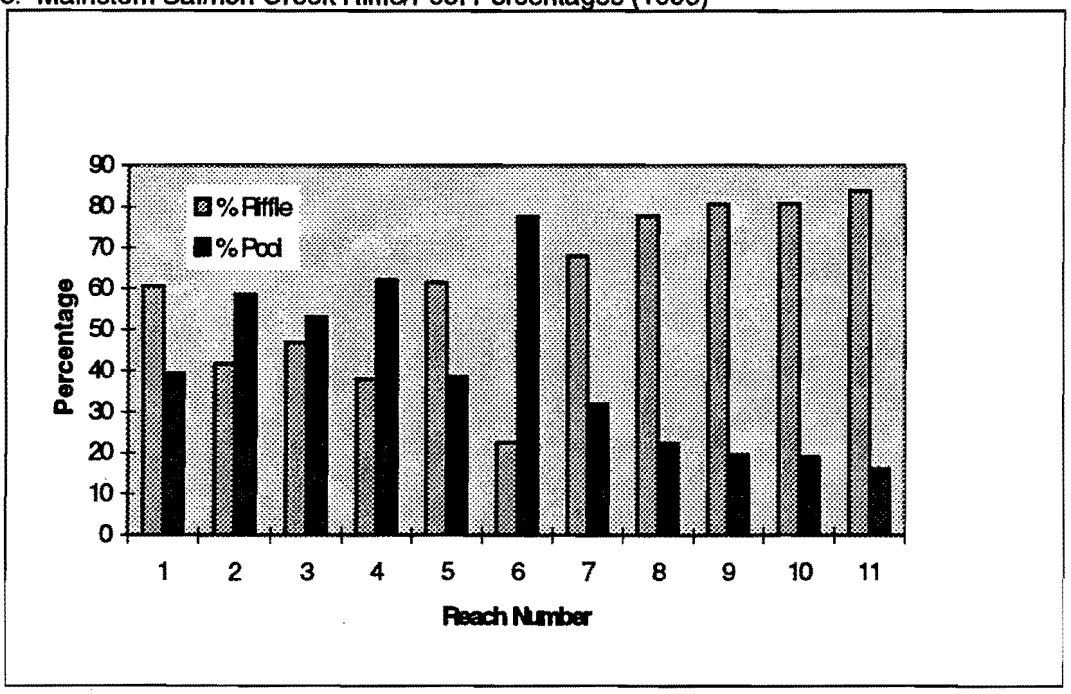


Table 19: Changes in the Number of Pools/Mile in the Mainstem of Salmon Creek from 1938 to 1995

1938 Survey*		% Difference from	1995 Survey**	
Location	pools/mile	1938 to 1992	pools/mile	Reaches
Mouth to Fish Hatchery Rd. Bridge	9.4	+1.1	9.5	1
Fish Hatchery Rd. Bridge to Salmon Ck. Falls	12.1	-9.1	11	2 to 4
Salmon Creek Falls to Wall Creek	14.3	-13.9	12.3	5 to 7
Wall Creek to Black Creek	17.7	-49.7	8.9	8
Black Creek to Furnish Creek	7.6	+122.7	16.9	9
Furnish Creek to end of Survey	20	+0.5	20.1	10

* McIntosh et al. 1992

** Oakridge Ranger District stream surveys 1995

(Note: location description was used rather than river miles for the mainstem Salmon Creek comparisons.)

Comparisons of the large pools/mile from the 1991 stream survey with the survey completed in 1938 (McIntosh et al. 1992) shows that large pools were not numerous in reaches 9 and 10 even in 1938 before intensive land management activities impacted this area (Table 19). The fact that we see an increase in the number of large pools may simply be a factor of differing definitions of "large pools" between the two different survey methods. This is to be expected in these smaller, headwater reaches. A large pool in the 1995 survey methodology simply meant that the pool spanned the entire channel width and would not necessarily be seen as "large" by the 1938 methodology. This difference in large pool definitions between the two survey methods should not be as great in the lower reaches where a "large pool" is actually expected to be large in size. In the lower and middle reaches (2-8) there was a decline in the number of large pools per mile from 1938 to 1995. The highest decline was in reach 8, the section of Salmon Creek that extends from Wall Creek to Black Creek. The 1938 survey indicated that the area above Wall Creek (the stream section above reach 7 during the 1995 survey) had "no signs of human habitation" so this section could be considered as being in reference conditions during the 1938 survey. The number of pools in this reach declined nearly 50 percent from 1938 levels. Reach 1, from the mouth of Salmon Creek to the Fish Hatchery Road bridge did not change between 1938 and 1995. This area was already impacted by the time of the 1938 survey, however. Therefore, 1938 conditions should not be considered to be the reference conditions for this reach.

Side channel habitat is also an important aspect of channel condition. Figure 19 shows that side channels are common throughout the mainstem of Salmon Creek especially in reaches 1, 3, and 7.

Figure 19: Mainstem Salmon Creek Habitat (1995)

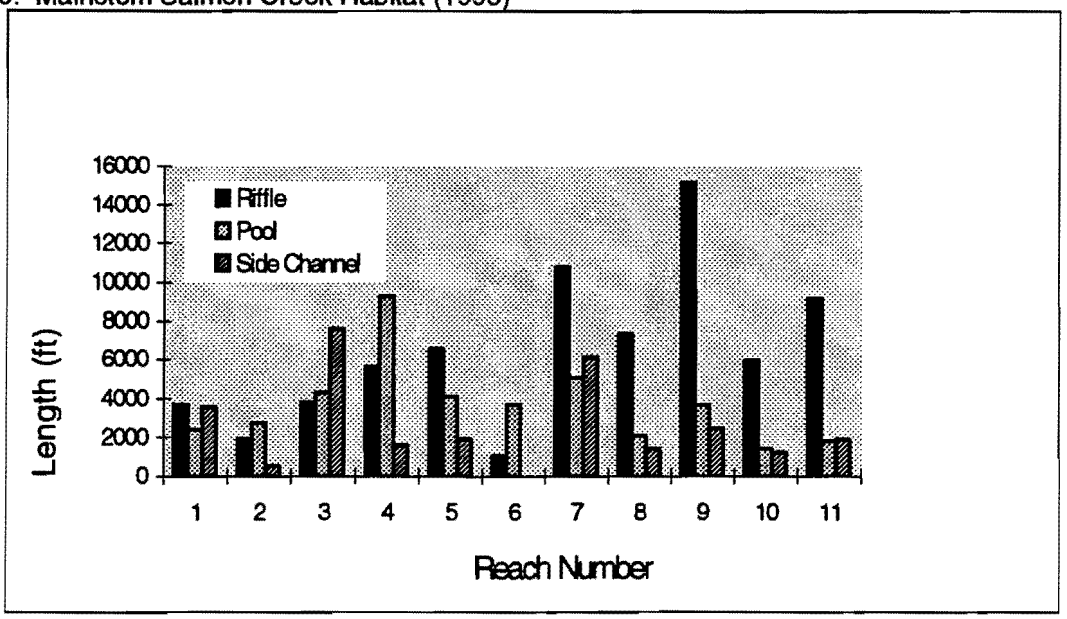


Table 20: Changes in the Average Channel Width in the Mainstem of Salmon Creek from 1938 to 1995

1938 Survey*		% Difference from	1995 Survey**	
Location	width (ft)	1938 to 1992	width (ft)	Reaches
Mouth	55	-20.0	44	1
Fish Hatchery Rd. Bridge	49	+32.7	65	2
Salmon Creek Falls	80	-28.8	57	5
Wall Creek	68	+1.5	69	7
Black Creek	58	-1.7	57	9
Furnish Creek	43	+18.6	51	10

* McIntosh et. al. 1992

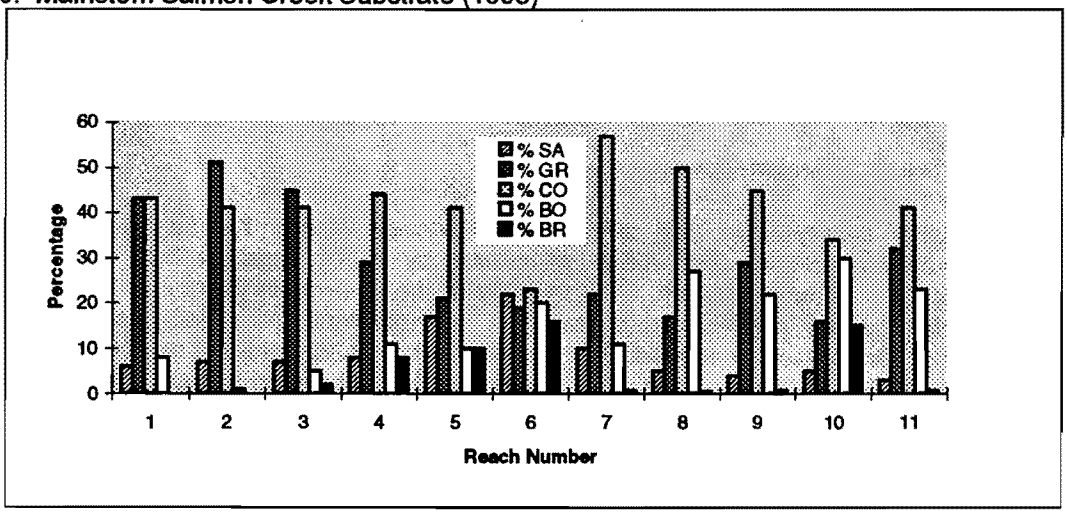
** Oakridge Ranger District stream surveys 1995

(Note: location description was used rather than river miles for the mainstem Salmon Creek comparisons.)

CHANNEL WIDTH

Channel width is another component of channel conditions for which data exists on conditions in 1938 (McIntosh et al. 1992). These can not be considered reference conditions for the lower reaches of Salmon Creek as human impacts were already evident by this time. Comparison of this 1938 data with data collected from the 1995 survey indicates that channel width has changed from 1938 to 1995 (Table 20). It should be noted that the 1938 measurement of channel width was taken from one specific point and the 1995 width is an average channel width for the reach, which contained the 1938 measurement point. The channel width near the mouth of Salmon Creek (reach 1) has decreased by 20 percent since the time of the 1938 survey. This may be due to the levees placed along this reach to protect the city of Oakridge from flooding. Channel width near the Fish Hatchery Road bridge (reach 2) has increased since the 1938 survey. It is possible that the widening of the channel in this location is due to the Fish Hatchery diversion dam. Channel width near Salmon Creek Falls (reach 5) has decreased, but 1995 channel widths near Wall Creek (reach 7) and Black Creek (reach 9) have remained nearly identical to widths measured in 1938. Notes from this 1938 survey indicate that there was no sign of human habitation above Wall Creek (above reach 7). Channel width near Furnish Creek (reach 10), however, has increased by 18 percent over channel width measured in 1938.

Figure 20: Mainstem Salmon Creek Substrate (1995)



SUBSTRATE

Substrate is also an important component of channel condition. Figure 20 shows the percentage breakdown of substrate observed in the mainstem of Salmon Creek during the 1995 stream survey. This survey showed that there are high percentages of gravel and cobble throughout most of the reaches of Salmon Creek. Data on substrate size was also collected during the 1938 stream surveys (McIntosh et al. 1992). To compare this data to that collected in 1995, some assumptions were made in the categorization of substrate size. Substrate called small rubble, medium rubble, and large rubble during the 1938 survey were assumed to be of similar size to those called gravel, cobble, and small boulder respectively during 1995 stream surveys.

Table 21: Changes in Substrate Size Classes in the Mainstem of Salmon Creek from 1938 to 1995

1938 Survey* Location	1995 Survey** Reaches	% small rubble 1938	% gravel 1995	% med. rubble 1938	% cobble 1995	% large rubble 1938	% small boulder 1995
Mouth to Fish Hatchery Rd. Bridge	1	37.6	43	41.1	43	17.7	8
Fish Hatchery Rd. Bridge to Salmon Creek Falls	2 to 4	27.8	41.7	38.8	42	28.6	5.7
Salmon Creek Falls to Wall Creek	5 to 7	22.1	20.7	26.6	40.3	43.7	13.7
Wall Creek to Black Creek	8	11.3	17	19.6	50	67.6	27
Black Creek to Furnish Creek	9	17.4	29	19.9	45	57.3	22
Furnish Creek to end of Survey	10	13.2	16	18	34	62.6	30

* McIntosh et al. 1992

** Oakridge Ranger District stream surveys 1995

(Note: location description was used rather than river miles for the mainstem Salmon Creek comparisons.)

Table 21 shows that in the section of Salmon Creek that extends from the mouth to the Fish Hatchery Road bridge (reach 1), the size of substrate has changed very little between 1938 and 1995. In the section of Salmon Creek from the Fish Hatchery Road bridge to Salmon Creek Falls (reaches 2-4), there was a higher percentage of gravel and a lower percentage of small boulders observed during the 1995 survey than was seen during the 1938 survey. In the segment from Salmon Creek Falls to Black Creek (reaches 5-8) the percentage of gravels was essentially unchanged, but the percentage of cobbles increased and the percentage of small boulders decreased between 1938 and 1995. The 1995 surveys of the upper reaches of Salmon Creek above the Black Creek confluence (reaches 9-10) there was a slightly higher percentage of gravels and cobbles and a lower percentage of small boulders than were seen in the 1938 surveys.

CHANNEL STABILITY

Channel stability for the mainstem of Salmon Creek was rated as good overall, although there were individual reaches in which bank instability was noted. Reaches with the highest degree of instability include reach 4 (5 unstable areas consisting primarily of eroding terraces), reach 5 (5 unstable areas where bank cutting was occurring), reach 7 (5 unstable areas consisting of both bank cutting and some bank sloughing), and reach 9 (9 unstable areas consisting of small rock slides, eroding banks, and cutbanks). Eroding banks are not a new condition in the lower reaches of Salmon Creek. 1938 surveys indicate that bank erosion was common below Salmon Creek Falls (reaches 1-4) (McIntosh et al 1992).

Lower Salmon Creek Subwatershed (18 1)

VALLEY SEGMENT TYPES

Streams that were surveyed in this subwatershed include Warble, Kelsey, Wall and Mule Creeks. Table 22 of this chapter shows the miles of stream by valley segment type for the tributaries of the lower Salmon Creek subwatershed. The majority of the streams in this subwatershed flow through steep, high gradient valley segment types, such as high gradient valley wall (headwater), very high gradient valley wall (headwater), v-shaped high gradient bottom , and v-shaped moderate gradient bottom. Other valley segment types found in this subwatershed include alluviated moderate slope bound valleys, steeply incised valley with a steep channel gradient, and alluvial fans.

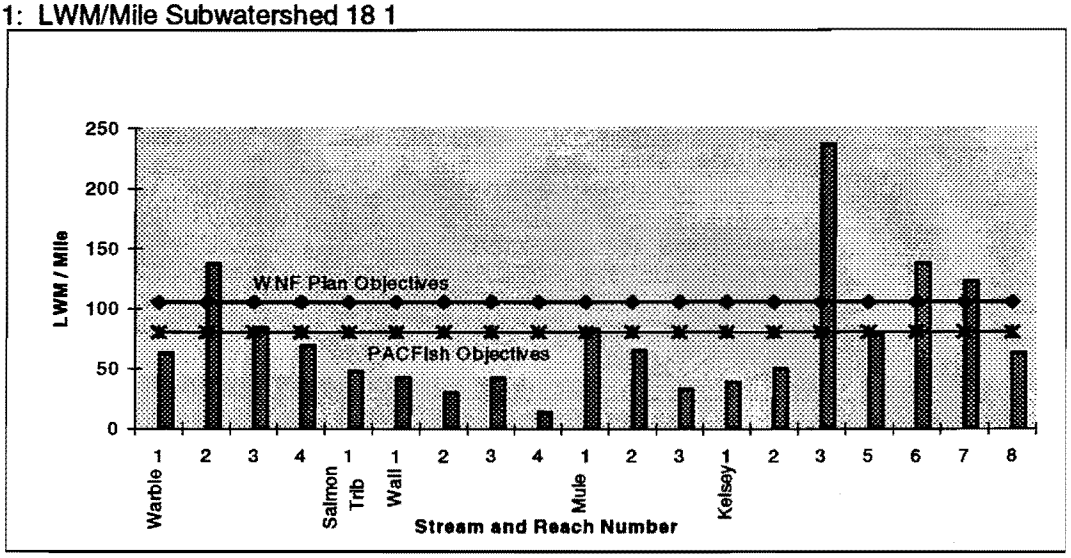
Table 22: Valley Segment Types for Tributaries in Lower Salmon Creek (Subwatershed 18 1)

Valley Segment Type	Miles	%
Alluvial Fan (2)	.6	5
Steeply Incised Valley / Steep Channel Gradient (4)	.3	2
Alluviated Moderate Slope Bound (M2)	1.7	14
V-Shaped Moderate Gradient Bottom (V1)	1.9	16
V-Shaped High Gradient Bottom (V2)	2.4	20
High Gradient Valley Wall / Headwater (H2)	2	17
Very High Gradient Valley Wall / Headwater (H3)	3.2	26

LARGE WOODY MATERIAL

Given the dominant valley segment types in this subwatershed, large amounts of woody material would be expected in the form of small debris jams and single pieces in the alluvial reaches with a few large jams in the higher gradient reaches. There were 75 debris jams of various sizes in this subwatershed. Stream surveys indicate that 72 percent of streams in this subwatershed did not meet PACFISH minimum objectives for the number of pieces of large woody material per mile and 83 percent of the streams surveyed in this subwatershed did not meet objective values outlined in the Appendix E of the Willamette National Forest Plan (Figure 21).

Figure 21: LWM/Mile Subwatershed 18 1



LARGE POOLS

In reaches dominated by boulders, pocket pools would be expected to make up the majority of pool habitat while in alluvial reaches composed primarily of cobbles and gravels, wood becomes an important component in the formation of channel spanning pools. The lack of large wood, especially in the alluvial reaches of this subwatershed, may explain the low numbers of large pools. Large pool habitat is currently lacking in the entire subwatershed (see Appendix E). None of the streams in this subwatershed meet minimum objective values outlined in Appendix E (page E-8) of the Willamette National Forest Plan or PACFISH.

SUBSTRATE

Dominant substrate types in this subwatershed varied by stream (see Appendix E). Wall Creek substrate was primarily composed of gravel, cobble, and boulders except for reach 3 which also contained a high proportion of bedrock, and reach 4 which had a relatively high percentage of sand. Mule Creek had a very diverse range of substrate consisting of sand, gravel, cobble, boulder, and bedrock. The dominant substrate in Warble Creek was rubble, although cobble, gravel, sand and boulders were also present. Cobble and small boulders were the dominant substrates for Kelsey.

CHANNEL STABILITY

Channel stability was rated as good for the majority of the subwatershed. There were 42 documented sites of mass wasting and bank cutting, with the majority occurring in reaches 1 (11 sites) and 2 (4 sites) of Wall Creek, reach 2 of Mule Creek (7 sites), Warble Creek (4 sites) and Kelsey Creek (10 sites) (see Appendix H).

Black Creek Subwatershed (18 2)

VALLEY SEGMENT TYPES

Black Creek is the only stream surveyed in this subwatershed. The numerous small tributaries to Black Creek were not surveyed. Tables 23 and 24 of this chapter shows the miles of stream by valley segment type for the Black Creek Subwatershed. This subwatershed is composed of several different valley segment types and Rosgen types (Figure 15 of this chapter). The first three miles (reaches 1-3) flow through an alluviated mountain valley. Black Creek then flows through a v-shaped, moderate gradient bottom for a short time before entering an incised, U-shaped valley with a high gradient bottom. This

valley segment type continues until the first swamp, which begins at river mile 6.5. After the first swamp, Black Creek flows through another u-shaped valley with a high gradient bottom until it reaches the second swamp beginning at approximately river mile 8.8. Above this second swamp Black Creek enters a moderate gradient valley wall (headwater) and then a very high gradient valley wall (headwater).

Table 23: Valley Segment Types for Mainstem Black Creek (Subwatershed 18 2)

Reach #	Reach Length	Cumulative Miles	Valley Segment Type	Reference Point for Start of Reach
1	1.8	1.8	Alluviated Mountain Valley (V4)	Confluence with Salmon Cr.
2	.1	1.9	Alluviated Mountain Valley (V4)	Unit Boundary in Sec 9
3	1.2	3.1	Alluviated Mountain Valley (V4)	End of Unit
4	.7	3.8	V-Shaped Moderate Gradient Bottom (V1)	Valley Type Change, Side Slopes Steeper
5	1.2	5	Incised U-Shaped Valley, High Gradient Bottom (U2)	Valley Type Change
6	.5	5.5	Incised U-Shaped Valley, High Gradient Bottom (U2)	Habitat Complex Change, More Large Pools
7	.5	6	Incised U-Shaped Valley, High Gradient Bottom (U2)	Habitat Complex Change, Riffles Dominant
8	.5	6.5	Incised U-Shaped Valley, High Gradient Bottom (U2)	Valley Type Change, Wider Valley Floor
9	.4	6.9	Palustrine Spring fed Meandering Flats (F6)	Beginning of First Swamp, Section 26
10	1	7.9	Incised U-Shaped Valley, High Gradient Bottom (U2)	End of First Swamp
11	.9	8.8	Incised U-Shaped Valley, High Gradient Bottom (U2)	Habitat Complex Change, Larger Substrate
12	1.7	10.5	Palustrine Spring fed Meandering Flats (F6)	Beginning of Second Swamp
13	.9	11.4	Moderate Gradient Valley Wall/Headwater (H1)	Edith Creek
14	.6	12	Very High Gradient Valley Wall/Headwater (H3)	Class III Tribe

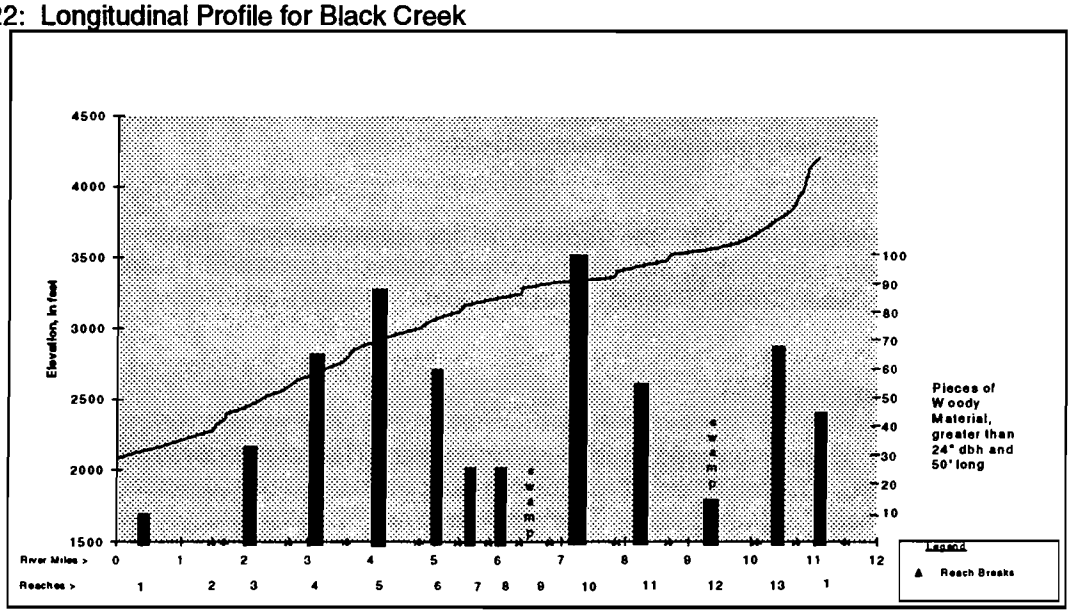
Table 24: Total Miles by Valley Segment Type for Mainstem Black Creek (Subwatershed 18 2)

Valley Segment Type	Miles	%
Alluviated Mountain Valley (V4)	3.1	25.8
V-Shaped Moderate Gradient Bottom (V1)	.7	5.8
Incised U-Shaped Valley, High Gradient Bottom (U2)	4.6	38.3
Palustrine Spring fed Meandering Flats (F6)	2.1	17.5
Moderate Gradient Valley Wall / Headwater (H1)	.9	7.5
Very High Gradient Valley Wall / Headwater (H3)	.6	5.0

LARGE WOODY MATERIAL

Given the dominant valley segment types in this watershed, infrequent large jams and more frequent small jams as well as individual pieces of wood would be expected in this subwatershed. Large wood appears to have historically been an important part component of the channel conditions in Black Creek. 1938 surveys indicate that Black Creek "was full of log jams" (McIntosh et al 1992). At the time of the 1992/1995 stream survey, there were 59 debris jams, many of them fully spanning the channel, located in the mainstem of Black Creek. In addition to this there were many beaver dams and sign of recent beaver activity in both of the swamp areas. Figure 22 shows the longitudinal profile for Black Creek along with

Figure 22: Longitudinal Profile for Black Creek



the pieces of large woody material per mile. Although Black Creek is currently below PACFISH large woody material minimum objective values for 81 percent of its length and below Forest Plan objective values throughout (Figure 23), it comes closer to meeting these values than many other streams in the Salmon Creek watershed. Reaches 1,2, 3,7,8, and 12 are currently most lacking in large woody material (although it should be noted that reach 12 is a swamp section that has many beaver dams throughout to provide habitat.)

Figure 23: LWM/Mile Mainstem Black Creek (1992 & 1995)

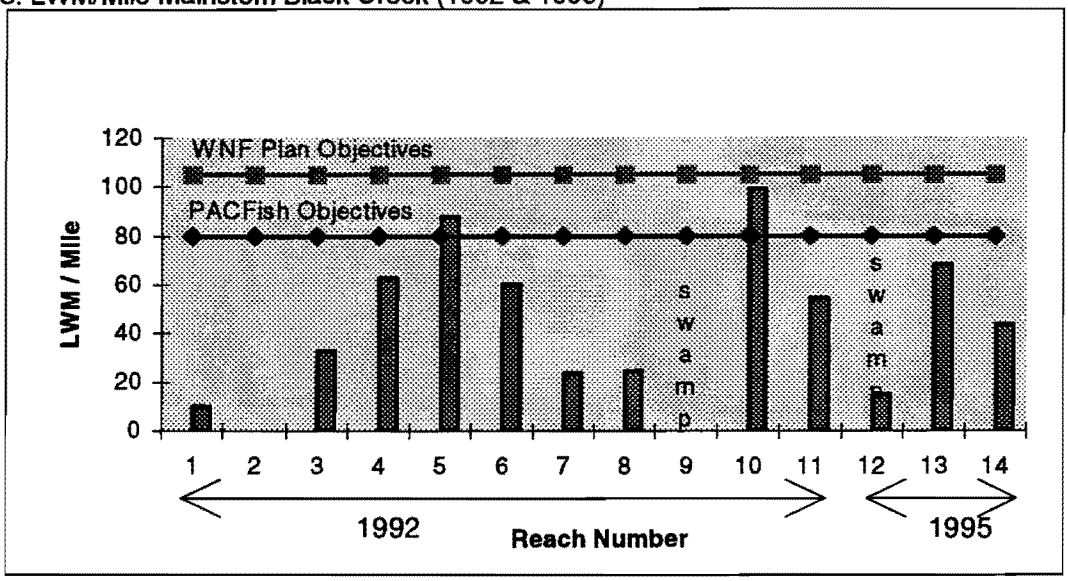
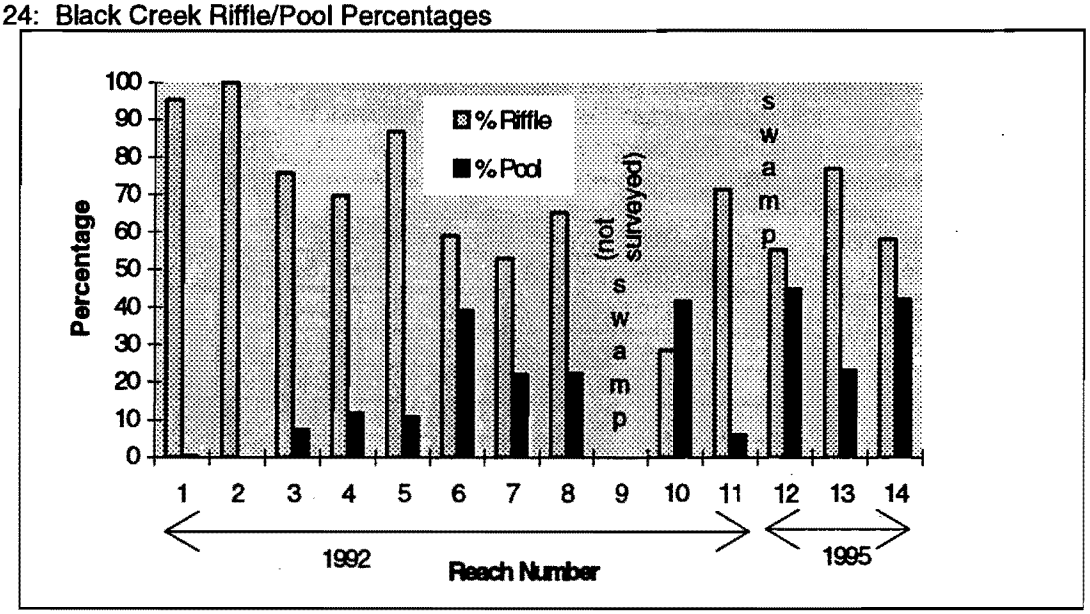


Figure 24: Black Creek Riffle/Pool Percentages

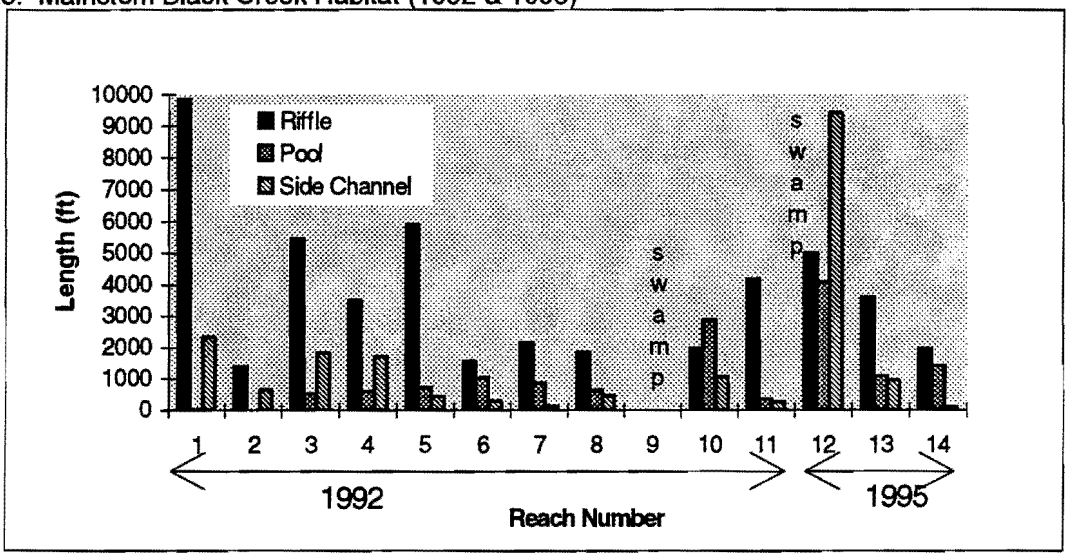


LARGE POOLS AND SIDE CHANNELS

In reaches dominated by small boulders, the most prevalent pools would be expected to occur as pocket pools. In the alluvial reaches, large woody material would be expected to be a component in large pool formation. Large pool habitat in this subwatershed is currently lacking in many reaches of the mainstem of Black Creek. All streams within this subwatershed are below the recommended objective values for the number of pools per mile (see Appendix E). Figure 24 shows that there are very few large pools in the lower reaches of Black Creek. Large pools are more common in the upper reaches. The lack of large wood may explain the low numbers of large pools, especially in the lower reaches of the subwatershed which are also lacking in large woody material.

Side channel habitat is common throughout the mainstem of Black Creek, especially in the lower reaches, which may help to make up for a lack of large pool habitat (Figure 25). Reach 12, which encompasses the second swamp, has a large amount of side channel habitat. Stream surveys indicate that much of the length of reach 12 was braided with ample amounts of overhanging vegetation and numerous beaver dams to provide fish habitat. Presumably reach 9, which was not surveyed, has similar habitat, as it appears in aerial photos to be similar to the swamp of reach 12.

Figure 25: Mainstem Black Creek Habitat (1992 & 1995)



CHANNEL WIDTH

Comparison of channel width from the 1992 stream survey with data collected in 1938 (McIntosh et al 1992) indicates that channel width has increased. It should be noted that the 1938 measurement of channel width was taken from one specific point and the 1995 width is an average channel width for the reach which contained the 1938 measurement point. Table 25 shows that channel widths have increased 20 to 61 percent in the nearly all of the lower reaches of Black Creek. The only exception to this was reach 4 which stayed about the same.

Table 25: Changes in Channel Width in Black Creek from 1938 to 1992

1938 Survey*		% Difference from	1992 Survey**		
River Mile	Width (ft)	1938 to 1992	Width (ft)	River Mile	Reaches
0 to 1	29.4	+ 20.7	35.5	0 to 1.8	1
1 to 2	27.9	+ 27.9	35.7	0 to 1.9	1 and 2
2 to 3	22.5	+61.3	36.3	1.9 to 3.1	3
3 to 4	27	- 2.7	26.3	3.1 to 3.8	4
4 to 5	25.2	+61.5	40.7	3.8 to 5.0	5
5 to 6	21	+ 51.9	31.9	5.0 to 6.0	6 and 7

* McIntosh et al. 1992

** Oakridge Ranger District stream surveys 1992

SUBSTRATE

The substrate in the lower reaches (1-8) of Black Creek is composed primarily of cobble and gravel. Sand and cobble are the dominant substrates in the first swamp (reach 9) (Appendix E). Gravel, sand, cobble, and small boulders are prevalent in reaches 10 and 11. Reach 12, the second swamp, is primarily composed of gravel, although sand and cobble are also present. The substrate in the upper reaches (13-14) consists of gravel, cobble, boulders, and sand.

CHANNEL STABILITY

Channel stability in Black Creek varies by reach from fair to good. There are a total of 32 sites of bank instability including bank cutting as well as sites of mass wasting. The areas that have the most sites of instability are reaches 3, 5, 6, and 12 (see Appendix E). Reach 3 has five sites that average 100 feet in

length and 20 feet high. Reach 5 has five sites that average 100 feet long by 50 feet high. The average size of bank instability sites in reach 6 is 60 feet long by 30 feet high. Instability in reach 12 consists primarily of bank cutting with an average length of 45 feet and an average height of 6 feet.

Upper Salmon Creek Subwatershed (18 3)

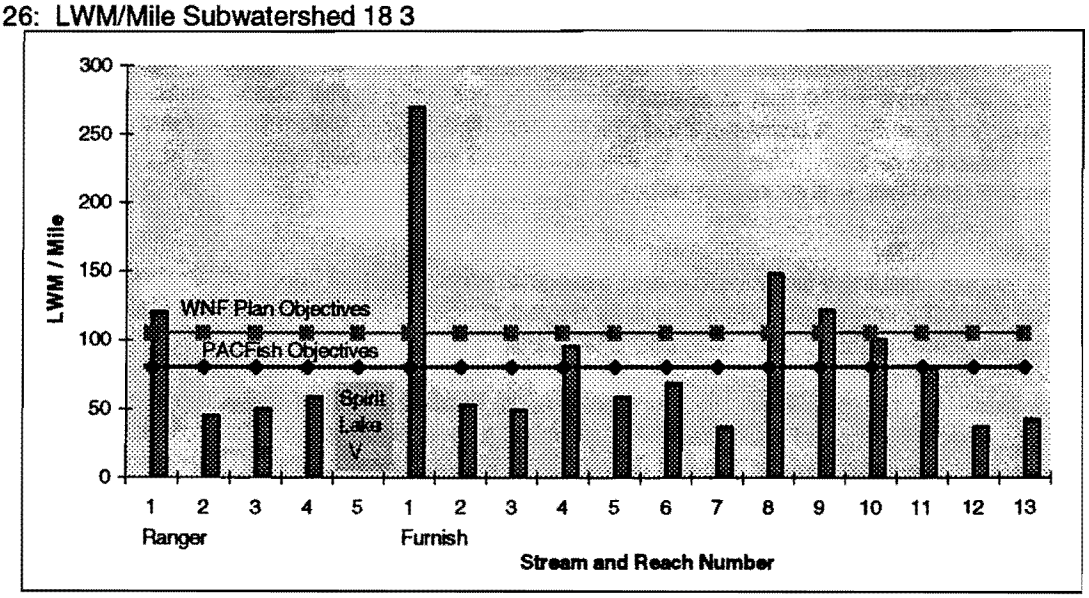
VALLEY SEGMENT TYPES

Streams that were surveyed in this subwatershed include Ranger Creek and Furnish Creek. The predominant valley segment type in this subwatershed is the V-shaped valley with a moderate gradient bottom (Table 26). Other valley segment types include V-shaped valley with a steep gradient bottom, incised U-shaped valley with a high gradient bottom, moderate slope-bound valley, as well as moderate and high gradient valley wall headwater.

Table 26: Valley Segment Types for Tributaries in Upper Salmon Creek Watershed (Subwatershed 18 3)

Valley Segment Type	Miles	%
Moderate Slope Bound (M1)	.8	9
V-Shaped Moderate Gradient Bottom (V1)	3.8	42
V-Shaped high Gradient Bottom (V2)	1.2	13
Incised U-Shaped Valley, High Gradient Bottom (U3)	1.3	14
Moderate Gradient Valley Wall / Headwater (H1)	.9	10
High Gradient Valley Wall / Headwater (H2)	1	11

Figure 26: LWM/Mile Subwatershed 18 3



LARGE WOODY MATERIAL

There were 62 debris jams in this subwatershed. Although it is difficult to know the amount of large wood in the stream channels prior to human activities in this subwatershed, the 1938 surveys indicated that Furnish Creek "was choked with log jams at regular intervals" (McIntosh et al 1992). Presently, 63 percent of the total stream miles surveyed do not meet PACFISH objective values and 70 percent do not meet WNF Plan minimum objective values for large woody material (Figure 26). Although large woody material objectives are not met for a large portion of the subwatershed, large woody material is relatively abundant and is nearing those objective values in many reaches. In some reaches, these objective values are exceeded.

LARGE POOLS

Large pools, while abundant in some stream reaches in this subwatershed, do not meet PACFISH or WNF Plan objective values for the number of large pools per mile (Appendix E).

CHANNEL WIDTH

Comparison of 1938 channel width (McIntosh et al 1992) with 1990 stream surveys indicates that channel width has increased from 13 to 25 percent in Furnish Creek since 1938 (Table 27). It should be noted that the 1938 measurement of channel width was taken from one specific point and the 1995 width is an average channel width for the reach, which contained the 1938 measurement point.

Table 27: Changes in Channel Width in Furnish Creek from 1938 to 1990

1938 Survey*		% Difference from 1938 to 1990	1990 Survey**		
River Mile	Width (ft)		Width (ft)	River Mile	Reaches
0 to 1	30.9	+13.3	35	0 to 1.2	1 and 2
1 to 2	25.8	+20.2	31	1.2 to 1.9	3 and 4
2 to 3	24.6	+ 25.6	30.9	1.9 to 2.8	5, 6 and 7

* McIntosh et al. 1992 ** Oakridge Ranger District stream surveys 1990

SUBSTRATE

Substrate in this subwatershed varied by stream. Ranger Creek substrate was composed of sand, gravel, cobble, boulders, and some bedrock. Dominant substrate in Furnish Creek was primarily boulder and rubble, with some cobble.

CHANNEL STABILITY

Stream channels in this subwatershed are relatively stable. There are only five sites of bank instability in this subwatershed. The majority of these sites (3) are located in reach 3 of Ranger Creek. Furnish Creek has two sites, one in reach 3 and another in reach 13 (see Appendix E).

Lakes

REFERENCE CONDITION

The Salmon Creek watershed contains hundreds of lakes and ponds located primarily within and adjacent to the Waldo Lake Wilderness area. The majority of lakes were formed by glacial scour. Nearly all of the lakes are located above 4,500 feet in elevation and are primarily in the Black Creek subwatershed (18 2) and the Upper Salmon Creek subwatershed (18 3). Nearly all lakes within the watershed had no naturally occurring populations of fish. The lakes in this watershed presumably contained high quality water prior to management activities and recreational use.

CURRENT CONDITION

Very little is known about the limnological and biological parameters of lakes within the watershed, with the exception of the following lakes, which were surveyed in 1995: Upper and Lower Salmon Lakes, Zircon Lake, Fig Lake, Photo Lake, Spirit Lake, and Blair Lake.

Information from lakes surveyed in 1995 is displayed in Table 28. All of the lakes surveyed were located in the subalpine ecoregion and were classified as being either oligotrophic (Zircon, Upper Salmon, Fig, and Photo Lakes) or oligo-mesotrophic (Lower Salmon , Spirit, and Blair Lakes). The coldest lake was Upper Salmon, which had many shoreline springs providing water to the lake. The levels of dissolved oxygen for this lake was higher than any of the other lakes that were surveyed. In contrast, Fig Lake and Photo Lake had very low levels of dissolved oxygen. This, combined with the low (acidic) pH values, indicates that these lakes may have limited refugia for fish and other vertebrates (WATER Environmental Services Inc., 1996). In addition, both Fig and Photo Lakes have a relatively low alkalinity. This indicates a low buffering capacity, and therefore a lower capacity to resist changes in pH, compared to the other lakes surveyed in 1995. Zircon Lake also has a relatively low buffering capacity. With the exception of phosphorous rich Upper Salmon Lake, the surveyed lakes appeared to be phosphorous and nitrogen limited (WATER Environmental Services Inc., 1996). Of the lakes surveyed, Blair Lake, Spirit Lake, and Lower Salmon Lake had the highest levels of chlorophyll A , an indication of the phytoplankton productivity in those lakes. Blair Lake and Fig Lake also had relatively high algal densities.

Many lakes have been stocked with brook trout, rainbow trout and cutthroat trout. Some lakes contain naturally reproducing populations of trout, while others are stocked regularly by ODFW. Appendix E shows the stocking records for lakes surveyed in 1995. Fish captured from surveyed lakes were in generally good condition (Table 28). Fish species fed primarily on aquatic insect larvae and terrestrial adults during the time of the survey. However, in Upper Salmon Lake, freshwater clams (*Pelycypoda sphaeridae*) were also a major component of the diet (Appendix E).

With the exception of Spirit Lake and Blair Lake the majority of the lakes are located within wilderness areas, and thus have only minor impacts from management activities. Due to the concentration of recreational use associated with several of the lakes including some within wilderness areas, water

quality could be affected due to the loss of shoreline vegetation and/or impacts from livestock use within riparian areas.

Table 28: Data from 1995 Lake Surveys

	Zircon Lake	L.Salmon	U.Salmon	Spirit Lake	Fig Lake	Photo Lake	Blair Lake
Trophic Status	Oligotrophic	Oligo-Mesotrophic	Oligotrophic	Oligo-Mesotrophic	Oligotrophic	Oligotrophic	Oligo-Mesotrophic
Elevation (ft)	5620	4784	4833	4749	5550	5500	4749
Basin Acreage	37	70	469	158	62	119	394
Max Depth (ft)	34	5	28	22	19	23	22
Sechli Depth	34	5	28	22	19	23	22
Surface Temp. Bottom Temp.	64.6 62.4	66.97 63.84	58.6 47.0	64.27 63.84	65.66 64.24	64.29 63.95	65.37 64.2
Surface DO Bottom DO	6.84 6.59	6.65 6.9	9.16 11.42	7.36 7.31	6.02 5.68	7.08 6.92	7.49 7.1
Surface pH Bottom pH	7.68 6.0	6.7 6.8	7.76 7.72	7.38 7.45	6.70 5.96	6.50 6.01	7.31 7.29
Nitrates (mg/l)	.003	.002	.001	.001	.016	.001	.001
Conductivity (umho/cm)	5.7	35.2	54.7	32.6	5.7	3.5	16.8
Alkalinity (ueq/l)	60.45	346.58	558.16	314.46	62.47	50.38	176.5
Total Phosphorus (ug/l)	5	15	66	12	4	3	6
Dissolved NA (mg/l)	.42	2.21	2.72	1.41	.29	.3	.89
Dissolved K (mg/l)	.14	.6	1.58	.34	.14	.09	.12
Dissolved CA (mg/l)	.28	3.29	4.5	3.01	.28	.16	1.4
Dissolved Mg (mg/l)	.095	.801	1.559	.973	.075	.054	.511
Chl a (ug/l)	.6	1.2	.7	1.7	.9	.6	1.7
Dominant Substrate	Silt	Silt	Silt	Silt	Silt	Silt	Silt
Subdominant Substrate	Talus/Lg BO	Silt	Gravel	GR/Cobble	Silt	Boulder	Boulder
Outlet	Intermittent	Intermittent	year-round	year-round	Intermittent	Intermittent	year-round
Inlet	Intermittent	year-round	3 year-round	year-round	Intermittent	Intermittent	Intermittent
Zooplankton Biomass	Calanoid Copepods (59%)	Cladocerans (62%)	Cladocerans (87%)	Cladocerans (77%)	Calanoid Copepods (59%)	Calanoid Copepods (55%)	Cladocerans (52%)
Zooplankton Density	Rotifers (70%)	Rotifers (96%)	Rotifers (60%)	Rotifers (95%)	Rotifers (76%)	Rotifers (93%)	Rotifers (60%)
Algal Densities (cells/ml)	100-400 x 10^3 Low-Moderate	10 Low	100-400 x 10^3 Low-Moderate	400-750 Mod.-High	400-750 Mod.-High	100-400 x 10^3 Low-Mod.	2300 High
Fish Species Stocked	BT & RB	BT, RB, CT	BT & RB	BT & RB	BT & CT	BT, RB, CT	BT, RB, CT·
Fish Species captured	NONE	NONE	BT (n=6)*	BT (n+5)*	CT (n=3)*	RB (n=1)*	BT (n=1)*
Fish Diet	--	--	Megaloptera (45%) Pelycypoda Sphaeridae (48%)	Aquatic Macros, Very Opportunistic	Ephemeroptera (83%) Diptera (12%)	Ephemeroptera (69%) Diptera (31%)	Hymenoptera (88%) Odonata Anisoptera(9%)
Mean X Factor	--	--	1.29 (n=2)	1.16	1.223 (n=1)	2.286 (n=1)	.932 (n=1)
Total Length (mm)	--	--	231-257	204-266	262-347	134	289
Age of Fish	--	--	3+	2+-4+ (n=4)	3+-5+	1+	3+
Amphibians	--	Pseudacris regilla	Bufo Boreas (thousands!)	Pseudacris regilla, Taricha granulosa	--	Pseudacris regilla	Ambystoma macrodactylum Taricha granulosa
Dominant Veg. Species	Pac. Silver Fir	Mt. Hemlock	DFir/Willow	Mt. Hemlock	Mt. Hemlock	Mt. Hemlock	Mt. Hemlock
Recreation Impacts	Low - camp	Low-no camp	High-3 camps, trail	High-3 camps, trail	Low-2 camps	Low-2 camps	High-FS campground

*Fish Measurements bases on (n=x) for next 4 rows unless otherwise noted

BIOLOGICAL

VEGETATION

Age Class/Successional Stage Distribution

Vegetation is always changing, and is difficult to typify as a result of its dynamic nature. To a large extent the following discussions compare two snap shots in time, one before large scale harvesting began in this watershed, and one that exists after 55 years of timber harvesting. It should be kept in mind that these two periods of comparison are not absolute. There may have been times when a majority of the watershed was occupied by young stands after very infrequent, regional scale wildfire (as discussed in the Vegetation/Fire History section of the Characterization chapter). Central to the following comparisons is that under natural conditions, the vegetation was occasionally heavily disturbed and recovered over periods of time that may have been centuries long on a given site. Under current and past management regimes, disturbance has been chronic: frequent and at low levels over short periods of time such that certain structural and age classes have or may become relatively more rare than they were in between natural fire occurrences.

REFERENCE CONDITION

Two hundred years ago (before European influence at least in terms of the vegetation and fire frequency), about 12 percent of this watershed was occupied by early-successional, or stand initiation stage forests. There was relatively little edge between early and late-successional forests in this historic landscape. The early-successional forest and edge were created by wildfire that burned large areas, both as stand replacement fire and as underburns. The amount of forest fragmentation before fire suppression and timber management can be seen in Figure 28 of this chapter.

Conversely, approximately 45 percent of this watershed was composed of late-successional forest. Mid-successional forests, those representing the stem exclusion and understory reinitiation stand development stages, occurred on about 37 percent of the area.

The watershed probably had more non-forested acres due to repeated fire that created and maintained large meadow complexes along ridge tops, but this percentage was probably not much larger than it is today. Aboriginal burning was probably also responsible for a greater amount of meadows along the river bottom. In some areas, likely south slopes near main campsites, the forest was very open and park-like due to repeated underburning. The Fisher and Long Prairie system is a probable example where the practice of burning would have occurred.

CURRENT CONDITION

Approximately 24 percent of the watershed is composed of early-seral stands in the stand initiation stage of development. This percentage is twice as large as what existed 200 years ago and it is distributed quite differently across the watershed. Nearly all the current early-successional forest occurs in the western two thirds of the watershed while two hundred years ago there was a much higher percentage of early-successional forests in the eastern portion of the watershed. Current early-successional forests are for the most part the result of dispersed regeneration harvest activities, and as such, create much more edge and associated fragmentation of interior habitat than in reference conditions (see Figure 29 of this chapter). Stand initiation acreage is currently three to four times greater in Douglas-fir/western hemlock plant associations than in reference conditions. Conversely, less than half of the initiation stage acreage occurs in true fir/mountain hemlock associations.

Currently, 9 percent of the mid-seral habitat across the watershed is in the stem exclusion stage and 28 percent is in the understory reinitiation stages. Stem exclusion acreage, as a percent of total, is not much different in Douglas-fir/western hemlock stands than in reference conditions, however, the distribution pattern of these acres is significantly different. Stem exclusion acreage is approximately four times less in true fir/mountain hemlock associations. Understory reinitiation stage acreage is slightly less in Douglas-fir/western hemlock associations and approximately double in true fir/mountain hemlock than what existed in reference conditions.

About 34 percent of the watershed currently consists of late-seral forests, which is about 75 percent of what existed before forest management began. As with early-successional habitat, this late-successional forest is more scattered throughout the watershed and much more fragmented than it once was. Current late-seral stand acreage in Douglas-fir/western hemlock plant associations is about one third less than in

reference conditions. Current late-seral acreage in true fir/mountain hemlock plant associations is approximately one third more than in reference conditions.

This watershed has a very diverse set of age classes (as shown in Table 29), resulting from five decades of timber harvesting and the incidence of wildfire, as discussed in Chapter I. Most of the current acreage of younger, early-successional forests shown in Table 29 have been created after harvesting. Forest management policy has changed considerably in the years since the first clearcut was implemented in the watershed. The first harvesting occurred as large, clustered clearcuts. Subsequent public concern with large clearcut areas resulted in law and agency policy directing management to avoid the creation of large openings in the forest. After about 1950, regeneration harvesting was limited in size, and dispersal was increased, without a concurrent reduction on harvest volumes, resulting in widespread fragmentation of the previously unfragmented forest. Widespread partial harvest also occurred from the 1950's to the 1980's. The objectives of the partial harvest areas were to salvage expected mortality in mature and old-growth stands and to minimize the openings created by harvest. This partial harvesting may have imitated somewhat the effects of low intensity fire in terms of canopy closure and numbers of live trees per acre. However, it removed stems that would have remained on site after low intensity fires, and it resulted in compaction of soil from tractor yarding. These are two results that do not have an analog in the natural system.

Table 29: Reference vs. Current Seral Stage Distribution by Plant Association

		Reference Condition								Current Condition							
		Sixth Field (Acres / % of sum total)								Sixth Field (Acres / % of sum total)							
Plant	Seral	18 1		18 2		18 3		Total		18 1		18 2		18 3		Total	
Assn.	Stage	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
DF/WH	SI	3,506	10	414	2	856	4	4,776	6	9,900	28	2,916	13	4,163	16	16,978	21
	SE	2,111	6	2,074	10	1,432	6	5,617	7	3,786	11	699	3	941	4	5,427	7
	UR	4,488	13	4,289	20	2,809	11	11,586	14	5,709	16	2,524	12	2,357	9	10,590	13
	LS/OG	19,321	55	5,310	24	7,429	29	32,061	39	10,057	29	5,948	27	5,066	20	21,072	26
sub total		29,425	83	12,087	56	12,527	49	54,039	66	29,453	83	12,087	56	12,527	49	54,067	66
TF/MH	SI	857	2	630	3	3,729	15	5,215	6	914	3	385	2	984	4	2,283	3
	SE	818	2	3,619	17	2,549	10	6,986	8	179	0.5	433	2	1,048	4	1,660	2
	UR	684	2	2,499	11	3,134	12	6,316	8	1,722	5	4,536	21	6,366	25	12,625	15
	LS/OG	1,223	3	1,369	6	2,062	8	4,654	6	766	2	2,763	13	3,075	12	6,605	8
sub total		3,581	10	8,117	37	11,474	45	23,172	28	3,581	10	8,117	37	11,474	45	23,172	28
SHAB		1,231	3	1,429	7	1,199	5	3,859	5	1,231	3	1,429	7	1,199	5	3,859	5
WX		32	0.1	97	0.4	199	0.8	328	0.4	32	0.1	97	0.4	199	0.8	328	0.4
XFOR		1,002	3	14	0.1	18	0.1	1,034	1	974	3	14	0.1	18	0.1	1,006	1
Sum Total		35,271	100	21,744	100	25,417	100	82,432	100	35,271	100	21,744	100	25,417	100	82,432	100

Table legend: DF/WH = Douglas fir/western hemlock TF/MH = true fir / mountain hemlock
SHAB = special habitat WX = water XFOR = non forested
SI = stand initiation (0-30 year old stand) SE = stem exclusion (31-80 year old stand)
UR = understory reinitiation (81-200 year old stand) LS/OG = late-successional / old-growth (201+ year old stand)

The numbers in Table 29 reflect the amount of various age and structural classes but not their distribution. The following section on Terrestrial Wildlife Habitat discusses the extent and implications of the fragmentation and structural changes which have occurred in these forests.

Overall Diversity of Vegetation

REFERENCE CONDITION

The pattern and timing of fire on this landscape created a relatively diverse complex of vegetation assemblages and structural conditions. Fire periodically created new early-successional communities, and areas that did not frequently burn gradually developed late-successional characteristics that in some areas persisted for centuries before stand replacement fire eventually returned. Many meadow complexes were created and maintained on ridge tops and on the north edge of the river bottoms as a result of repeated fire, some of which was the result of aboriginal burning.

CURRENT CONDITION
While certain types of plant communities are not as widespread as they once were (for example late-successional forest, or dry meadows), they still exist in fairly large percentages compared to 200 years ago. No plant communities have been eliminated from this watershed as a result of fire suppression or timber harvesting. However, fire suppression has resulted in a reduction in the acreage of meadows and timber harvest has resulted in a reduction in the acres of late-successional forests.

The structural diversity of some young stands regenerated after harvest may be less complex than natural young stands. Some young managed stands were planted with mostly Douglas-fir. Pre-commercial thinning was often designed to select against trees other than Douglas-fir. However, dense, predominantly Douglas-fir stands can also be found in natural young stands regenerating after fire. Young managed stands often contained little in terms of residual structure (snags and large wood material) especially those created by harvest between 1960 and 1990. Furthermore, natural young stands sometimes reburned, resulting in low structural diversity.

The main effect that management activities have had on vegetational diversity is an increase in stand edge (fragmentation) as mentioned above. Harvesting and associated road construction has increased the amount of edge habitat (discussed in a following section on wildlife habitat), decreased the amount of late-successional habitat, changed the distribution of late-successional habitat, accelerated the establishment of non-native plants, and may have created non-forest vegetation types that would not have existed otherwise. The vegetation may be more diverse now than it was prior to management in terms of early-successional herb/shrub communities created by harvest. However, these communities are relatively ephemeral as shrubs and sapling trees tend to dominate such sites quickly. Fire suppression has decreased the extent of meadows, and may have resulted in some areas of late-successional forest that would not have persisted otherwise.

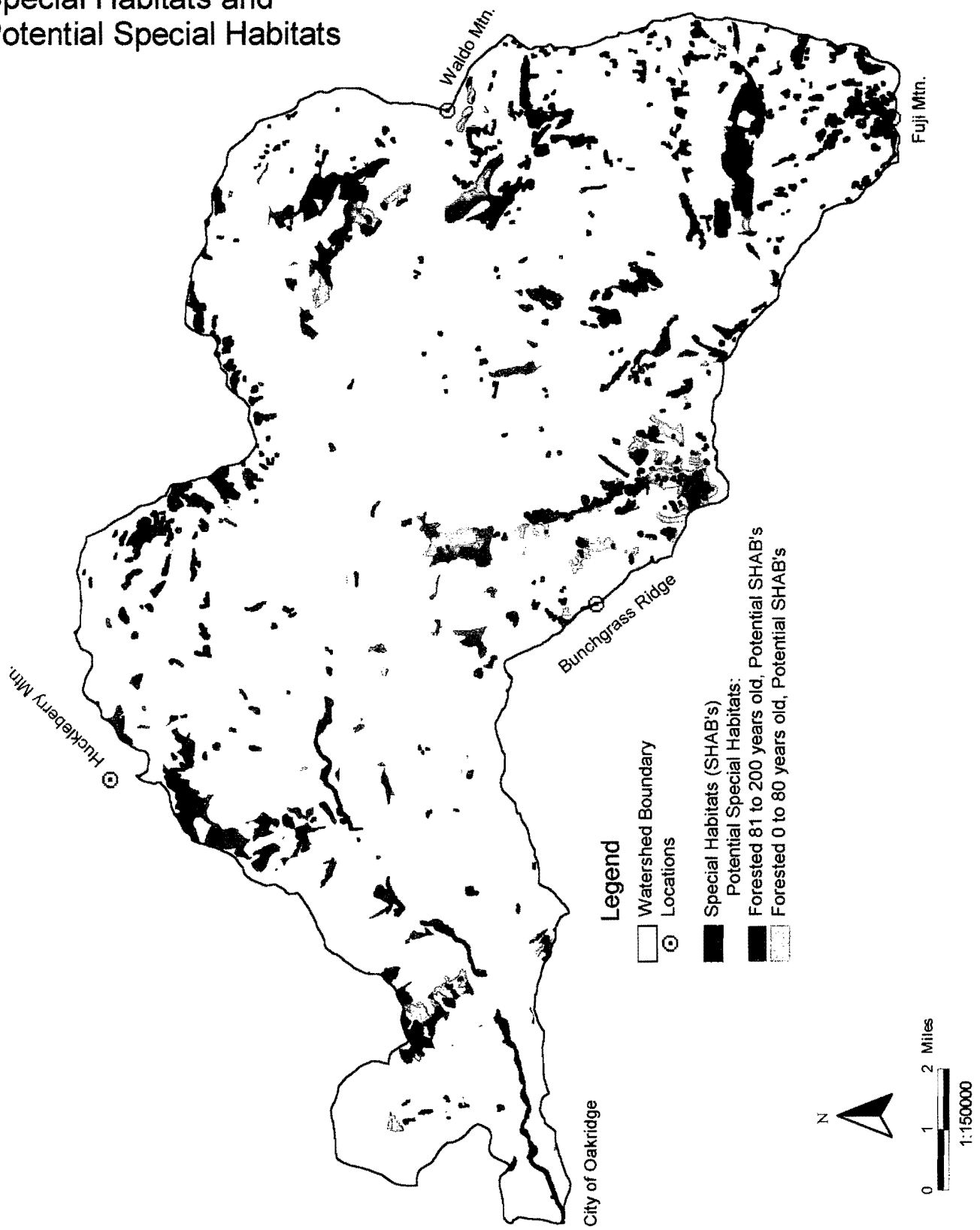
Special and Unique Non-Forested Habitats (SHABs)
REFERENCE CONDITION
It is suspected that prior to European settlement, Native American populations used fire as a tool to create or perpetuate meadow habitat in order to maintain early seral conditions for longer periods than natural fire intervals. As a result, vigor and productivity increased for berries, roots and associated wildlife use. Forested areas were also probably underburned in places to provide more productive animal forage and to facilitate travel. Several non-forested meadows and prairies in the watershed have undergone past modifications to habitat diversity in the form of post-settlement use. A representation of potential non-forested openings on fire prone soils (Figure 27 of this chapter), in stands less than 80 years of age, and in stands 81+ years was compared with a current map of non-forested special habitats (also Figure 27 of this chapter) and with a fire history map (Figure 2 of the Characterization chapter). The comparison suggests that fire events could have contributed towards the development of a larger amount of non-forested acres than what might have developed with fire suppression. Past livestock grazing, logging history, and fire suppression all contributed to changes in the diversity, composition and function of the plant communities.

Several meadows and prairies were included in major grazing allotment ranges on the district. The effects of grazing contributed to maintaining more open conditions in meadows. It is assumed that the total meadow acreage was higher around the turn of the century, prior to the cessation of grazing. Historical records indicate that cattle were grazed in the mid 1860's. District records show cattle and sheep were grazed in the late 1800's and early 1900's.

CURRENT CONDITION
Meadow opening size and abundance in the watershed may have been influenced by a reduction in the fire maintenance regime, caused by 70 to 80 years of natural fire suppression activities. Subsequent conifer invasion has since been occurring, being particularly prevalent on ridge line meadows where repeated lightning ignited bums may have maintained meadow conditions. *Vaccinium embranaceum /Xerophyllum tenax* communities present in the upper elevations of the watershed are examples where fire is thought to have played a key role in producing non-forested openings in drier mountain areas (Franklin and Dyrness, 1988). Spirit meadow is an example of where tree encroachment has been taking place and is contributing to loss of meadow habitat. The watershed has not yet been extensively surveyed for SHAB types and associated floristic inventories. Sampling is usually accomplished when associated with site specific projects.

Figure 27:

Special Habitats and
Potential Special Habitats



Reference / Current Conditions