CHAPTER 3

REFERENCE AND CURRENT CONDITIONS

GEOLOGY

The Lookout Point WAA lies in the lower Middle Fork Willamette subbasin; hence it is not a true watershed. Approximately 900 square miles of the Middle Fork Willamette subbasin lies to the east of the project area. The analysis area is 49,049 acres in size and has been subdivided into fifteen drainages. The largest is Goodman (9,099 acres); Lookout Point Reservoir is the smallest with 127 acres.

An east-west trending ridge divides the analysis area from South Fork Winberry drainage to the north. The Calapooya mountains lie between the analysis area and Layng watershed to the south. Numerous face tributaries drain directly into the Middle Fork Willamette River from the project area. The largest of these are Tire, Goodman and Deception Creeks.

Igneous extrusive such as tuffs, lapilli tuffs, tuffaceous sedimentary pyroclastics, and lava flows predominate. Igneous intrusive rocks account for less than 1% of the watershed. Distribution estimates of extrusive rock types range from 75-80% pyroclastic origin and 20-25% lava flows (Peck and others, 1964, Sharrod, 1991). Spatially, the older rocks are predominately tuffs and tuffaceous sedimentary rocks and tend to be found at lower to middle elevations. Younger rocks are predominantly basaltic or andesitic lava flows and are generally found at higher elevations, such as Saddleblanket Mountain and the Calapooya mountain range.

Emplacement of numerous dioritic-dacitic intrusions between ten and three million years ago resulted in thermal and hydrothermal alterations of the rocks already present. This alteration produced an increase in clay minerals, now found in the soils of many areas. Hydrothermal activity is also responsible for weathering many flow rocks, resulting in decreased strength and rapid degradation when these are used as crushed aggregate. Some have been used in the past, resulting in marginal aggregates that degraded quicker than expected and generated more fines than acceptable.

Hydrothermal activities were responsible for the mobilization and subsequent deposition of most quartz, agate and jasper found throughout the WAA at lower and middle elevations. Some of these silica deposits were utilized by the indigenous people for tools such as projectile points, scrapers, knives, etc. Today this material is frequently found at cultural resource sites and is referred to by archeologists as "cryptocrystalline silica" (CCS).

The volcanoes that produced these rocks have weathered away and created the landscape seen today, which is almost entirely erosional. The older, less altered rocks in the western portion of the WAA have weathered longer and at a more uniform rate, resulting in flatter ground and thicker soils at lower elevations. These are the areas most prone to landflows and rotational failures. Some of the higher ridges are

examples of *"inverted topography"*, where lava flows filled stream valleys and were left as topographic highs when surrounding pyroclastic rocks eroded more quickly. These areas and steep stream sides are the most prone to debris failures.

Large scale faulting in the area tends to follow a northwest trend and predates the eruption of intra-canyon Black Canyon lavas. The Eugene-Denio fault zone is commonly shown following the Middle Fork Willamette River valley in the vicinity of Lookout Point Reservoir (Lowell Watershed Assessment, 1994).

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 SRI was written in 1973 and its maps revised in 1990.

To simplify soil analysis, the 1990 SRI soil mapping units within the WAA have been grouped into five categories. These categories are based on similar soil properties and expected behavioral response to management activities *(see Map 10)*

Category 1 consists of 1990 SRI mapping units 25, 35 and mapping unit complexes which include 100% of Units 25 and 35, i.e., 255. Typically, these soils are on gentle to moderately hummocky sideslopes (5-40%), deep (6-12+ feet), clayey, and sometimes 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 strength can be low to high depending on the moisture content, but the remolded strength (such as in roadfills and subgrades) tends to be low.

During construction controlled compaction techniques are required and the material is not allowed to saturate. It is often necessary to exclude the surface and subsurface water from these soils to maintain a stable road prism. Due to these soils' low permeability, overland flow of water commonly results in sag ponds and supports hydrophytic vegetation and habitat for aquatic and amphibian animals.

Category 2 consists of SRI complexes which include at least 50% of the mapping units in Soil Category 1. The behavior of soils in this category is similar to that outlined for Category 1, but the frequency of occurrence is limited to 50-60% of the mapping area. Landforms tend to be slightly steeper than Category 1 and are often associated with draws and swales on midslopes.

Category 3 is 100% of SRI mapping units and complexes, characterized by steep terrain with shallow rocky soils (depth to bedrock is 0-3 feet). This category is more likely to have high surface and subsurface erosion potential and exhibit the highest number of road and harvest related failures. Sediments produced are typically coarse-grained. Harvest related slope failures tend to result from the loss of root strength after timber harvest and often occur where water concentrates.

Category 4 consists of SRI complexes which include at least 50% 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 lesser frequency.

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

The preceding soil categories were first used in the Geology/Soils section of the 1993 Lowell Ranger District Watershed Assessment (pp. 90-99), by Mark Leverton, South Zone Geotechnical Leader. The reader is referred to this document for a more detailed discussion.

Table 2. SRI Mapping Units by Soil Category

Soil Category	Definition of SRI Soil Categories	SRI Mapping Units
Category 1	nearly 100% clayey soils	22,25,35,255
Category 2	at least 50% clayey soils	23,33,235,251,252,253,254,256, 335,353,356
Category 3	nearly 100% steep ground and shallow soils	1,2,3,8,16,21,31,61,201,202, 203,204,210,301,302,310,315, 316,444,601,602,603,610
Category 4	at least 50% steep ground and shallow soils	161,168,212,213,214,215,216, 304,305,313,332,441,517,604, 605,606,607,608,614,615,616, 617
Category 5	all others	all others

Erosion Processes

In order to evaluate the assumptions behind soil behavior categories and evaluate trends, adjacent watershed analysis were used. Since the geology and topography is similar or basically the same it is thought that the percentage of failures from management activities will remain the same. Watershed analysis cited are: *Layng Creek* (Umpqua National Forest, Cottage Grove Ranger District), *Winberry and Lower Fall Creek* and *Fall Creek* (both on Willamette National Forest, Lowell Ranger District).

Layng Creek Watershed lies just to the south of Lookout Point WAA. The Layng Creek Watershed Analysis identified a complete reversal of landscape disturbances from the 1946 to 1966 aerial photo series. The 1946 photos series suggests that 69% of the landslide features were associated with natural disturbances. In the 1966 photo series, 54% of the landslide features appear to be associated with timber harvest and road construction. The 1988 photo series identified a large number of additional landslide features not identified on previous photo series. Of these, 88% were related to timber harvest and associated road construction (Layng Watershed Analysis, 1995).

Winberry and Lower Fall Creek Watershed Analysis discusses the area to the north. This analysis suggests that failure frequency on unmanaged ground has remained constant during the past 50 years. On managed acres, failures from roads represent 63% percent of the total; of these, 36% are related to harvest units. They occur in Category 3 and 4 soils (Winberry and Lower Fall Creek Watershed Analysis, 1996).

Fall Creek Watershed lies to the north of Winberry Creek Watershed. The geology is similar to that of Lookout Point WAA. Aerial photo analysis recognized that 64% of the failures were road-related; of these, 78% were in Category 3 and 4 soils. Ninety percent of all failures occurred on managed land (Winberry and Lower Fall Creek Watershed Analysis, 1996).

All three watershed analyses indicate that 88 to 90 percent of all recent failures (from 1955 to present) occurred on managed lands. They all found that most failures occurred on steep shallow soils and a high percentage was associated with road construction.

District engineers and others think that the analysis area does not have the same frequency of failures associated with management activities as do surrounding watersheds. This may result from less precipitation, since the east-west trending valley of the WAA allows weather systems to move through without releasing precipitation, and later timber harvest which resulted in better road construction practices.

Prior to logging and road construction, slope failures were typically assumed to be landflows on shallow slopes with deep soils and debris slides on steep sideslopes having thinner soils. The age of these failures is unknown, but presumably they are hundreds of years old, judging by the age of trees growing on top of these slope movements. Large scale landflows and landslides may be thousands of years old. Currently, these large scale landslide areas have a stable slope geometry. The Oregon State Geology Map shows six areas of landslide deposits found in Rolling Riffle (1), Goodman (2), Carpet Hill/Hospital (one large landslide), Rock (1), and Tire (1) drainages. Streams cut across the toes of these landslides producing fine-grained sediments, which stay in suspension for long periods of time *(see Map 9).* This may contribute to the turbidity of the reservoir.

On Forest Service lands, the 1973 SRI map identifies numerous landflows or slumps in areas associated with Category 1 soils. These areas produce fine-grain sediments. Failures in these landflows or slump areas are usually associated with road cuts or stream channel sideslopes. Failures are small, rotational slumps producing fine-grained sediments that can be suspended in water for long periods of time. This can prove detrimental to fish spawning areas.

The SRI also identifies unstable areas associated with steep, shallow soils characterized by Categories 3 and 4. Debris slides are found along steeper streamsides and on higher, steeper mountainsides. Still, it is valid to say that the number of failures on unmanaged land is basically constant, or has only slightly increased, during the past 50 years.

Table 3. Miles of Road on Sideslopes (by Drainage)

Drainage	Road on Sideslopes				
	Miles < 51%	% < 51%	Miles ≥ 51%	% ≥ 51%	Total Miles
Rhodes	6.6	97%	.19	3%	**6.79**
School	9.48	84%	1.8	16%	**11.28**
Cain/Armet	15.48	98%	.62	3%	**16.1**
Carpet Hill/Hospital	10.4	96%	.44	4%	**10.84**
Tire	18.81	94%	1.26	6%	**20.07**
Buckhead	14.82	85%	2.6	15%	**17.42**
Rolling/Hazel-Fern	11.46	95%	.62	5%	**12.08**
Goodman	32.49	85%	5.49	15%	**37.98**
Crale	12.65	96%	.49	4%	**13.14**
North/South/ Schweitzer	13.43	94%	.93	6%	**14.36**
Duval	14.64	88%	2.02	12%	**16.66**
Rock	17.68	99%	.52	1%	**18.2**
White-Bridge/Dell	22.94	95%	1.09	5%	**24.03**
Deception	24.85	79%	6.82	21%	**31.87**
TOTAL	**225.73**	**90%**	**25.09**	**10%**	**250.82**

Table 4. Miles of Road on Sideslopes (by Soil Category)

SRI Soil Category	Road on Sideslopes				
	Miles < 51%	% < 51%	Miles ≥ 51%	% ≥ 51%	Total Miles
1	26.7	98%	0.71	2%	**27.41**
2	96.47	98%	1.76	2%	**98.23**
3	35.98	72%	14.5	28%	**50.48**
4	57.26	91%	5.62	9%	**62.88**
5	12.35	99.5%	.07	0.5%	**12.42**
TOTAL	**228.76**		**22.66**		**251.42**

As indicated above, most failures were associated with roads on steep slopes. In order to evaluate potential failures, the number of road miles in each Soil Category on sideslopes greater than 50% was calculated for each drainage *(see Table 3).*

Although 55% sideslope is usually used as the limit on which typical fills can be constructed, information available from GIS required definition of steep ground to be "greater than 50%." For this analysis, it is thought that the 5% difference does not have a significant effect on slope failure distribution.

The erosion potential for each Soil Category was determined by averaging the surface and subsurface erosion potential using SRI erosion potentials. Category 3 had the highest erosion potential, followed in order by Categories 4, 1, 2, and 5 *(see Table 5 and Map 10).* Based on the gradation of SRI soils comprising the Soil Categories, Categories 1 and 2 can be expected to yield the greatest percentage of fine-grained sediments, Categories 3 and 4 can be expected to yield the greatest volume of coarse grained sediment, while Category 5 produces a mixture of both at a more moderate rate.

Table 5. Erosion Rating of SRI Soil Categories

Rating	Soil Category	Surface and Subsurface
Least	5	Low to Moderate
Second	2	Moderate to Moderately/High
Third	1	Moderate
Fourth	4	Moderate/High to Severe
Highest	3	Moderate/High to Very Severe

The watershed has approximately 251.42 miles of road. Goodman has the most with 37.84 miles of roads followed by Deception drainage with 32.74 miles of road. The rest of the drainages range between 5.62 miles of road to 23 .76 miles. Table 7 shows the Soil Category distribution by drainages in acres. Table 8 shows the percentage of drainages in each Soil Category.

As mentioned earlier, 88-90% of slope failures occur as a result of management activities with a high percentage related to roads. Most occur in Categories 3 and 4, which feature steep sideslopes and shallow, coarse-grained soils. These soils represent 55% of the WAA and contain 45% of the roads. Of these roads, 89% are constructed on sideslopes greater than 50%. *(see Table 8).*

Table 6. Road Distribution by Drainage

Drainage	% of total roads in drainage	% on sideslopes > 50%
Rhodes	2%	3%
School	4%	16%
Cain/Armet	6%	3%
Carpet Hill/Hospital	4%	4%
Tire	8%	6%
Buckhead	7%	15%
Rolling Riffle/Hazel/Fern	5%	5%
Goodman	15%	15%
Crale	5%	4%
North/South/Schweitzer	7%	6%
Duval	7%	12%
Rock	7%	1%
White/Bridge/Dell	10%	5%
Deception	13%	21%
TOTAL	**100%**	

Table 7. Soil Category Distribution by Drainage (in acres)

	Soil Category				
Drainage	**1**	**2**	**3**	**4**	**5**
Rhodes	19.65	357.2	164.54	483.7	0
School	302.2	67.7	747.6	371.2	1.5
Cain/Armet	254.4	428.6	430.3	1012.4	0
Carpet Hill/Hospital	0	1561.6	32.3	193.2	0
Tire	1128.5	644.4	1474.9	627.6	20.1
Buckhead	89.7	845.1	1635.76	480.9	263.2
Rolling Riffle/Hazel/Fern	454.2	1203.3	14.5	646.3	0
Goodman	314.1	2106.9	4190.76	1423.4	0
Lookout Pt	1.5	46.8	8.3	70.8	0
Crale	133.4	878.4	100.5	722.9	0
North/South/Schweitzer	139	922.9	2024.9	708.8	0
Duval	357.6	840.7	584.2	1556.6	163.79
Rock	160.8	1501.1	490.8	709	180.1
Whitehead/Bridge/Dell	336.4	1653.6	293.1	955.2	299.1
Deception	537.6	1138.9	4686.5	463.4	568.9

Table 8. Percentage of Drainage in Each Soil Category

	Soil Category				
Drainage	**1**	**2**	**3**	**4**	**5**
Rhodes	2%	35%	16%	47%	0
School	20%	5%	50%	25%	0
Cain/Armet	12%	20%	20%	48%	0
Carpet Hill/Hospital	0	87%	2%	11%	0
Tire	28.9%	16.5%	37.8%	16.1%	.1%
Buckhead	2.7%	25.5%	49.3%	14.5%	7.9%
Rolling Riffle/Hazel/Fern	18.5%	49.1%	6.1%	26.3%	0
Goodman	4%%	26%	52%	18%	0
Lookout Point	0	37%	7%	56%	0
Crale	7%	48%	6%	39%	0
North/South/Schweitzer	4%	31%	46%	19%	0
Duval	10%	24%	17%	44%	5%
Rock	6%	49%	16%	23%	6%
Whitehead/Bridge/ Dell	10%	47%	8%	27%	8%
Deception	7%	15%	63%	6%	8%

Hydrology

Reservoir

Lookout Point Dam was constructed in 1954. It is an earth and gravel filled dam with a concrete spillway 276 feet high. Full pool 929 feet in elevation and encompasses 4,255 acres. Minimum pool drops to 819 feet in elevation and 2,090 acres. This reservoir is one of the earliest Upper Willamette Army Corps of Engineers projects to be drawn down to meet specific instream flow requirements in Salem. The rapid draw-down occurs during the summer months and the reservoir is refilled by mid-May. Shoreline wave action is common along the reservoir creating erosion and increasing turbidity. This also results in areas of sparse aquatic vegetation.

Stream Flow

Reference Condition (Pre-Reservoir)

Stream flow fluctuations responded to both rainfall and snow melt which extended relatively high flows into late spring. Annual precipitation in the Western Cascades ranges from 45 inches per year in lower elevations to 70 inches at higher elevations. The actual precipitation in the WAA may be lower. The analysis area is a broad valley trending from east to west through which weather systems move without releasing

precipitation. In conjunction with this the Calapooya mountain range may act as a barrier and intercept marine air entering from the southwest (Weyerhaeuser, 1996). Therefore the actual precipitation in the project area may be less than in surrounding areas. Most of the precipitation falls between November and February.

A marked decline in stream flow during the summer months was typical both in reference and current conditions. This low stream flow impacted fisheries, recreation, irrigation, and domestic use along the Middle Fork Willamette River during the turn of the century. The largest historical flood occurred in 1861 with an estimated peak discharge of 87,000 cubic feet per second (cfs) at Lookout Point Dam. Considering bankfull conditions (the equivalent of a 1½-year event storm) are approximately 16,000 cfs, these historical storms undoubtedly damaged crops and settlements located adjacent to the Middle Fork Willamette River. These flood volumes exceeded any subsequent flood events.

Current Condition (Post-Reservoir)

As mentioned earlier, approximately 900 hundred square miles of the Middle Fork Willamette River basin lies to the east of the analysis area. Approximately 40% of this drainage area is regulated by Hills Creek Dam, located southeast of Oakridge on the Middle Fork Willamette River. Hills Creek Dam regulates 31.0% of the annual runoff entering the project area. The other main unregulated tributaries entering the Middle Fork Willamette River above the WAA are: Salt Creek (contributing 6.6 percent of the annual runoff), Salmon Creek (9.6 percent of the annual runoff), and the North Fork Willamette River (17.7 percent runoff).

Natural flow of the Middle Fork Willamette River has changed significantly from historic conditions due to the installation of Hills Creek and Lookout Point Reservoirs. Regulation of flow from Hills Creek Reservoir began in 1961. The average annual volume of water passing through Lookout Point WAA has not been changed by the Hills Creek project. What has changed is the average mean monthly flow. Data shows a change in flow regimes due to regulated flow from Hills Creek Dam. Less water is released during the winter months (January-June) and more water is released in late summer to early winter (July-December). The regulation of flow regimes provides flood protection in the winter and water supply in the spring. Conversely, more water is released during the fall and early winter to prepare for the next flood season (COE, 1997).

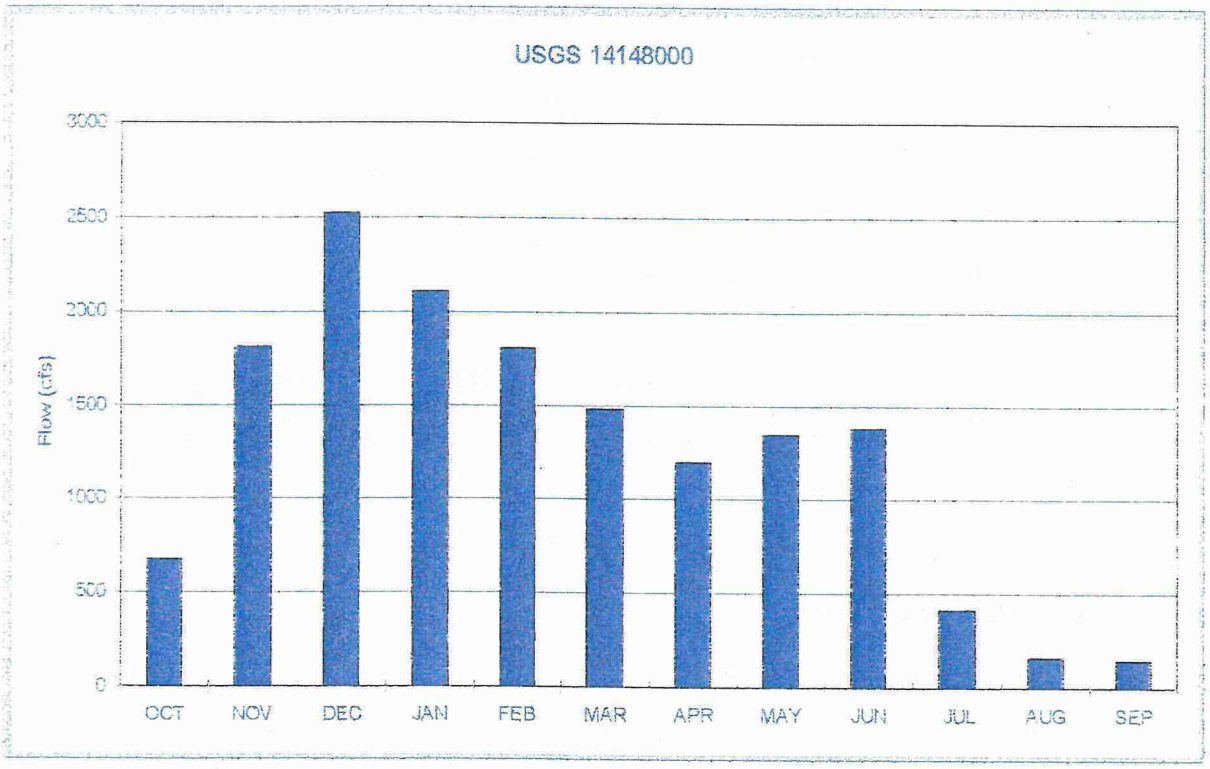
Average Runoff

Average annual runoff for the Middle Fork Willamette River in the analysis area was calculated using USGS gauging stations 14148000 (located upstream from Lookout Point Reservoir) and 14150000 (located below Dexter Reservoir) *(see Map 8 and Table 9)*. The data shows that approximately 4% or 143,000 acre-feet of the annual runoff for the Middle Fork Willamette River originates from the analysis area. Average monthly discharge is illustrated in Figure 3.

Table 9. Middle Fork Willamette River Watershed Total Yield and Peak Flows

	Middle Fork Willamette River	
	Middle Fork Willamette River below the North Fork Willamette River USGS Station 14148000	**Middle Fork Willamette River, near Dexter, OR** USGS Station 14150000
Total Yield	2,148,000 acre-ft/yr	2,292,000 acre-ft/yr
Maximum Recorded Flow	81,800 cfs (1945)	62,000 cfs (1953)
Minimum Recorded Flow	322 cfs (1961 Reg)	100 cfs (1960 Reg)
Average Recorded Flow	2,785 cfs (1923-1987) (adjusted since 1961)	3.163 cfs (1946-1987) (adjusted since Jan., 1953)

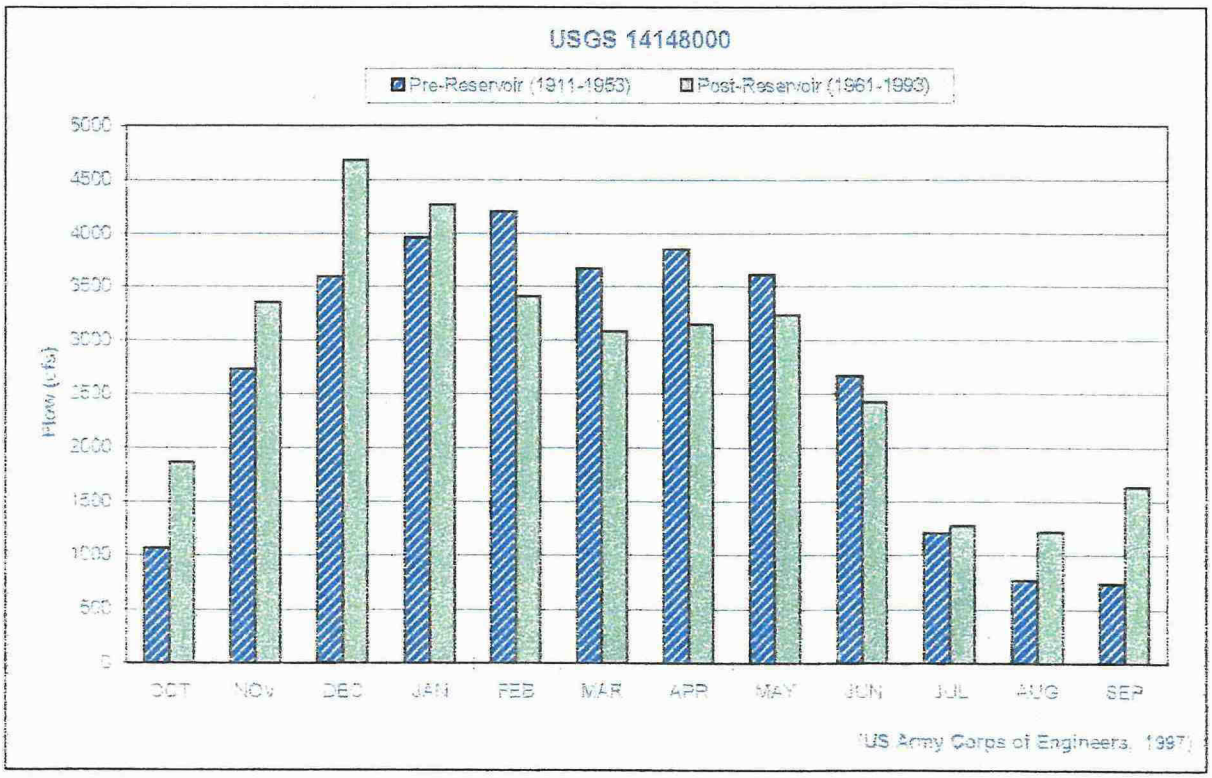
Figure 3. Average Monthly Discharge - Middle Fork Willamette River



The natural flow of the Middle Fork Willamette River in the analysis area has changed significantly from historic conditions due to the installation of Hills Creek Reservoir and the Lookout Point Reservoir. Regulation of flow from Hills Creek Reservoir begun in 1961. The average annual volume of water passing through Lookout Point analysis area has not changed overtime by the Hills Creek project. What has changed is the average mean monthly flow. The data shows a change in flow regimes due to

regulated flow from Hills Creek Dam. Less water is released during the winter months (January-June) and more water is released in late summer to early winter (July-December). Regulation of flow is to provide flood protection in the winter and water supply in the spring. Conversely, more water is released during the fall and early winter to prepare for the next flood season. Figure 4 compares average monthly discharge of the Middle Fork Willamette River at the USGS gaging station 14148000 before and after Hills Creek was constructed. Lookout Point Dam was completed in 1953. It is located 22 miles southeast of Eugene on the Middle Fork Willamette River. Approximately 20% of the Lookout Point Reservoir is within the analysis area. (COE, 1997).

Figure 4. Average Monthly Discharge (Pre- and Post-Hills Creek Dam)



Instantaneous Peak Flow

Reference Condition (Pre-Reservoir)

Instantaneous peak flow is defined as the highest water level measured at a gaging station on a single day. A *recurrence interval* is the probability that a certain magnitude flood event will occur over a given period of time. Significant flood events in the analysis area for the period of record occurred in water years 1943, 1946, two in 1953, and one in 1955. The instantaneous peak flow for a five-year flood event on the Middle Fork Willamette River in the analysis area is estimated at 37,400 cfs. On December 28, 1945 (water year 1946) there was a instantaneous peak flow of 81,800 cfs; therefore this flood was slightly higher than a one hundred-year event at this

location. On November 22, 1953 there was a instantaneous peak flow of 72,900 cfs. This storm produced flows slightly higher than a 50-year flood event for that channel *(see Figure 5).*

Figure 5. Instantaneous Peak Flow Middle Fork Willamette River (USGS 14148000)

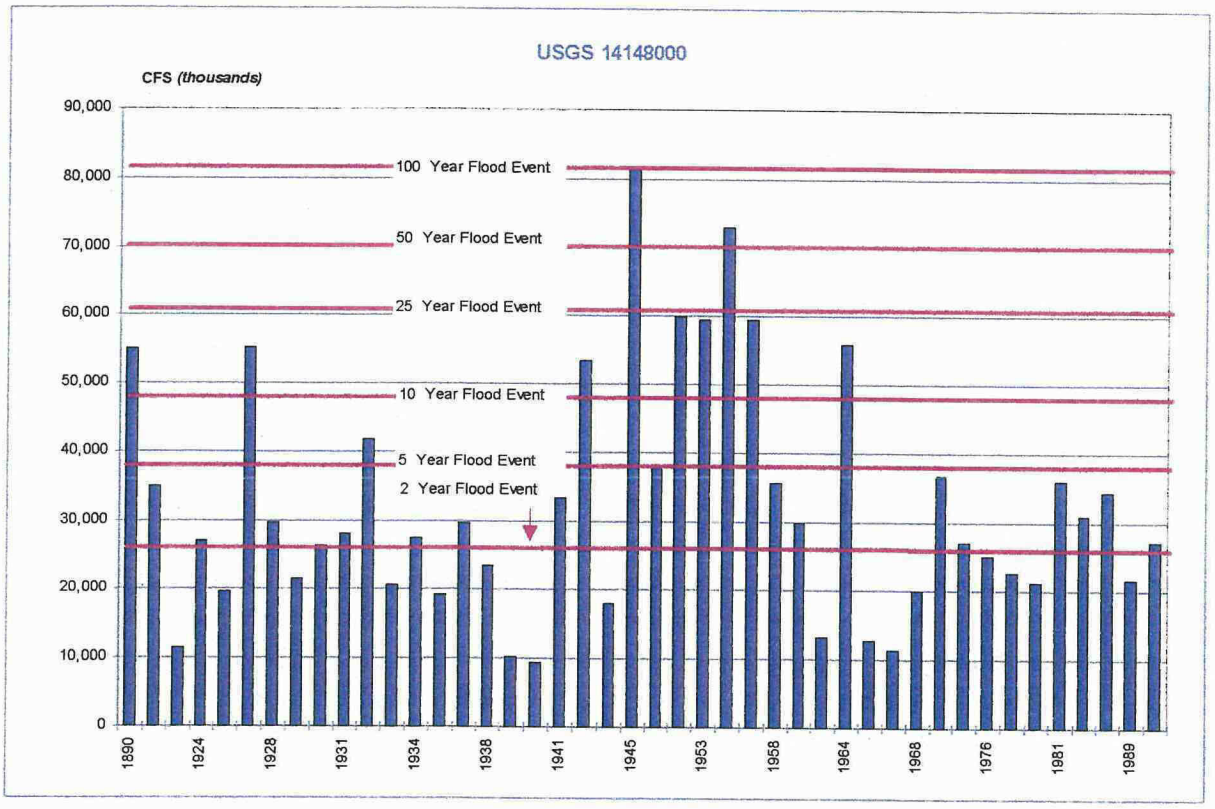


Table 10. Instantaneous Peak Flows from USGS Equations

Recurrence Interval (Years)	Exceedance Probability	Middle Fork Willamette River (USGS station 14148000)
1.25	80%	15,300 cfs
2	50%	24,000 cfs
5	20%	37,400 cfs
10	10%	47,000 cfs
25	4%	59,900 cfs
50	2%	69,900 cfs
100	1%	80,400

Current Condition

USGS created statistical estimates for 2, 5, 10, 25, 50, and 100 year flood events at gaging station locations shown in Table 10. The volume of water typical for a historical five-year event (37,400 cfs) on the Middle Fork Willamette River has not occurred since operation of Hills Creek Reservoir began in 1961, with one exception (1964) *(see Table 10 and Figure 5).*

Minimum Flow

Historically, average minimum flows on the Middle Fork Willamette River ranged from 50 to 100 cfs during July through September. Following completion of Hills Creek Dam, average minimum flows between July and September ranged from 250 to 600 cfs (USGS, 1997).

Rainfall/Runoff Characteristics

Runoff characteristics of a watershed are evaluated based on the amount of precipitation an area receives, water retention properties of the soil, aspect, drainage density, elevation, road density, and vegetation. The effects of timber harvesting and road construction on local hydrology is under study by researchers, but is not easily quantified. Research in western Oregon has indicated that the majority of larger peak flows have resulted from snowmelt during rainfall. R. D. Harr (1981) found that in watersheds within the zone containing transient, shallow snowpacks, higher peak flows were up to five times more prevalent from rain-on-snow storm events than only from rain. Not surprisingly, a higher number of landslides occurred during rain-on-snow storms than during rainstorms alone. Not only are the uplands altered by landslides during these events, but streams also carry large amounts of sediment and deposit woody debris in the channels. Channel morphology can be altered by bank undercutting, downcutting of the stream bed and redistribution of sediment in the channel.

Nearly 74% of the Lookout Point WAA is within the transient snow zone, situated between 1500 feet and 4200 feet in elevation *(see Map 13).* The transient snow zone exhibits a high potential for runoff when warm wind and rain follow a period of snow accumulation. Aspect influences the type of vegetation growing on the site, local precipitation patterns, snowmelt, and wind exposure. South and west slopes respond to snowmelt much more quickly than north and east aspects. About 18% of the analysis area has a south or southwest aspect *(see Map 14)* with a precipitation range from 45 inches per year at lower elevations to a maximum of 70 inches per year at higher elevations.

Groundwater storage capacity is directly related to the type and depth of soil and bedrock. Relatively shallow soils store less water, thus having the greatest potential of contributing to increased stream flow during high runoff events. Deep soil areas generally have the ability to store water and contribute to the maintenance of base flows. *Base flow* is defined as the sustained or fair-weather runoff found in a drainage.

In Lookout Point WAA, soil Category 1 is considered to have a low runoff rate, high water retention capacity (due to greater thickness and higher clay content) and is important in sustaining base flow. Soil Category 2 tends to occur on steeper terrain and has a moderate runoff rate, moderate water retention capacity (>50% clay soil) and contributes both to base flow and overland flow. Soil Categories 3 and 4 are found on steep terrain, have coarser sediments (such as broken rock, sand and silt), and are shallower than Categories 1 and 2. These soils have a high runoff rate, low water retention capacity (due to grain size) and contribute primarily to overland flow.

Vegetation affects surface runoff by changes in evapotranspiration rates. Closed or dense canopies can intercept some precipitation before it reaches the ground. Dense stands of timber also protect an accumulated snowpack from rapid melting by reducing the amount of light and wind in the understory.

Basins with high drainage density are characterized by a finely divided network of streams with short lengths and steep slopes. In contrast, a basin with low drainage density is less strongly textured. Stream lengths are longer, valley sides flatter and the streams further apart. Table 13, page 40, shows stream miles for each drainage in the WAA. Stream density is controlled by bedrock type, its resistance to erosion, amount of precipitation, and vegetative cover. Not surprisingly, the highest drainage densities are found on the steeper topography of the analysis area.

Water Quality

Reference Condition

During the early 1900s, heavy logging took place in the area surrounding the community of Oakridge. In these early days timber was harvested within 200-300 feet of the stream along main tributaries of the Middle Fork Willamette River. Logs were sluiced down the Middle Fork to mills in Springfield when stream flows were high enough to move them. At this time, a very rough road provided access to the city of Oakridge. This road could have contributed to suspended sediments in the stream system, but it was probably insignificant compared to the practice of transporting logs down the river. Slope failures also introduced sediment into the waterways, but data quantifying the extent of such an impact to water quality is unavailable.

In 1912 the Southern Pacific Railroad was built along the Middle Fork Willamette River. It runs along the south side of Lookout Point Reservoir, crosses the Middle Fork Willamette River at Hampton Campground, then continues along the north side of the river. It undoubtedly introduced large amounts of sediment to the river system during construction.

Current Condition

Current water quality conditions are evaluated on the basis of water resource usage. Standard parameters have been identified by the Oregon State Department of Environmental Quality (DEQ) to determine the quality of water required for those uses.

These parameters list the acceptable limits of various conditions found in the stream system, such as water temperature, sediment and bacteria.

The State of Oregon, as directed by the Clean Water Act and the EPA, is responsible for protecting the quality of rivers and other bodies of water in the public interest. The Oregon Administrative Rules (Chapter 340, Division 41) list the beneficial uses associated with each river and standards of monitored parameters. The Oregon Department of Environmental Quality (DEQ) is the State agency responsible for enforcing these standards.

There is little data water quality perimeters other than temperature during recent times. In a personal communication with Gary Arnold of Oregon Department Environmental Quality (DEQ), he stated: *"it is thought that the waters from the upper Middle Fork Willamette River are within Oregon standards,"* but added that *"more monitoring and analysis should be conducted"* (1997).

Water quality may be affected by the abandoned Hines Mill at Westfir. This mill site is located adjacent to the North Fork of the Middle Fork Willamette River just above its confluence with the Middle Fork. Hazardous chemicals may be leaching into the North Fork from this site.

Temperature

In the late 1950s and early 1960s, water temperatures at the Middle Fork Willamette River gaging station (USGS 1414800) were in excess of 70°F for at least a week during the summer (June and September). This is probably due to clear cutting of the area now covered by Hills Creek Reservoir.

Since 1961, when Hills Creek Dam became operational, maximum stream temperatures on the Middle Fork Willamette dropped from 70°F to below 65°F. This is a result of colder water released from the bottom of Hills Creek Dam. The period of record for this temperature data is 1952 to 1987. The data suggests that temperatures are generally lower in the Middle Fork Willamette River after construction of Hills Creek Reservoir than they were from 1952-1956 *(see Figure 6).*

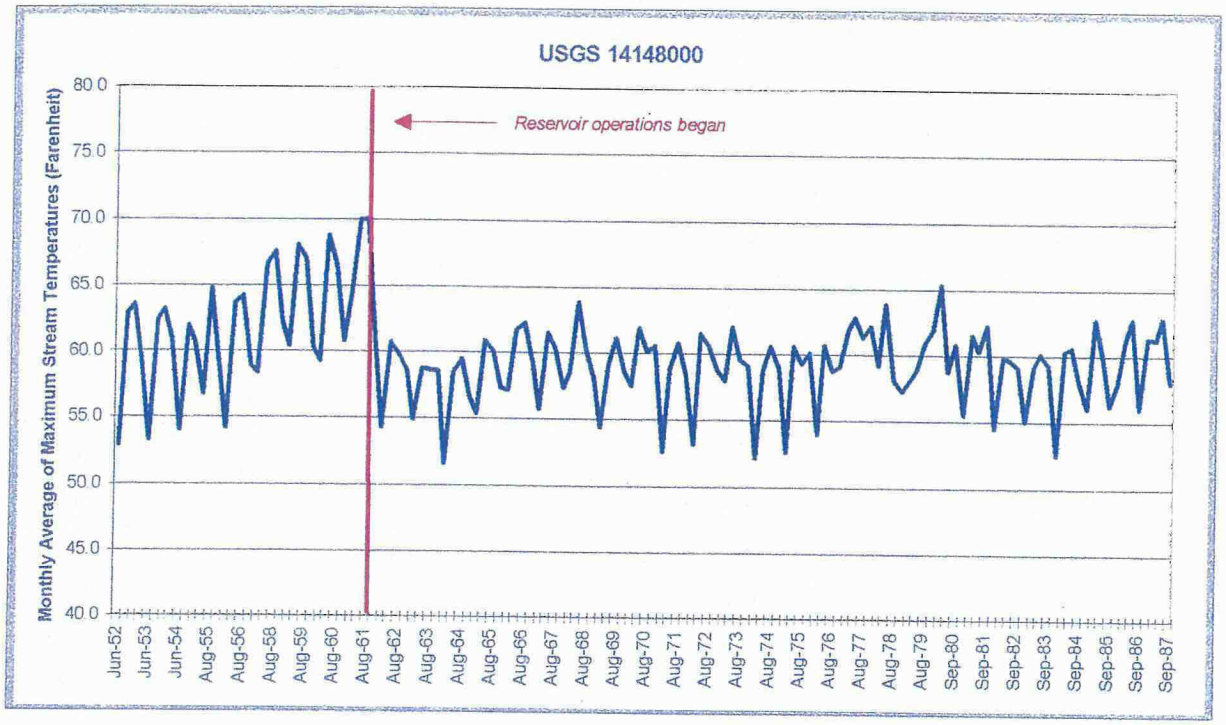
During surveys of fish habitat in Deception Creek, a steam sample was taken on August 8, 1996, indicating stream temperature to be 64°F. Data to suggest that this temperature exceeds the state standards is insufficient.

Water Supply

A few surface water right permits are on record with the County for lands within the WAA. It is unlikely that any of these users are utilizing this water for drinking. In any case, DEQ's ambient monitoring program is not designed to assess water quality potability and it is assumed that some level of treatment is required to provide potable water.

Monitoring data addressing water quality in tributary streams for private domestic water uses is unavailable.

Figure 6. Monthly Average of Maximum Temperatures of Middle Fork Willamette River



Transportation

Lookout Point WAA has a total of 250.8 miles of road *(see Map 33).* Roads are managed by the USDA Forest Service, Lane County, and Oregon Department of Transportation (ODOT). Road density for drainage groups in the analysis area ranges from 2.4 to 4.8 miles per square mile. Roads provide a source of fine sediment to streams, particularly in earthflow terrain. School, Tire and Rolling Riffle/Hazel Drainages have the highest percentage of earthflow terrain within the WAA.

A study by Sam Dimas (USDA, 1996) on the Lowell Ranger District, suggested that higher quality road surface decreases sediment runoff concerns. Table 11 indicates the miles and percentage of roads for each drainage separated by type of road surface *(also see Map 34).* Paved and aggregate are the highest quality surface and produce the least amount of fines. These two surface types comprise 86% of the total roads within the WAA. Native roads are of highest concern as they have no surfacing. However, since these comprise only five percent of the WAA, fine sediment produced by roads does not appear to be a significant concern.

Table 11. Road Miles and Percentage by Surface Type and Drainage

Drainage Group	Paved		Aggregate		Improved		Native	
	Miles	%	Miles	%	Miles	%	Miles	%
Rolling Riffle/Hazel	1.2	11%	10.0	86%	0.4	3%	0.0	0%
Goodman	2.3	6%	31.3	84%	1.9	5%	1.6	4%
Crale	2.9	22%	7.0	53%	2.3	17%	1.0	8%
North/South/Schweitzer	0.3	2%	11.3	79%	2.0	14%	0.6	5%
Duval		0%	15.3	92%	0.9	5%	0.6	3%
Whitehead/Bridge/Dell	3.4	14%	19.1	80%	0.1	0%	1.3	5%
Deception	0.0	0%	26.8	85%	2.4	8%	2.2	7%
Rock	4.4	25%	12.3	69%	1.1	6%	0.0	0%
Rhodes		0%	5.8	85%	1.0	15%		0%
School		0%	10.1	91%	0.4	4%	0.6	5%
Cain/Armet		0%	12.6	81%	1.8	11%	1.3	8%
Carpet Hill/Hospital		0%	8.2	75%	0.9	8%	1.8	16%
Tire		0%	15.5	77%	4.1	20%	0.6	3%
Buckhead	1.2	7%	12.8	73%	2.1	12%	1.4	8%
Totals	**15.7**	**7%**	**197.9**	**79%**	**21.3**	**9%**	**12.9**	**5%**

Maintenance levels for roads within each drainage group are shown in Table 12 and on Map 35. Level I roads are closed to all motor vehicles exceeding a 42 inch wheel base. Level II are opened to high clearance vehicles. Level III are gravel roads open to all vehicles. Both Level IV and V roads are paved and open to all vehicles. Level IV are typically single lane roads and Level V usually have double lanes.

Sixty percent of the roads within the WAA are at Maintenance Level II. This is of concern since these roads may not receive adequate surface maintenance causing ruts to develop. Increased fine sediment may be deposited into stream channels and possible catastrophic failure of sidecast material may result, as seen during recent flooding events.

Aquatic and wildlife concerns have led to decommissioning and closure of roads *(see Map 36).* This has reduced fine sediment deposition into streams and decreased the open road density to benefit big game *(see page 76).*

Table 12. Road Miles and Percentage by Operational Maintenance Level by Drainage

Drainage Group	Level I		Level II		Level III		Level IV		Level V	
	Miles	%	Miles	%	Miles	%	Miles	%	Miles	%
Rolling Riffle/Hazel	0.6	5%	9.8	84%	-	0%	0.3	3%	0.9	8%
Goodman	2.6	7%	26.7	72%	5.4	15%	2.1	6%	0.2	0%
Crale	2.9	22%	7.4	56%	-	0%	-	0%	2.9	22%
North/South/Schweitzer	2.3	16%	8.6	61%	0.1	1%	2.9	21%	0.3	2%
Duval	1.3	8%	13.4	80%	-	0%	1.9	12%	-	0%
Whitehead/Bridge/Dell	1.4	6%	13.3	55%	6.1	26%	0.4	2%	2.7	11%
Deception	3.0	10%	15.7	52%	11.2	37%	-	0%	0.0	0%
Rock	1.1	6%	9.0	50%	1.3	7%	4.0	23%	2.5	14%
Rhodes	1.0	15%	2.6	38%	0.2	3%	-	0%	3.0	44%
School	2.3	20%	5.6	50%	3.2	29%	-	0%	0.1	0%
Cain/Armet	2.8	18%	6.8	43%	2.7	17%	-	0%	3.4	21%
Carpet Hill/Hospital	2.5	23%	5.1	47%	3.2	29%	-	0%	0.1	1%
Tire	3.3	16%	13.2	66%	3.6	18%	-	0%	-	0%
Buckhead	2.4	14%	12.0	69%	1.9	11%	-	0%	1.1	6%
Totals	30.4	12%	149.7	60%	39.2	16%	11.9	5%	19.7	8%

Stream Channels

Reference Condition

The WAA contains 402 miles of streams; 46 miles are fishbearing. These channels range from low-gradient depositional reaches to steep, high-gradient source channels. Drainages were grouped for the purpose of analysis *(see Map 7).* Stream classes are displayed on Map 30. Tributaries in earthflow terrain (soil Category 1) contribute fine sediments to the system, while streams found in debris slide basins (Category 3) are source areas for coarse sediments such as gravels and cobbles *(see Table 13)* Soil Category 2 has some of the characteristics of Category 1, while Category 4 is similar to Category 3.

Tributaries entering the Middle Fork Willamette tend to have a fairly high gradient. The deeply entrenched channels are usually bedrock controlled and classified as Rosgen 'A' channels. Some are relatively less steep and moderately entrenched. These are classified as Rosgen 'B' channels although many of these also tend to have some 'A' characteristics *(see Map 29).*

Table 13. Miles of Stream by Soil Category

Drainage	Soil Category 1	Soil Category 2	Soil Category 3	Soil Category 4
Rhodes	0.4	1.9	0.6	3.7
School	4.8	0.5	7.4	3.4
Cain/Armet	3.9	3.8	4.9	7.3
Carpet Hill/ Hospital		8.3		1.6
Tire	13.5	4.0	9.1	5.9
Buckhead	0.9	6.1	14.8	3.3
Rolling Riffle/ Hazel	5.0	8.0	0.5	4.6
Goodman	4.4	16.1	38.0	11.2
Crale	2.3	6.1	1.4	5.4
North/South/ Schweitzer	1.5	5.5	17.4	8.5
Duval	5.6	4.7	5.9	15.0
Whitehead/ Bridge/Dell	5.5	12.4	1.3	7.4
Deception	7.9	12.0	45.1	3.1
Rock	1.6	11.9	3.9	5.4

The Middle Fork Willamette was a free flowing river prior to Lookout Point Dam construction. Aerial photos from 1944 indicate a braided channel meandering across the valley bottom. Many side channels provided backwater habitat, and floodplains were commonly inundated during high winter flows. Part of the river was highly sinuous, non-entrenched with a low channel gradient and classified as a 'C' Rosgen channel. These areas were the depositional/response reaches of the WAA. Interspersed with these wide alluvial reaches, there are two other confined, low gradient canyons, in the Hospital/Carpet Hill Creeks and Black Canyon areas. These sections are bedrock controlled and classified as Rosgen 'F' channels. They function primarily as transport reaches and have not changed significantly from historic conditions.

Current Condition

During the early 1900s, splash damming was a common method for transporting logs downstream. Streams were dammed until a significant number of logs collected upstream, upon which dams were breached and logs released. This caused one of the

first impacts to the stream channel, reducing habitat complexity. Records exist of splash dams at Black Canyon in the Middle Fork Willamette River and Rolling Riffle Creek.

Many of the tributary stream channels have been affected by road construction and harvest of riparian trees. Table 14 displays the road density, soil type and riparian condition for each drainage within the WAA. Roads not only confine the channel but also provided easy access for past management practices such as harvesting riparian trees or instream large woody debris. Large woody debris helps create stream channel morphology, especially evident in a stairstep type of habitat, and provides channel stability.

Downed large wood is particularly important for providing stability in earthflow terrain where soils are deep (Category 1). Such areas are also sources for fine sediment. Roads within these areas easily transport fines into stream channels. High road densities with midslope roads and stream crossings can be a concern for potential increase in fine sediments to the stream.

Aerial photos from 1944 were consulted and compared with current photos to determine changes in the Middle Fork Willamette River from the head of the reservoir to the North Fork Middle Fork confluence. Large changes occurred in the Buckhead area, where the river is controlled by alluvial processes. The channel fluctuated back and forth across the floodplain. At the time of the photos, the majority of channel flow was on the north side of the valley with several side channels. Now one confined channel exists on the south side of the valley adjacent to Highway 58. Hills Creek Reservoir regulates 31% of the flow for the Middle Fork Willamette River reducing its extreme high and low flows. In conjunction with downcutting of the streambed, this has resulted in a very limited use of overflow channels and subsequent floodplain inundation.

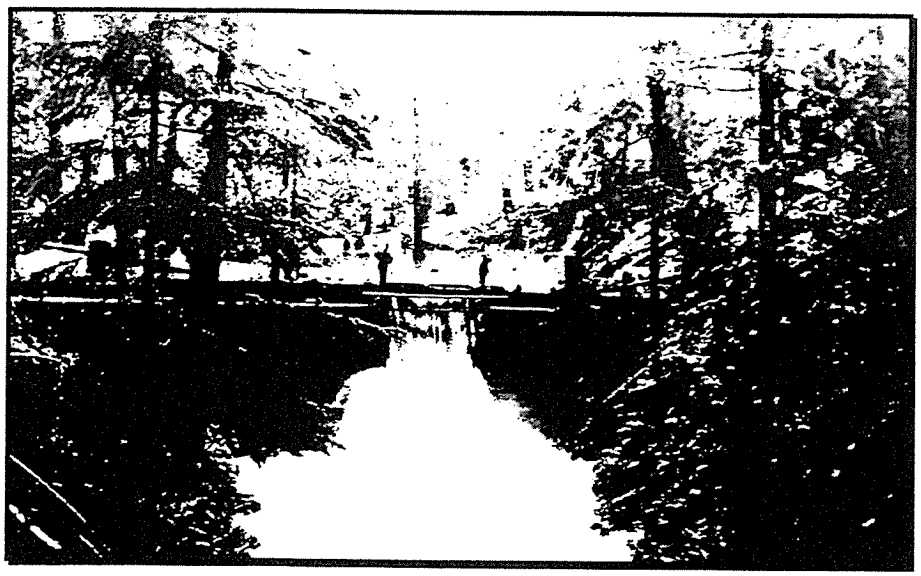


Figure 7. Log drive splash dam at Rolling Riffle Creek.
Photo courtesy of Lane County Historical Museum.

Table 14. Drainage Densities

Drainage Group	Acres	Square Miles	Miles of Fishbearing Streams	Miles of Class III Streams	Miles of Class IV Streams	Total Stream Miles	Stream Density mi/mi²	Miles of Road	Road Density mi/mi²	Riparian Seral Condition	
										0-80 years	80+ years
Rolling Riffle/Hazel	2356.3	3.7	1.1	1.2	15.3	17.7	4.8	12.3	3.3	31%	69%
Goodman	8100.4	12.7	8.0	8.7	52.0	68.8	5.4	41.9	3.3	27%	73%
Crale	1841.1	2.9	0.9	2.7	9.6	13.3	4.6	19.2	6.7	48%	51%
North/South/Schweitzer	3796.7	5.9	4.5	6.1	21.8	32.4	5.5	19.2	3.2	21%	79%
Duval	3503.2	5.5	1.9	7.8	22.7	32.4	5.9	17.1	3.1	44%	53%
Whitehead/Bridge/Dell	3537.5	5.5	6.4	4.9	19.2	30.5	5.5	24.1	4.4	37%	63%
Deception	7395.7	11.6	8.2	6.5	57.4	135.9	11.8	36.2	3.1	33%	65%
Rock	3091.2	4.8	3.3	3.6	17.5	24.4	5.1	21.4	4.4	25%	67%
Rhodes	1050.4	1.6	0.2	1.2	4.4	5.8	3.5	6.8	4.2	43%	57%
School	1495.3	2.3	2.0	3.1	11.0	16.1	6.9	11.1	4.8	50%	47%
Cain/Armet	2139.3	3.3	1.6	1.8	14.6	17.9	5.4	15.7	4.7	35%	65%
Carpet Hill/Hospital	1732.5	2.7	0.7	1.1	8.2	9.9	3.7	11.6	4.3	28%	72%
Tire	3895.6	6.1	1.3	7.7	23.9	33.0	5.4	23.2	3.8	24%	74%
Buckhead	3314.8	5.2	5.7	4.6	17.1	27.4	5.3	22.2	4.3	44%	53%
Lookout Point Reservoir	1777.8	2.8	0.1	0.1	0.2	0.4	0.2	9.4	3.4	82%	0%
Totals	**49,027.8**	**76.6**	**46.0**	**61.0**	**295.1**	**402.1**	**5.2**	**291.5**	**3.8**	**33%**	**65%**

Vegetation

The Lookout Point WAA is fragmented into small stands due to human activity. The largest stand is in the Hardesty area where fires occurred more than a hundred years ago. In the early 1900s forest management activities began and have reduced the average age, complexity and stand size of the forest. Many acres are now in earlier seral stages and smaller blocks, which do not provide historic levels of forest diversity, wildlife habitat or stand structure.

The predominant forest climax series found within the analysis area is western hemlock. This series is found in warm, moist conditions and lies between the lower, drier Douglas-fir series and the higher Pacific silver fir series. In the western hemlock series, Douglas-fir is the dominant species, growing with western hemlock and western red cedar. Common associates include incense cedar and western white pine. Hardwood associates include bigleaf maple, red alder, vine maple, chinquapin, and madrone. Other plant species represented in this series are dwarf Oregon grape, salal, rhododendron, swordfern, vanilla leaf, Oregon oxalis, twinflower, and redwoods violet.

The Douglas-fir series is found in droughty areas of the WAA where soils may be heavy and clayey. Tree species associated with this series are Douglas-fir, madrone and incense cedar. Pockets of sugar pine and western white pine are found in the Deception Creek and Shady Dell areas. Shrubs include dwarf Oregon grape, whipple vine salal, baldhip rose, and trailing snowberry. Herbs common to this series are swordfern, snowgreen, wild strawberry, and pathfinder.

Reference Condition

The chosen reference year for the analysis area is 1900. Landscape information was developed from estimated year of origin, ecoplot/stand data and other USDA Forest Service data.

Fires and windstorms are the most frequent mechanisms in stand replacement events. Fire patterns created a mosaic of stands. Floods and insect damage caused small and more localized stand changes. Early records (circa 1860) tell of grass savannas with scattered Douglas-fir and oak at the interface of the Willamette Valley watershed. Native Americans created savannas by repeatedly burning grasslands in the valley and foothills to improve big game habitat.

Forest seral conditions are descriptive labels for the four major stand developmental stages as described by Oliver and Larson (1990). These stages are related to tree age, size and forest structure. A stand will begin in stand initiation (SI), progress through stem exclusion (SE), understory reinitiation (UR), and climax as late-successional old-growth (LSOG) *(see Table 15 for stand ages).* These seral conditions are used as general descriptive guides. Description of developmental stages for this assessment were based on GIS stand ages. Stand ages north of the reservoir were developed from stand exams while ages on the south side of the reservoir were developed from a few ecoplots and aerial photo interpretation.

In 1900, mature and old-growth forest covered more than 56% of the watershed in large undisturbed tracts. Intermixed were younger forests and early regenerating stands resulting from human or lightning fires.

Table 15. Reference Seral Condition, 1900.

Seral Classes	Estimated Stand Conditions	Area Acres	Area %
Stand Initiation 0-30 years	**Fires**	7,584	15
Stem Exclusion 31-80 years	young stands	12,934	26
Understory Reinitiation 81-200 years	mature stands	23,815	49
Late Successional Old-growth >200 years	old-growth stands	3,290	7
Non -Forest	Non-Forest	1,502	3
	Total	**49,125**	

Current Condition

The present vegetation is the result of fires and management activities in this area *(see Table 16).* Currently, 63% of forested area in the WAA is in understory reinitiation and late-successional old-growth seral stage. Twenty two percent of the area is in stand initiation seral condition, and 9% in stem exclusion. These younger stands are forest plantations well stocked by silvicultural management activities, but lacking snags or downed logs.

Table 16. Current Seral Condition, 1997.

Seral Classes	Estimated Stand Conditions	Area Acres	Area %
Stand Initiation 0-30 years	Management Activities	10,580	22
Stem Exclusion 31-80 years	young stands	4,427	9
Understory Reinitiation 81-200 years	mature stands	16,225	33
Late Successional Old-growth >200 years	old-growth stands	14,811	30
Non-Forest	Non-Forest	3,074	6
	Total	**49,125**	

Stand initiation has increased with harvest activities. The oldest stem exclusion stands have grown into the next seral class. Understory reinitiation stands have been harvested or grown into late-successional stands.

Non-forested acres have increased and include areas such as the reservoir which are removed from harvest status. For a comparison between current and reference seral conditions, refer to Table 17.

Table 17. Comparison of Reference and Current Seral Classes for Forested Lands.

Seral classes	Reference acres	Current acres	Acre Change
Stand Initiation 0-30 years	7,584	10,580	+2,996
Stem Exclusion 31-80 years	12,934	4,427	-8,507
Understory Reinitiation 81-200 years	23,815	16,225	-7,590
Late Successional Old-growth >200 years	3,290	14,811	+11,521

Fire Regimes

Reference Condition

The historical fire regime for Lookout Point WAA is characterized as a low-severity, high-frequency fire regime as described by Agee (1981). Low-severity fire regimes are associated with frequent fires of low-intensity where most of the dominant trees are adapted to resist low-intensity fires. Natural, or in this case human-caused, fire cycles are usually less than 25 years apart (Agee, 1981).

Due to the high frequency of fires, oak savanna and prairie grasslands dominated this area. Oak woodlands were an important feature in the culture of the indigenous people *(see Chapter 3, Reference Conditions, page 90).*

> *"Annual firing of the prairies and underburning of the forest were intentionally utilized by native people throughout the Willamette basin to increase the range and abundance of game and edible and useful plants."* (Winkler, 1984)

Observation of current seral stages indicates that the majority of trees are 80-200 years old or in the understory reinitiation stage. Notable exceptions are Patterson Mountain, upper Duval and Whitehead Creeks, the lower two thirds of Deception Creek, and lower Bridge and Rock Creeks. On the north side of the Middle Fork Willamette River only Buckhead Creek, the lower third of Burnt Bridge Creek, and the very top of Tire Mountain show significant stands of late successional old-growth. This is consistent with surveys completed in 1854-55, only ten years after settlement began and about the

same time as cessation of aboriginal burning in the Willamette Valley basin (Morris, 1934; Cole, 1977; Burke, 1979).

Current Condition

The Lookout Point WAA is currently classified as a high-severity, low-frequency fire regime. A high-severity fire regime is characterized by infrequent crown or severe surface fires usually resulting in total mortality of trees in the stand. Such fires are associated with drought years, east wind events or other synoptic, low-humidity weather patterns, coupled with an ignition source such as lightning (Huff and Agee, 1980; Pickford, *et. al.*, 1980). Fire return intervals have never been calculated in these forests because the intervals between fires are long and may not be cyclic (Agee and Flewelling, 1982).

Historical fire records show that Lookout Point WAA had 273 fires totaling 396.15 acres during 1949-1995. Average fire occurrence was 5.9 fires per year and average fire size was 1.45 acres.

Although a high percentage of the fires were caused by railroad activity ignitions (59.3%), most of these fires were small and only amounted to 11.2% of the total acreage consumed by fire during this record period. The number of railroad-related fires has decreased significantly during the past two decades, from 147 fires in the 1960s and 1970s, to 10 fires from 1980 to the present. This decrease in railroad-related fires is a direct result of improved train brake systems and an increased effort to control vegetation along railroad tracks.

Lightning fires in Lookout Point WAA account for 11.4% of total fires and only 0.98% of the total acreage consumed by fire during this record period *(see Table 18).*

Table 18. Human Caused Fire History 1949-1995

Fire Causes	Number of Fires	Percent of Total Fires	Number of Acres	Percent of Total Acreage
Railroad	162	59.3%	44.27	11.2%
Lightning	31	11.4%	3.61	0.9%
Other Human	80	29.3%	348.27	87.9%
Total Human Caused Fires	273	100.00%	396.15	100.00%

FUELS

Average fuel loading for seral stages was calculated using PNW photo series (PNW-51 (Maxwell and Ward, 1976), PNW-105 (Maxwell and Ward, 1980) and PNW-GTR-258 (Ottmar, 1990)) *(see Table 19).* Maximum acceptable fuel loading set by the WNF-LRMP are shown in Table 20.

Table 19. Average Fuel Loading by Seral Stage

Seral Stage	Stand Age (years)	0-3" Fuels (tons/acre)	3-9" Fuels (tons/acre)	9-20" Fuels (tons/acre)
Stand Initiation	0-30	7.15	12.1	11.75
Stem Exclusion	31-80	6.6	6.7	11.7
Understory Reinitiation	81-200	3.8	5.0	18.5
Late Successional Old Growth	201	3.8	5.0	30.0

Table 20. Maximum Acceptable Fuel Loading from WNF-LRMP

Allowable Down Woody Material			
Diameter (small end)	Tons/Acre	Pieces/Acre	Length
0" - -3"	7-11	NA	NA
3" - 9"	8-12	NA	NA
9" - 16"	18-20	NA	NA
> 16"	NA	8-15	> 20 feet

From a fuels perspective, the two seral stages of concern are stand initiation and late successional old-growth. As shown in Table 19, fuel loading in the stand initiation stage falls within the allowable range of 7-11 tons/acre for 0-3" fuels, as set by the WNF-LRMP *(see Table 20)*. While tonnages falling within the range of allowable down woody material may be cause for concern, mitigating measures are not necessarily required to reduce fuel loading. Rather, these areas need to be mapped and monitored. Often this higher fuel loading results from silvicultural prescriptions, and will be relatively short-lived (3-6 years).

In 9-20" fuel category, the late successional old-growth seral stage exceeds fuel loading limitations delineated by the WNF-LRMP *(see Table 19 and Table 20)*. Excessive fuel loading in this category is the result of wind-cast limbs, tops and overall decay of the timber stand. This additional fuel loading does not increase the overall fire danger but rather the intensity of a fire, should one begin.

Reference Condition

Stand initiation accounted for 7,583 acres (15.4%) of the total analysis area in the reference condition. This seral stage had lower overall fuel tonnages than currently due to present silvicultural practices. With no clear record it is impossible to determine what those tonnages might have been; therefore current tonnages were used for fuel loading determination. Late successional old-growth accounted for 3,290 acres or 6.7% of the

total analysis area. Present tonnages should be consistent with reference conditions for this seral stage.

The other two seral stages, stem exclusion and understory reinitiation, did not have fuel loadings that met or exceeded the Allowable Down Woody Material Standards. These seral stages accounted for 36,749 acres (74.8% of the analysis area); of these 12,934 acres (26.3%) were in stem exclusion and 23,815 acres (48.5%) were in understory reinitiation seral stages.

Current Condition

The area in stand initiation seral stage has increased from a reference condition of 7,583 ac (15.4%) to 10,588 acres (21%). Late successional old-growth has increased from a reference condition of 3,290 acres (6.7%) to the current 14,811 acres (30.1%). From a fuels point of view, the area of concern (stand initiation and late successional old-growth) has increased in the analysis area from 22.1% to 51.7% of the total area.

Fuels Treatments

Fuels in harvested areas have traditionally been treated for hazard reduction using prescribed fire. Treatments have included dozer piling and burning, grapple piling and burning, hand piling and burning, burning of slash concentrations, and broadcast burning. In a very few cases (<1%), fuels were left untreated.

The majority of harvest units are treated by prescribed broadcast burning. Until 1986, broadcast burns primarily occurred between July 15 and September 30. During summer burns fuel consumption was high, completely consuming the majority of fuels <9". Summer burning was costly, as most units required burning crews, holding crews and extensive mopping. Resource damage, in the form of burned timber lands ("slop-overs"), soil damage and wildlife tree mortality, was not uncommon.

In 1986 the Oregon Smoke Management Plan banned most smoke-creating fuels treatment from July 1 to September 30. The majority of broadcast burns now occur during the spring months of March through June. Consumption of fuels 0-3" in diameter is still significant enough to reduce fire hazard and allow for reforestation, but spring burning significantly reduces the risk of resource damage to soil and timber due to excessive heat.