

3.0 WRIA CHARACTERIZATION

3.1 LOCATION¹

Water Resource Inventory Area (WRIA) 46 is located along the eastern slopes of the Cascade Mountains in north-central Washington State, Chelan County. It comprises the Entiat and Mad River watersheds, collectively known as the Entiat subbasin, as well as some minor Columbia River tributary drainages. The WRIA is approximately 305,641 acres, and is bounded on the northeast by the Chelan Mountains and the Lake Chelan drainage; to the southwest are the Entiat Mountains and the Wenatchee River subbasin. [Figure 3-1](#) on page 3-2 shows the location of the Entiat WRIA within Chelan County, the Upper Columbia Region Evolutionarily Significant Unit (ESU) for salmon recovery, and the state of Washington.

The Entiat River is the largest within the WRIA. It originates in glaciated basins 4.5 miles east of the Cascade crest and flows 43 miles in a southeasterly direction to its confluence with the Columbia River (RM 482.7 on the Columbia) near the city of Entiat, approximately 20 miles north of the city of Wenatchee. The Entiat River has two major tributaries: the North Fork Entiat, which joins the mainstem at river mile 34; and the Mad River, which flows into the lower Entiat River near the town of Ardenvoir (RM 10.5). The Entiat's headwaters are fed by a rim of snow-covered peaks that include Tinpan, Buckskin, and the Pinnacle Mountains; Mt. Maud, Seven Fingered Jack, and Mt. Fernow; Ice Creek Ridge, Spectacle Buttes, Fourth of July Mountain, Garland Peak, and Rampart Mountain. The highest elevation in the watershed is the 9,249-foot summit of Mt. Fernow. The lowest elevation occurs at the Entiat River's mouth, at approximately 713 feet. This range of elevations results in a wide variety of ecosystems from alpine, with 90 inches of precipitation per year, to shrub-steppe, which receives less than 10" of precipitation/year. Refer to [Figure 3-19](#) on page 3-36 for a depiction of the ranges of annual precipitation experienced in WRIA 46.

3.2 HUMAN ENVIRONMENT

3.2.1 Historical Overview²

Native Americans used the Entiat valley for hunting and gathering prior to its use by trappers and settlers of European origin. Bitterroot was gathered on the lower valley hillsides, and is still relatively common in some locations today. Native Americans also harvested game from the forests and grasslands, and fish and other water dependent species from the Entiat River and its tributaries. The Yakama Nation, under the 1855 Treaty with the Yakima, maintains hunting and gathering rights in the WRIA (see [Appendix H](#) and Section [3.2.5](#) for more information about the ethnology of the WRIA, and [Appendix I](#) for the full 1855 Treaty).

¹ Information in this section, and the topography and geology section, has been excerpted from the Entiat Co-operative River Basin Study (USDA et. al. 1976).

² This overview is based on information taken from a recorded oral history of lifelong valley residents (Entiat Valley History videotapes #1 and #2, CCCD 1996) and from the Watershed Assessment, Entiat Analysis Area (USFS WNF 1996), with additional corrections and updates from Conard Petersen and others in 1999. The Wenatchee National Forest Overview (Hollenbeck and Carter 1986), listed as a reference on p. 3-16, was prepared as part of the Wenatchee National Forest Plan effort.

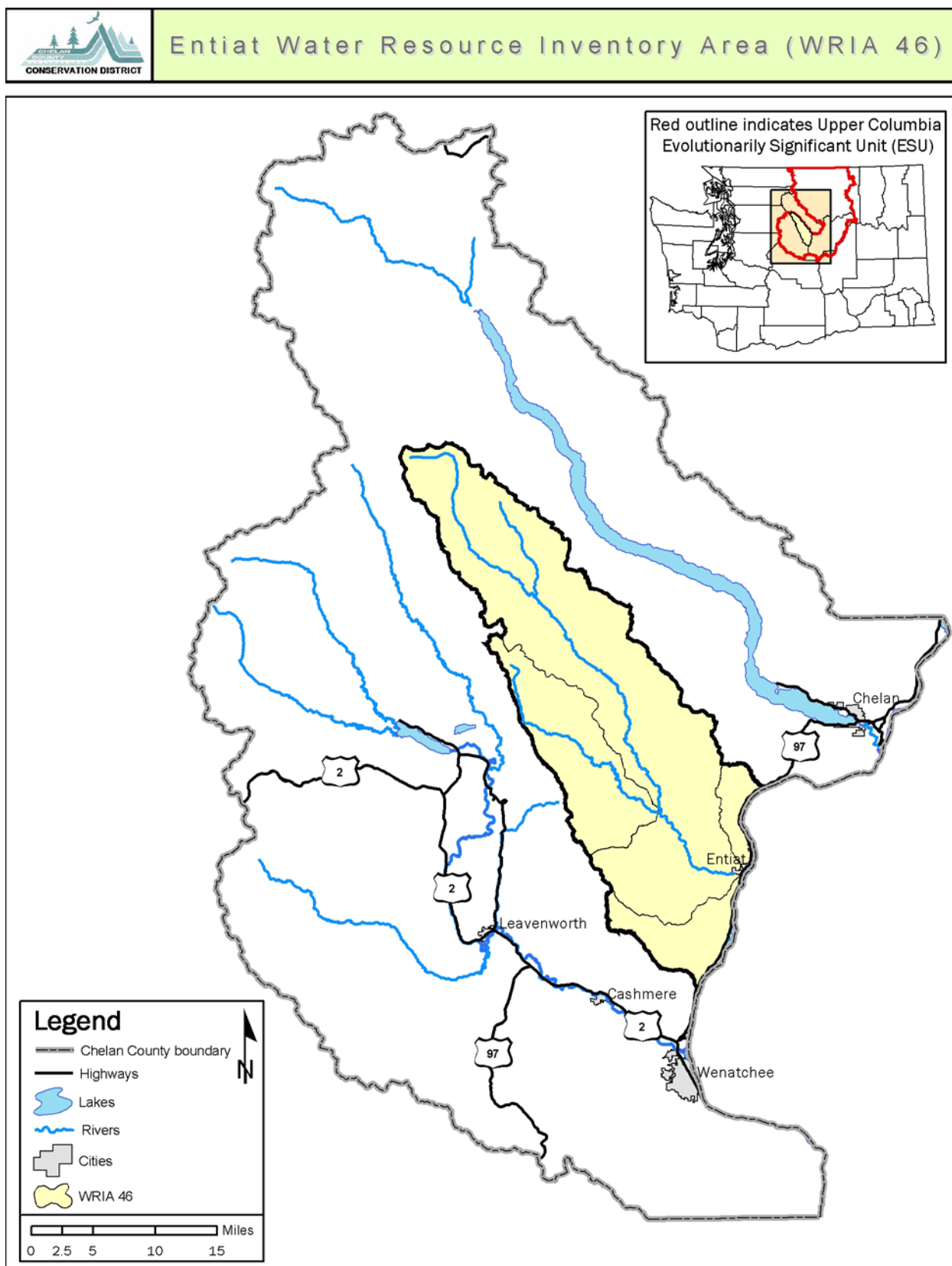


Figure 3-1. Location of WRIA 46 within Chelan County, the Upper Columbia Evolutionarily Significant Unit, and Washington State.

Trapping in the 1880s was the first non-Native American activity to occur in the Entiat watershed. It is thought that pine martens were the primary furbearers that early trappers targeted, and marten sets cut into trees can still be seen today. Speck (1970), in his book *Northwest Explorations*, documented some of this early resource use, and long time residents relate stories about early trappers and trapper cabins throughout the mid and upper valley. Relics of trappers' old cabins are still evident in some locations, and one of the cabins near the mouth of the North Fork Entiat River has the Northwest Fur Company logo on some of its logs. Trapping continued through the 1980s and into the 1990's as a source of revenue for some current residents' ancestors.

Sheep grazing also began about 1880, and was one of the most extensive earlier uses of the valley. Before the coming of the railroad, sheep were herded from their winter grounds to the mountains, grazing as they went. Various sources indicate that 13,000 to 16,000 sheep grazed the valley in the late 1800s and early 1900s. The Plummer report indicated that in 1902 there were upwards of 60,000 sheep along the head of Mad River (USDI Geologic Survey 1902). Sheep also came into the valley via the Chumstick drainage. After 1911 many sheep were brought into a stockyard in the old town of Entiat by railroad, and grazed along the Columbia Breaks before being herded into the valley for the late spring, summer and early fall months.

Many of the sheep bands moved into and out of the subbasin throughout the year, using both the Wenatchee and Chelan River subbasins concurrently with the Mad and Entiat River valleys during the grazing season. In 1908 A.H. Sylvester, an early supervisor of the Washington Forest Reserve, stated that the district between Baldy Mountain and Snowbrushy Creek had been overgrazed for at least 10 years and needed careful handling to be restored to its original condition. At the same time, the Federal Grazing Act required that herders run their bands of sheep on a permit basis. In the 1940s sheep grazing on federal lands in the Entiat was cut back from two to three bands (1,000 sheep/band) to one band annually, the number allowed to graze for 1-2 months annually or semi-annually today.

Cattle and horses also used the valley, although not as heavily or extensively as sheep. In the early 1900s wild horses were rounded up and brought to the railroad stockyard at Entiat. Hogs and dairy cows were grazed in a few locations. The number of cattle now grazing on federal lands is less than 200 head, with approximately another 100 head using private lands for part of the year.

Prospecting and mining for gold and other minerals occurred in the valley between 1885 and 1910. Most of this activity was concentrated around Crum Canyon. In the late 1940s, pumice was taken out of open pit mines between Stormy Creek and Cottonwood, and commercial pumice was mined in Stormy Creek up until 1956.

Logging within the valley has had a rich and varied history. In 1892 the first log mill was established near the mouth of the Entiat River. Early timber activities focused primarily on roading and harvest along valley bottoms of private lands, particularly holdings of the Northern Pacific Railroad Company. The presence of valuable species led to roading and harvest activities over much of the lower Entiat River area. Mud Creek (RM 11.7) was one of

the first tributaries to be developed for harvesting, and logging eventually spread into mid-elevation areas, especially for fire salvage purposes.

At the turn of the twentieth century, logging began to increase in response to home construction and the apple box industry. Other mills were built near the mouth of the river and in some of the lower river tributaries, including: Mills Canyon, Crum Canyon, and Muddy Creek (Mud Creek). Small portable mills were also located within the valley. Prior to significant road construction, logs were transported to mill sites using horses as well as the river.



Figure 3-2. Entiat valley-bottom log holding area associated with the Kellogg Mill (background) near the mouth of Mills Canyon, 1914.

*photograph courtesy of the Washington State Historical Society, Curtis Collection, #30017.

Because downriver log drives relied on higher streamflows and a passable channel way, the Entiat River was impounded at varying levels and lengths of time between the late 1880s and the first half of the 1900s. A large holding dam associated with the Harris-Cannon sawmill was constructed near the mouth of the river in 1898 (see Figure 3-3 on page 3-5). A log-holding dam built in association with a sawmill constructed in Mills Canyon created a barrier that prevented log transport to the mill downstream near the river mouth. The controversy that ensued resulted in litigation and preemption rights of navigation

designation for a portion of the mainstem Entiat River. In 1904 Gray built an electric power plant at the site of the dam; the plant experienced winter closure due to low water levels from 1905-1906. In 1909 C.A. Harris constructed a dam and power plant about 1.5 miles up the river, near the present day Keystone Bridge. In some years only a little water remained in the channel below the Harris dam. In 1932 the Harris mill moved from Mud Creek to the mouth of the Mad River at Ardenvoir (RM 10.5) and some remnants of the 13.5 foot high log storage dam constructed to serve the mill are still evident just upstream of Cooper's store (see [Figure 3-5](#) on page 3-6).



Figure 3-3. Log holding dam constructed at the mouth of the Entiat River, 1898. The Entiat community later removed it to restore fish passage into the Entiat River.

Most of the road network that exists within the Entiat WRIA today was constructed by 1980 for access to timber sales. Jammer logging, a yarding system involving the construction of closely spaced contour roads within harvest units, was common and required the most extensive roading. Harvest techniques progressed over time from horse, to tractor, to current cable and helicopter methods that enable access to more difficult, steep ground. Timber harvest reached its peak in the valley just after the 1970 Entiat Fires; between 1972 and 1977 almost 50 million board feet of fire salvage timber was sold from National Forest lands. Logs were milled locally and also shipped out of valley to other mills.

Logging and milling were an important part of the local economy until 1979 when the last operating sawmill in the valley (Ardenvoir Mill) closed. The Big Toys mill, located in the town of Entiat, opened in the early 1980's and is the only local timber-manufacturing mill still active today. Logging still occurs to some extent today, with notable "booms" due to timber salvage from the 1988 Dinkelman (58 million board feet) and the 1994 Tyee wildfires.

The Entiat valley has been shaped in large part by a long history of natural disturbance events such as wildfire, flooding, earthquakes, landslides, glaciation, and volcanic eruptions. Wildfire and flooding are very common events in the subbasin, as evidenced by the past 50 years: wildfires in 1970, 1976, 1988, and in 1994 have affected over 60% of the subbasin. The flood of record occurred in 1948 (approximately 10,800 cfs). Other significant floods occurred in 1972, twice in 1977, and in 1989 following wildfire events. See section 3.3.8 for more wildfire information.



Figure 3-4. View of the 1948 flood, at the Fish Hatchery near RM 7.



Figure 3-5. Remnant of the Ardenvoir Mill dam, washed out by the 1948 flood.

U.S. Bureau of Fisheries surveys in 1934, 1935 and 1936 noted that three dams still remained on the Entiat River (Bryant and Parkhurst 1950). Of the three the last to remain was the Ardenvoir Mill dam, which was washed out in the 1948 flood and never rebuilt (see Figures 3-4 and 3-5).

Fruit production has always been and still is very important to the local economy. The first orchard irrigation ditch, built in 1887, was the Hanan-Detwiler ditch. In 1888 a small peach orchard was planted near the mouth of the river. The site had as its irrigation source a ditch used prior to that time for placer mining. Orchard growing conditions in the lower valley were favorable. By 1889-90 almost every homesteader had fruit trees for subsistence. The Entiat Improvement Co. Ranch constructed a ditch in 1894 that ran from four miles upriver downstream to the mouth and Ribbon Cliff. The Knapp-Wham ditch was filed for in 1903 and was furnishing water to three and one-half miles of land on the south side of the Entiat River between Roaring Creek and Keystone Canyon by 1905. The first tree fruit nursery in the State had been established in 1865, and by 1900 the resulting nurseries on the west side of the Cascades were used as a source for tree stock in the area. In 1906 fruit trees were made available locally, and by 1912-1913 about 40,000 fruit trees had been planted in the lower Entiat valley. The Knapp-Wham and Hanan-Detwiler partnership ditches, along with several smaller ditches for orchard and/or hay and pasture irrigation, still exist today.



Figure 3-6. Keystone orchard, 1914.

*photograph courtesy of the Washington State Historical Society, Curtis Collection, #30014.

Valley residents and others have enjoyed hunting and fishing in the Entiat valley for many years. Hunting mule deer and fishing for local trout were important recreational and subsistence activities for local residents. They feel that deer numbers may be higher now than in the past, and remember a significant winterkill in 1943. Senior lifelong residents recall that when they were younger it was relatively easy to catch a 20 fish limit, and that there were at least two bull trout in the limit. They feel that this fishery has declined significantly since in the 1940's. Current residents do not recall significant salmon runs but have heard stories from earlier residents of significant steelhead spawning activity in the Mad River. Early Bureau of Fisheries surveys of the Entiat River from the 1930s showed that it was virtually devoid of salmon (Bryant and Parkhurst 1950).

Table 3-1 beginning on page 3-10 provides a historical overview of events that have occurred in the Entiat valley since the late 1800s.



Figure 3-7. Old town of Entiat, circa 1900.

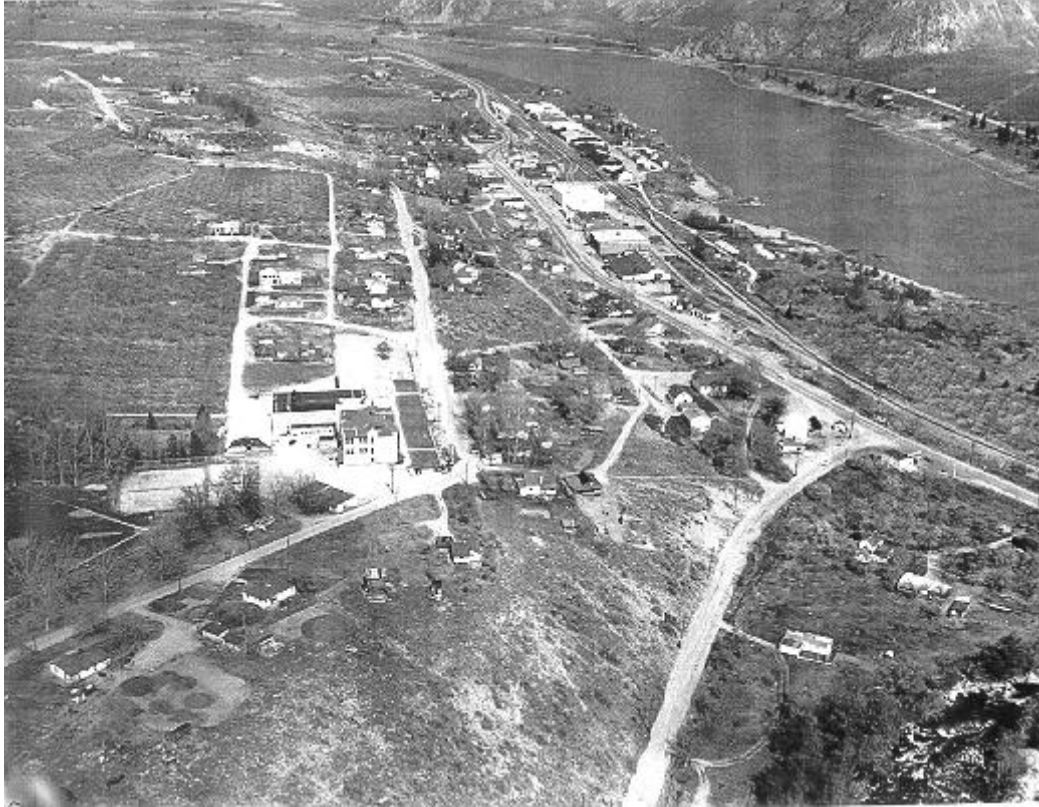


Figure 3-8. City of Entiat circa 1950, pre-Rocky Reach dam construction.



Figure 3-9. City of Entiat in 1999, post-Rocky Reach dam construction.

* Photographs of the City of Entiat (ca. 1900, 1950, 1999) courtesy of Phyllis Griffith.

Table 3-1. Entiat valley history.

DATE	EVENT	REFERENCE INDEX NO.
Dec. 14, 1872	Ribbon Cliff Earthquake.	1
1888	-Fire - Mad River Gorge to Blue Creek Meadows.	2
1890	-Overuse of forage by sheep grazing. USDA photos of upper Entiat region show 13,000 sheep grazing. There are reports of eight bands of 2,000 sheep grazing in the Mad River and Entiat range areas.	4 & 16
1892	-C.A. Harris sawmill (Grays Mill) located below the present day Numeral Mountain at the mouth of the Entiat River. Logs were harvested upriver, along the riverbanks and driven down the Entiat River during high water. -C.A. Harris plants orchard two miles above mouth of Entiat River.	5 & 16 21
1894	-Major flood. -Grazing reports - 1,000 cattle and 400 horses graze year round, between the town of Entiat and Stormy Creek. In the head of Entiat Valley 13,000 sheep graze, and in the foothills there were 150 hogs. -Irrigation ditch constructed for the 600-acre Entiat Improvement Co. Ranch. The intake was located above the present-day Naumes Orchard, four miles up the Entiat River, extending to the mouth of the River and toward Ribbon Cliff. Cattle ranged as far as Potato Creek. Corrals for summer grazing were located at Mud Creek. -The dam and bridge at C.A. Harris Mill washed out by flooding.	7 4 & 8
Oct. 27, 1894	-A.L. Rogers of Waterville files water rights on behalf of Entiat Improvement Company.	22
1898	-A dam/sawmill constructed one mile from the mouth of the Entiat River. -Reports show significant salmon and steelhead runs prior to 1898.	7 2
1902	-Upwards of 60,000 sheep graze in the head of Mad River.	16
1904	-Gray constructs electric power plant at the mouth of the Entiat River. -Construction of Knapp sawmill at Mills Canyon. Logs were harvested up valley. Mills Canyon originally named Gray's Canyon and then Knapp Canyon. -The last (sizable) Chinook salmon run on the Entiat River. -Entiat Ranger District experiences heavy fire season.	8 3 & 8 2 25
1905 & 1906	-Gray's power plant experiences winter closures due to low water levels.	3
1906	-Shift from cattle to apples hits the Valley. Orchard tracts begin to appear.	3
1908	-Sheep grazing allotments in Mad Lake area; included approximately 18,000 sheep. -Forest Service Supervisor, A.H. Sylvester, states at least ten-year period of overgrazing has occurred in Baldy Mountain and Snowbrushy Creek areas.	4 4
1909	-C.A. Harris's 2,000 horsepower electric plant constructed at present day Keystone Bridge 1 ½ miles up the Entiat River. Puget Sound Power eventually buys plant and shuts it down in the 1950's. Power provided from Wenatchee.	3 & 8
July 31, 1910	-Signal/Tyee Peak Fire - 2,560 acres.	2
1912	-Forest Service records show two permittees for sheep grazing; about 7,300 sheep for a four-month season. H. Harder grazed Entiat Summit to the Mad Lake. George Hendricks grazed North Fork and upper Entiat. Both permittees operated until 1940 and 1950. -Kellogg Lumber Mill located three miles up the Entiat River operates until 1918. The River is dammed and logs are floated from up-valley logging areas.	4 5

DATE	EVENT	REFERENCE INDEX NO.
1913	-First recorded timber sale located in the South Fork of Mud Creek.	9
Jun 13, 1913	-The Entiat Times reported that "250,000 trout from the Spokane fish hatchery were deposited in the Entiat River last month."	17
1914	-Coleman Mill located at Crum Canyon.	14
Aug. 31, 1914	-Burns Creek Fire - 600 acres.	2
1915	-Gordon Mill located up Johnson Creek - operated until 1940's.	8
Jan. 1, 1915	-Severe winter 1915/1916.	1
	-Extreme conditions cause starvation of wildlife.	8 (photo)
Jan. 29, 1915	-Entiat River planted with 310,000 trout from a Seattle hatchery.	17
1916	-Mott Mill located at Mud Creek and later purchased by C.A. Harris.	8
	-Cannon logging camp located at mouth of Tyee Creek. Operated through 1918, and utilized horse skidding and chutes.	8
1917	-Period of drought through 1932.	18
	-Harris circular sawmill located at Mills Canyon; operated through 1919. Logs harvested from Mills Canyon and processed at 15 MBF per day.	5
1919	-Harris Mill moved from Mills Canyon location due to depletion of logs. New location three miles up Mud Creek. Mill operated as a box factory until 1932, when it moved to Mad River location.	5 & 11
April 8, 1921	-Entire town of Entiat burns.	1
1922	-Harris Mill at Mud Creek becomes a single-band mill with a 40 MBF per day capacity. Logging performed in the winter on snow. Logs decked to run in the summer.	5
Aug. 15, 1924	-Summer rainstorm causes extensive flooding in Goman, Byrd and Ribbon Cliff Canyons. Electrical storm preceding heavy rains, responsible for largest number of forest fires ever reported (to date) on the Entiat District.	17
1925	-Large Fires * Mad River Fire (between Windy and Young Creeks) - 1,500+ acres * Spectacle Butte Fire - 600 acres * Borealis Ridge Fire - 500 acres	12 & 24
	-Fires in the 300-acre range, included: * Three Creeks * Lake Creek * Brennegan Creek * Gray Canyon * Mud Creek	12&24
	-Horse logging continued, but transportation to the Mill was by Mac trucks with hard rubber tires. Logging began to change with Road construction, new equipment and transportation methods.	5
1926	-Potato Creek Allotment. Area included Potato and Stormy Creeks. One permit issued for 65 cattle and 6 horses.	4
1928	-Harris Mill purchased first shovel loader.	5
	-Forest Service land acquisition in T24, 26 and 27N, R20E, which expands range in Mud Creek and Moe and Crum Canyons.	4
Aug. 28, 1928	-Coal Oil Fire - 600+ acres, caused from coal oiling irrigation canal.	17
1929	-Extreme fire season.	1
Aug. 1, 1929	-Upper Entiat River planted with 160,000 rainbow trout.	17
1930	-Construction of fire lookouts begins.	2
	-Entiat River survey shows the river is virtually devoid of salmon.	
1932	-Harris Mill at Mud Creek moved to mouth of Mad River (Ardenvoir) due to low water caused by the drought period. The Mill is steam-powered with a capacity of 60 MBF per day.	5
1935	-By this year, three dams on the Entiat R. and 19 irrigation diversions still exist.	5

DATE	EVENT	REFERENCE INDEX NO.
1939	-Harris Company entered into voluntary cooperative sustained-yield agreement, which reduced ponderosa pine harvest while increasing minor species.	5
	-New inventions bring about discontinuation of horse skidding.	5
1940	-Truckloads of salmon planted into the Entiat River for four consecutive years at several locations in Still Water Meadows vicinity.	8
1941	-Larch Lake Fire - 400 acres.	16
	-Introduction of contract loggers.	5
	-National Fish Hatchery fish culture began.	
1946	-Flood Control Act.	
1948	-Harris Mill at Ardenvoir began conversion from box shooks to commercial lumber.	5
June 8, 1948	-Worst flood in Entiat valley history (10,800 cfs); major regional flooding. Extensive damage from Ardenvoir to mouth of river, which was caused by a spring rainstorm. Several bridges were lost or damaged.	1
	-Army Corps of Engineers begins flood rehabilitation, including channelization of the lower river.	30, 34
	-Logging of cottonwood begins in the Stillwater area and continued until 1950. Logs were hauled to the railhead in Entiat.	
1950	-Winter '49-'50 coldest/heaviest snowfall on record for 61 years. Coldest recorded day in history (2/1/50 at 24 degrees F below zero). Eastern Washington paralyzed during 1/13/50 blizzard	10, 32
1953	-Harris mill installed horizontal resaw, which increased production capacity to 70 MBF per day.	5
1955	-Harris Mill increased to year-round production, processing more timber per employee than any other mill in the area.	5
1956	-In 1956-57, Mud Creek area is relogged. Trees too small by 1917 standards were cut under U.S. Forest Service marking rules.	5
July 13, 1956	-Unusually heavy snowfall in higher elevations in Cascades in early part of year; high flood threat relieved by gradual spring melt	31
	-Flash flood covers Highway 97 with up to four feet of mud, water and debris.	1
Sept. 1957	-USGS establishes continuous recording stream gage on the Entiat near Ardenvoir (Gage #12452800; near Stormy Creek).	26
1958	-No. 1 hottest recorded year.	10
	-Potato Creek erosion control project covered 110-acre area. It resulted from the impacts of logging and grazing.	2 & 11
Aug. 26, 1958	-Entiat Fire 12,000 acres. Lightning caused.	1 & 12
October 1958	-USGS removes old stream gage on the Entiat River near Entiat (RM 0.5) (Gage #12453000; located 0.25 miles above mouth of the River).	26
1960	-Potato Creek Allotment permit - 219 cattle AUM. Intensive three-year development study initiated.	4
June 29, 1961	-Tenas George Fire - 3,750 acres. Equipment caused.	12 & 23
Nov. 11, 1961	-Rocky Reach Dam commences commercial operation.	1
1962	-Forest Mountain Fire - 520 acres. Lightning caused.	12 & 23
1964	-Potato Creek Allotment improvements include six stock ponds and 25 springs. Study shows that the Allotment could support 159 AUM for a 4.5-month season.	4
	-First steelhead planting in the Entiat River.	2
Aug. 26, 1966	-Hornet Creek Fire #143 - 1,520 acres. Lightning caused.	12 & 23
Aug. 5, 1968	-Harris Mill Fire #065 - 1,210 acres. Started at mill site and moved to private, National Forest, BLM and county lands.	12 & 23

DATE	EVENT	REFERENCE INDEX NO.
1970	-Department of Game permitted cattle to graze in Mud Creek (Stepping C Ranch). Lands sold to City of Seattle in 1974. Through a tripartite exchange, lands became National Forest in 1995.	4
July 7, 1970	-Mills Canyon fire - 933 acres, human caused.	12 & 23
Aug. 23, 1970	-Lightning storms cause major fires covering over 122,000 acres on Entiat and Chelan Districts. * Gold Ridge Fire - 16,100 acres. * Entiat/Slide Ridge Fire - 49,200 acres -Fires involve 25 percent of the Entiat watershed.	1 2
1971	-One of three highest recorded April snowpacks in Entiat (73" at Pope Ridge; 180" at Fox Camp; also see '72 and '74) -Agreement between Department of Game, Entiat Valley Stockman's Association and Forest Service curtails grazing in Johnson Creek, Oklahoma Gulch and Entiat Breaks.	33 4
April 1971	-Corps of Engineers removes ten miles of river debris.	2
Nov. 18, 1971	-First helicopter fire salvage sale contract on Wenatchee National Forest and first in Washington State history.	1
1972	-Preston Creek slide area debris removal. -Entiat River channel altered below Fox Creek to protect road. -Pack River purchases Harris' Ardenvoir Mill. -Ardenvoir Mill begins to rely on logs from outside the Entiat basin to continue production levels. -One of three highest recorded April snowpacks in Entiat (55" at Pope Ridge; 182" at Fox Camp; also see '71 & '74)	2 11 5 33
Jan. 16, 1972	-River ice jams blasted in Entiat River. Entiat River freezes from the bottom upward (termed "anchor ice").	2
March 1972	-Record high temps with 150 percent normal snowpack, which increased flow rates; McCrea Creek slope failure and debris-dam break flood.	2
June 1972	-Record 1971-1972 snowpack combined with heavy rainfall results in severe flooding and streambank erosion (325 acres of agricultural land is damaged by floodwaters).	2
June 10, 1972	-Preston Creek slides and floods; four people killed; mud and debris avalanches also occur in Brennegan, McCrea & Fox Creeks.	1 & 2
1973	-Drought forces cattle off federal rangelands early.	1
Aug. 23, 1973	-Northwest experiences worst drought in history.	1
1974	-One of three highest recorded April snowpacks in Entiat (74" at Pope Ridge; 182" at Fox Camp; also see '71 & '72)	33
Jan. 15, 1974	-Entiat River rises 1.5 feet as a result of three inches of rain in three days.	1
Spring 1974	-Above-average spring runoff causes severe bank erosion over entire basin.	
Dec. 12, 1975	-Ardenvoir Mill Fire, 150 mill workers affected.	1
1976	-Ardenvoir Mill rebuilt.	11
July 24, 1976	-Crum Canyon Fire #050 - 9,000 acres.	12
Oct. 24, 1976	-Entiat River planted with 570,000 salmon eggs. -Construction of spawning channel below Fox Creek.	1 1
June 13, 1977	-First Crum Canyon flood with runoff estimated at 5,050 cfs in Crum Canyon; 1,260 cfs in Ringstead Canyon.	1
July 25, 1977	-Second Crum Canyon flood with nearly same runoff	1
1979	-Ardenvoir Mill closes.	11
1983	-No. 1 wettest recorded year (from 1952). -Establishment of the 11,600 acre Mosquito Ridge Sheep Allotment.	10 6

DATE	EVENT	REFERENCE INDEX NO.
1984	-Permit for 2,000 to 2,500 sheep on Mosquito Ridge Sheep Allotment from May 15 through August 31.	4
1987	-No. 1 record year of consecutive days without precipitation - a total of 103 days (July 20 through October 30, 1987).	10
Sept. 4, 1988	-Dinkelman Fire - 53,000 acres. Human-caused fire.	1 & 12
1989	-Salvage logging operations allowed for only five percent ground disturbance, logging by helicopter, cable, or tractor on snow.	1 & 15
Jan. 17, 1989	-Hurricane-force winds cause massive blowdown in Lake Creek basin, and Young, Billy and Cougar Creeks.	1
July 1989	-Roaring Creek flood.	1
Aug. 19, 1989	-Dinkelman flood; Thousands of small chinook salmon and 10,000-50,000 non-game fish perish as a result.	1
July 24, 1990	-Dick Mesa Fire #110 - 1,151 acres. Lightning caused.	12
Jan. 10, 1991	-Ice dam in Entiat blasted. Largest build-up in 50 years.	1
May 1993	-City of Seattle & USFS close riparian pastures in Mud & Potato Creeks.	6
12/24/1993	-Lowest mean daily flow for the 43-day period of record at the Entiat near Ardenvoir gage -- 22 cfs (25 cfs 12/17/64; 27 cfs 2/16/93; 32 cfs 12/12/01)	26
1994	-City of Seattle closes Mud Creek lands to range due to overuse.	6
June 1994	-USFWS found bull trout populations in the Columbia River Population Segment (including Entiat System) to be warranted for listing as a threatened species.	27
	-Tye Fire Complex #047 - 140,196 acres. Lightning caused. Total Entiat District acres 85,968; accounts for 61% of fire area.	12
	-Fire involved 33% of Entiat watershed.	12
Oct. 1994	-No. 1 wettest recorded month.	10
Nov. 1994	-Tye Fire salvage begins on private lands (most fire salvage activity on private lands completed by November 1996).	17
	-State Department of Fish and Wildlife implements winter deer feeding (continued winters of 95-96 & 96-97; discontinued winter 97-98).	28
Aug. 1995	-Tye Fire salvage begins on National Forest System Lands	27
Sept. 1995	-Tye Fire Burned Area Emergency Rehabilitation work substantially completed; approximately \$15,000,000 spent on revegetation and road/channel/slope stabilization work by several federal agencies.	20
Nov. 1995	-City of Seattle-USFS land trade; City holdings in Entiat area traded for USFS lands in Cedar River watershed.	
March 1996	-New stream gage installed on the Entiat River near Entiat (Gage #12452990; located at Keystone Bridge, at RM 1.5).	26
May 1996	-Reforestation work on Tye Fire area continues with completion of 6,500 acres of tree planting in the spring of 1997 (5,000 acres in 1996; 1,800 acres in 1995).	27
June 17, 1996	-Oklahoma Gulch debris torrent/flood initiated by severe thunderstorm.	27
Aug.-Oct. 1996	-Three streambank restoration/fish habitat enhancement demonstration projects completed on the Entiat upstream of the Potato Creek moraine through cooperative effort of landowners, conservation groups and State/Federal agencies.	17
Apr. 1, 1997	-Snowpack well above average in the Entiat at 223% of normal; March precipitation was 225% of normal.	29
Aug. 26, 1997	-Potato Creek/Stormy Creek debris torrent/flood initiated by severe thunderstorm.	27

DATE	EVENT	REFERENCE INDEX NO.
Oct. 1997	-Approximately 12,145 acres of salvage logging have been completed on National Forest lands to date since 8/95; 14,560 acres were included in 10 salvage sales sold; completion anticipated in 1998 field season.	27
Oct. 17, 1997	-Upper Columbia Steelhead were listed as a proposed Endangered Species by NMFS.	27
Nov. 1997	-Forest Service completes another group of watershed restoration projects targeted as road rehabilitation, a continuation of emphasis on road system rehabilitation started in 1992.	27
Dec. 1997	-Local deer population very low due to a combination of adverse conditions.	28
Aug. 1998	-Entiat CRM group receives first installment of grant funding for development of a watershed plan under the Washington State Watershed Planning Act	
1999	-First year for Entiat River longitudinal temperature monitoring network	35
March 2000	-Entiat WRIA Planning Unit sponsors 3-day regional workshop on Instream Flow analysis using the Instream Flow Incremental Methodology (IFIM)	38
Apr.-May 2000	-Salmon Recovery Funding Board Chairman and State Ag-Fish-Water Committee tour the Entiat	38
Apr. 19, 2000	-Entiat WRIA Planning Unit formally adopts a robust application of IFIM as the approach to address Instream Flow issues for watershed planning	38
Sept. 20, 2000	-Entiat WRIA Planning Unit formally adopts EDT as the habitat analysis technique for watershed planning and received assistance from the Yakama Nation and Colville Tribes.	39
Dec. 2000	-An earthquake registering 3.3 on the Richter Scale hits the Entiat area. Source is likely the active fault that lies between the Entiat and Lake Chelan	
2001	-Low flow year – regional drought conditions. Lowest total water yield for the 43 year period of record at the Entiat near Ardenvoir gage (116,200 acre-feet). Seven day low flow for 2001 WY at this gage was 44 cfs (32 cfs in 1994 & 36 cfs in 1974 and 1993 – need to move 7-day lows for 1994, 1974, and 1993 to those years).	26
June 2001	-Entiat WRIA Planning Unit holds first “Resource Roundup” Open House to advertise EWPU and related activities	38
Aug. 2001	-BLM installs demo LWD habitat structures at RMs 10.3 and 15	36
Sept. 2001	-CCCD/NRCS installs 3 demo habitat rock cross vanes between RMs 3-4	37
	-ENTRIX, Inc. selected to develop Instream Flow Work Plan for IFIM	
Nov 2001	-Tommy Creek Fire burns 640 acres in the Entiat valley. -EWPU submits formal statement to WDOE that it will develop instream flows -EWPU becomes a partner in the Institute for Rural Innovation and Stewardship (IRIS)	38
Jan. 2002	-Entiat Watershed Project Co-coordinator hired	
April 2002	-Well monitoring initiated with volunteer landowner participants -“Working” Final Instream Flow Work Plan Completed -New USGS continuous recording gage (#12452890) installed at mouth of Mad River. -EWPU members present at Trans Boundary Watershed Conference in Spokane, WA	38 38
May 2002	-Real-time data from Keystone USGS gage made available online	38
June 2002	-CWU/EWPU Entiat land use and riparian vegetation community inventory begins	38
July 2002	-Final CRMP/First Draft WRIA 46 Management Plan released for comment -EDT Alternatives approved for first treatment model run -IFIM field work begins -CCCD Water Resources specialist hired	 38

DATE	EVENT	REFERENCE INDEX NO.
Aug 2002	-Water Quality assessment and Stream Network Temperature Modeling (SNTMP) begins	38
Sept-Oct 2002	- WDOE-SHU / CCCD staff install 8 continuous recording gages, 6 staff gages, and 3 bank operated cableways in the Entiat subbasin	
	-Land Use/Riparian inventory completed and presented to Planning Unit	38
Nov 2002	-EWPU receives National Rural Community Assistance funds and "Spirit Award"	
	-LSC members participate on panel at Governor's Water Resources/Implementation conference in Olympia, WA.	38
Dec 2002	-Comment period on First Draft WRIA plan ends	38
Feb 2003	-First of 6 facilitated Instream Flow meetings held	38
	-EWPU hosts evening community water balance meeting	
Jun 2003	-Water Quality analysis completed	38
Aug 2003	-Facilitated Instream Flow meetings end; 2 sets of instream flows and reserve developed	38
Sep 2003	-Field work done to check riparian vegetation planting recommendations, and identify additional potential planting sites.	38
Oct 2003	-Content approved for release of Internal review/EWPU draft WRIA 46 Plan	
	-SRFB Chair, William Ruckelshaus, UCSRB members and elected officials tour the Entiat valley	38
Jan 2004	-Final Review Draft WRIA 46 Plan content/recommendations approved. Plan released to public for comment	38
Mar 2004	-Landowner Steering Committee hosts community meeting on March 18 re: WRIA 46 Plan	38
April 2004	-70-day public comment period on Final Review Draft ends April 2, 2004	
	-EWPU approves final edits/additions to WRIA 46 Plan in preparation for Final Draft Plan presentation to County on May 21, 2004.	38
May 2004	-EWPU unanimously recommends that the priority date of proposed minimum instream flows be the date of rule adoption, and votes to submit the Plan to Chelan County for approval.	
	-Final Draft WRIA 46 Management Plan presented to County on May 21, 2004.	38

For specific detail related to all EWPU Decision Points made from 1999-2004 and a summary of public involvement and outreach activities, see Appendices D and E, respectively.

Reference index for Entiat valley history table:

1. *Wenatchee World Newspaper*
2. *Entiat Cooperative River Basin Survey*
3. *Entiat School publication*
4. *Grazing publications/Albert "Shorty" Long's notes*
5. *Soil Conservation publication (1958). January - February "Western Conservation Journal"*
6. *Entiat Ranger District - 2200 Grazing files*
7. *"Production and Habitat of Salmonids in mid-Columbia River Tributary Streams", USFWS*
8. *Albert Long, Entiat Valley historian*
9. *Entiat Ranger District timber atlas*
10. *NOAA Climate of Wenatchee, Washington, 1994 publication*
11. *Reflections, Images of our Past*, WVC publication
12. *Entiat District fire reports*
13. *Dinkelman Restoration Accomplishment Report*
14. *Power and sawmill literature*
15. *Entiat Ranger District fire occurrence map*
16. *Plummer Report*
17. *The Entiat Times (newspaper)*
18. *USDA Handbook - Climate Agricultural Atlas, 1941 Precipitation Almanac*
19. *A Historical Overview of the WNF, WA*
20. *WNF Supervisor's Office historical files*
21. *Thesis of Lois Morrell Harmon*
22. *A History of the Famous Wenatchee, Entiat, Chelan and Columbia Valleys*, by Lindsay Hull
23. *Land and Resource Management Plan Wenatchee National Forest (1990a)*
24. *Historical microfiche files*
25. *Wenatchee Republic Newspaper*
26. *USGS streamflow records*
27. *Entiat Ranger District files*
28. *Washington Department of Fish and Wildlife*
29. *Natural Resources Conservation Service (formally SCS) snow measurement data.*
30. *Personal contact with Conard Peterson 2001.*
31. *NOAA Annual Climatological Summary for 1956*
32. *Washington State Top Ten 20th Century Events (NOAA)*
33. *NRCS and USFS snow survey data*
34. *Historic Flood Restoration Records, US Army Corps of Engineers, Seattle*
35. *USDA Forest Service monitoring records*
36. *USDI-BLM, Joe Kelly, Project Coordinator*
37. *USDA-NRCS, Joe Lange, Project Coordinator*
38. *Entiat Watershed Planning Unit records*
39. *The Entiat Explorer (newspaper)*

3.2.2 Land Ownership

Ownership patterns in WRIA 46 result from public domain, railroad land grants, homestead and timber entries, and subsequent land sales and exchanges. The majority of privately owned land is located within one mile of the mainstem Entiat River in a band that extends 26 miles upriver to the National Forest boundary. The settlement pattern along the valley bottom is a result of accessibility and the agricultural suitability of the land. There are some privately held sections intermingled with National Forest lands outside of the valley bottom area in the eastern portion of the watershed. This checkerboard ownership pattern is a result of historic railroad land grants.

Ownership is predominantly public. Slightly less than nine percent of the land in the Entiat WRIA is in private ownership. The US Forest Service (USFS) manages approximately 83% of lands. Other notable federal land owners include the Bureau of Land Management (BLM) and the US Fish and Wildlife Service (USFWS). Almost all state lands are managed by either the Washington Department of Fish and Wildlife (WDFW) or the Washington Department of Natural Resources (WDNR). Table 3-2 and [Figure 3-10](#) on page 3-19 provide an overview and depiction of primary land ownership in WRIA 46.

Table 3-2. WRIA 46 Land Ownership Acreages.

Owner	Approximate Acreage+	Percentage of WRIA
Federal	258,477	84.6%
BLM	4424	
USFWS	798	
USFS	253,255	
State	17,467	5.7%
WDFW	7525	
WDNR	9930	
Other	12	
County/City/Local	361	0.1%
Chelan County	2	
City of Entiat	68	
City of Seattle	261	
Districts (Fire, Cemetery, Irrigation, School)	30	
Private	26,720	8.8%
NCW Museum	36	
Chelan-Douglas Land Trust	415	
Longview Fibre Company	9878	
Chelan County PUD	543	
Boat Club	32	
Other	15,816	
Columbia River*	2436	0.8%
TOTAL	305,641	100%

+ Acreages generated via GIS analysis of USFS ownership, Chelan County parcel, and WDOE WRIA shapefiles.

* The WRIA 46 boundary extends into and encompasses a portion of the Columbia River.

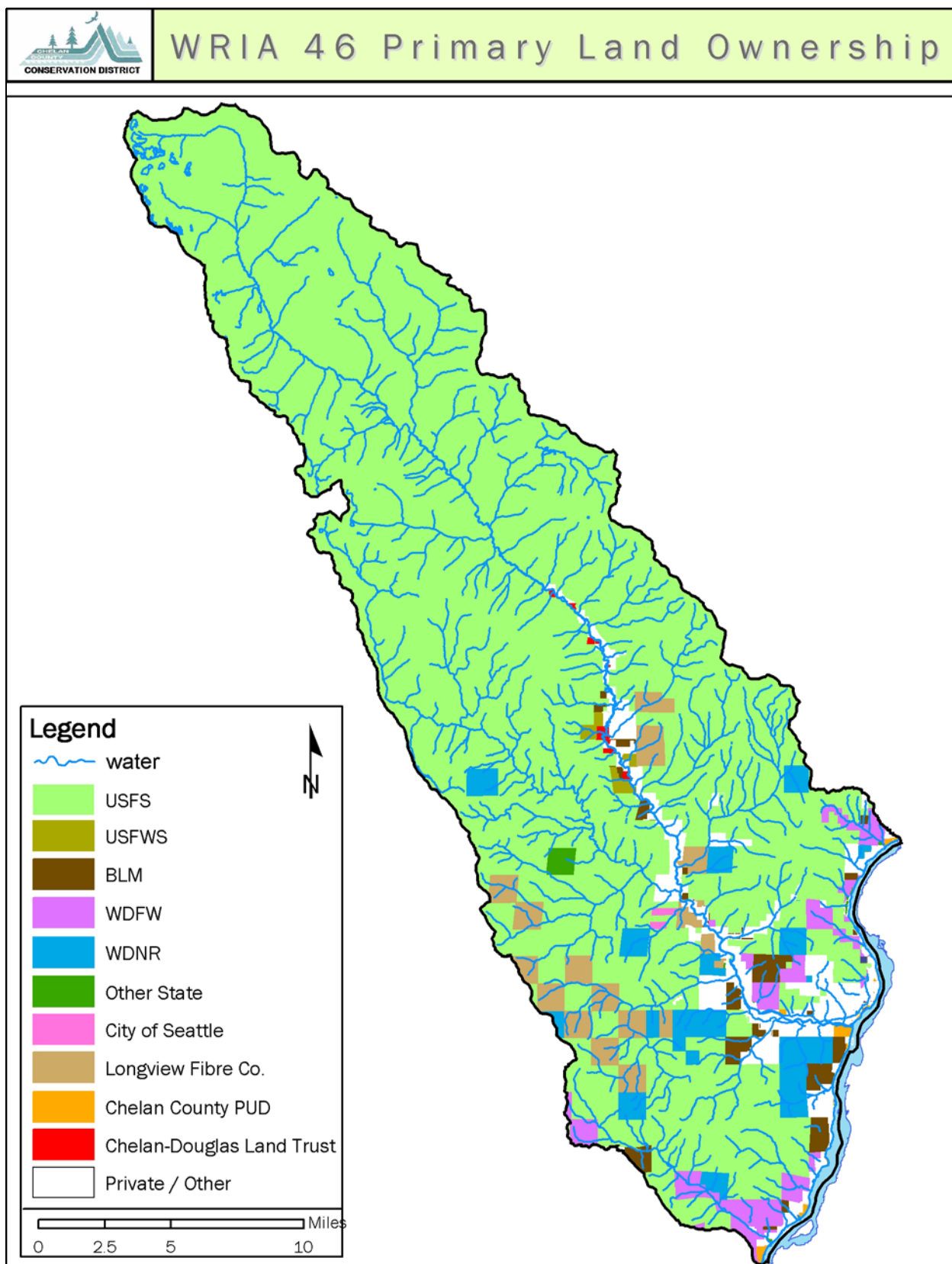


Figure 3-10. WRIA 46 primary land ownership in 2003.

3.2.3 Land Use

Current land uses within the Entiat WRIA include agriculture, primarily pear and apple orchards; livestock production and grazing; timber harvest; residential housing; and recreation. These uses have been discussed previously in a historical context; this section elaborates on the current situation.

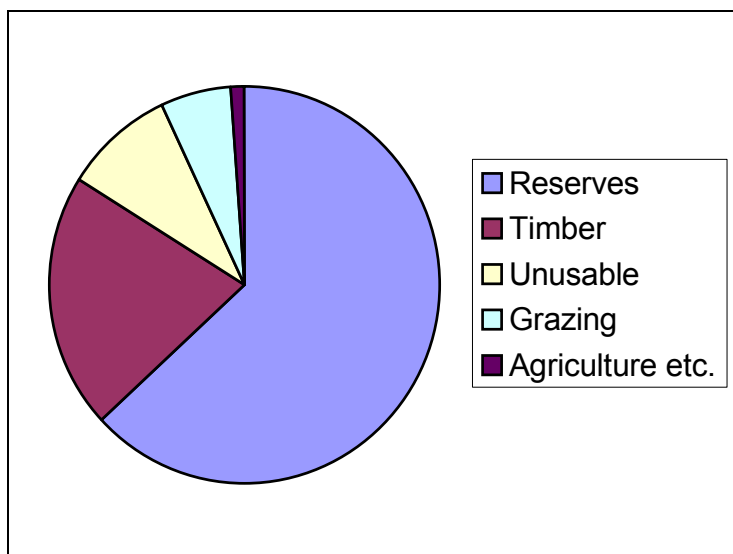


Figure 3-11. Entiat River watershed - approximate land use percentages.

Figure 3-11 shows the approximate apportionment of various land use areas within the Entiat subbasin. Wilderness, old growth reserves, wildlife and riparian reserves comprise about 63% of the USFS reserves land designation, which includes some areas in the lower valley that currently do not fall within the other land use categories. Federally designated reserve areas are primarily used by wildlife, but are not specifically designated for wildlife use. The unusable category is land intermingled with designated timber and/or grazing lands that is unsuitable for these uses due to topography or productivity, or is inaccessible for other reasons such as rock or cliff formations. Data show that irrigated agricultural lands comprise approximately 0.5% of the WRIA. It is estimated that agricultural lands, developed recreation areas (including trails), and residential areas, make up approximately 1% of the total land area.

Agriculture (Crops)

Pears and apples are the primary economic crop within the Entiat WRIA, although some cherry and grape production is also present. Orchards within the Entiat subbasin are primarily concentrated in a narrow band near or adjacent to the mainstem Entiat River, between its mouth and the Mud Creek confluence (RM 11.7). Few orchards exist upstream of this point, as distribution is largely dictated by climate/length of growing season. The orchards on the north side of the river/Entiat River Road, stretching for approximately 1.5 miles upstream from river mouth, are irrigated from the Entiat Irrigation District. This system originates at the Columbia River. The remaining orchards in the valley depend on either wells or the Entiat River and a few of its tributaries for irrigation water. With the exception of

the Naumes holdings, the orchards are owned and, in most cases, operated by local residents dependent on their profits as the primary source of family income.

The 1979 Entiat River Co-Operative River Basin Study reported 1,300 acres of irrigated orchard existed within the Entiat valley (USDA 1979). In 1996 the CCCD estimated³ that approximately 910 irrigated orchard acres of pears and apples existed in the Entiat watershed at that time, indicating that fruit production continued to be the single most important industry in the watershed. A more recent GIS assessment of irrigated orchard performed by Central Washington University (CWU) in 2002 and updated by the Planning Unit, identified approximately 1427 acres of orchard within WRIA 46 (Lillquist and Erickson 2002). It was estimated that 890 of these acres are irrigated by water drawn from within the Entiat subbasin, while the remaining 537 are irrigated by water drawn from areas in hydraulic continuity with the Columbia River, or pumped directly from it. The 2002 land use assessment also showed that at that time, approximately 111 acres of orchard that are located/draw water from within subbasin had been pulled (taken out of production) since 1992 (Lillquist and Erickson 2002).

The CCCD data from 1996 showed that, of the 33.8 miles (mouth to Entiat Falls) of the mainstem Entiat River that are capable of supporting anadromous fish, approximately 6.7 miles of the lower 11.4 miles between the mouth of the Entiat and Mud Creek had orchards adjacent to the river. Three and three quarters of the 6.7 miles lay along only one side of the river. Further, only 1.05 miles had orchard along both banks of the same reach. It was estimated that 25,300 linear feet of commercial orchard existed adjacent to the river in 1996, amounting to 7.1% of the total linear feet of habitat capable of supporting anadromous fish.

The Knapp-Wham and Hanan-Detwiler irrigation systems, along with smaller irrigation ditches and individual irrigators, utilize Entiat River flows. The Hanan-Detwiler system is largely an open ditch, while the Knapp-Wham was recently converted to a pipeline system. Both systems experience sediment build-up during high flows and flood events in the mainstem; however, this condition has improved over the years since the 1972 floods. Benefits realized from converting the Knapp-Wham system to pipeline include decreases in water loss and water temperature, fewer pathogens and less seed pick-up, eliminated need for ditch bank repairs, and protection of the system from side canyon washouts. Options for consolidation of the two major ditches, along with other water conveyance efficiency improvements in the subbasin, are currently being pursued by the Planning Unit

Fish screening measures have been greatly improved on both systems over the last several years (C. Petersen, per. comm. 1999). The photographs on the next page show the upgraded fish screen that was installed on the Hanan-Detwiler irrigation ditch intake in 1998 by the WDFW Yakima Screen Shop. Staff from the screen shop has worked with Entiat valley irrigators over the past several years to improve their systems. WDFW completed an inventory of irrigation structures in the Entiat valley in 1997, which determined there were six irrigation ditches and 45 irrigation pumps being used to irrigate approximately 1,100 acres (approximately 900 orchard and 200 hay and/or pasture). Of the six ditches, four

³ Aerial photos combined with ground truthing were used to estimate acreage.

were reported as adequately screened and two were not; 37 of the 45 pumps were adequately screened, with eight reported as inadequately screened. In total, 41 out of the 51 irrigation structures identified by WDFW in 1997 were reported as adequately screened.



Figure 3-12. General view Hanan-Detwiler fish screen, completed April 1998.



Figure 3-13. Close-up view Hanan-Detwiler fish screen.

In October 2003 the WDFW Yakima Screen Shop received funding from the Bonneville Power Administration (BPA) to perform an inventory and prioritization of fish passage and screening problems in the Entiat and Wenatchee subbasins; passage improvements to a side-channel associated with the Hanan-Detwiler irrigation ditch; and a comprehensive re-assessment, re-inventory and mitigation of pump screen sites in the Entiat that were identified by the 1997 inventory. The EWPU is also pursuing additional irrigation system and screening improvement assistance from the U.S. Bureau of Reclamation (USBR) to continue their work to address the screening and passage issues that have been identified within the subbasin.

Timber

As stated earlier, logging and milling were very important to the local economy from about 1900 through the mid-1980s. The harvest levels and types of logging activities seen in the Entiat watershed in the past are not likely to be duplicated again in the foreseeable future. Logging activities increased again briefly in the mid-to-late 1990s as a result of timber salvage operations on lands burned in the 1994 Tye Fire. Factors contributing to the overall decrease in logging activities include the effect wildfire has had on over 60% of the subbasin since 1970. Management strategies developed as part of the Wenatchee National Forest Land and Resource Management Plan, as amended by the Northwest Forest Plan (discussed in [Chapter 2](#)), also reduced allowable harvest acres.

Timber on Federal Lands

[Table 3-3](#) on page 3-24 shows the volume of timber sold from National Forest System lands on the Entiat RD over the past several decades, and the declining trend in harvest. Timber related activities on NFS lands in the Entiat WRIA during the next few decades will focus on reforestation of burned areas, underburning, and thinning overstocked unburned stands in order to bring the landscape back to a more natural condition, and to enhance other values such as old growth and riparian ecosystems. Forest Service officials estimate that they will treat between 1,500 to 2,000 acres annually for forest health purposes over the next decade. These practices may result in an average of approximately 500,000 board feet of timber a year being made available for sale over the next five years. For more information on National Forest System lands available for timber harvest, refer to Chapter 2. Most of the scattered BLM lands within the subbasin were burned over in the last few decades. The BLM sold approximately 1 million board feet of timber after the Tye fire, but has no immediate plans for timber sales in the near future.

Timber on State and Private Lands

Most of the State school lands administered by the Washington State Department of Natural Resources (WDNR) were affected by fire over the past few decades, and salvage timber has been harvested from WDNR lands. Currently, silvicultural practices on WDNR lands are primarily focused on the reforestation of burned areas. There are some scattered tracts of WDFW land within the watershed, but very few are forested lands that could be commercially harvested. Minor amounts of timber harvest may occur in order to reduce fuel loading after wildfires.

Some timber harvest could potentially occur on a few parcels of private land adjacent to the river and above Dill Creek that were not burned by wildfires in the past few decades;

however, most of these lands are being subdivided for homesites. Almost all land in the Entiat valley below Dill Creek has been involved in wildfires. Most of the private land in this area that is not long term agricultural land has either been logged in the past or salvage logged. Sections of Longview Fibre Company timberlands have also been logged in the past and/or salvaged logged after the wildfires. These private lands are interspersed throughout the WRIA, primarily in the southeast portion. Although Longview Fibre may currently conduct some logging on a few unburned areas in Stormy Creek and the Dinkelman fire areas, there is not expected to be very much timber harvest from these corporate lands within the next few decades.

Table 3-3. Volume of timber sold (in millions of board feet), Entiat Ranger District.

Time Period	Volume	Annual Average
1962 - 1970	196.5	24.56
1971	36.1*	-
1972 - 1977	49.5	8.25
1977 - 1983 +	-	-
1984 - 1989	64.5	10.75
1990	58.4*	-
1991	1.0	-
1992	3.4	-
1993	6.0	-
1994	3.0	-
1995	18.1*	-
1996	39.4*	-
1997	14.2*	-
1998	0.25	-
1999	0.20	-
2000	0.52	-
2001	1.03	-
2002	1.02	-
2003	.619	-

* Volumes reflect salvage from major fires in 1970, 1988 & 1994.

+ Sell volumes for 1977 through 1983 were not readily available.

Sell volumes for 1962 through 1977 taken from the Entiat Co-operative River Basin Study (USDA et al. 1979); volumes for 1984 through 1997 compiled by B. Modic (WNF); volumes for 1998-2001 provided by T. Graham (WNF); 2002 volumes provided by W. Armes, E. Stutzman (WNF).

Grazing on Federal Lands

Current livestock grazing on federal lands is confined to a few locations in the lower valley in tributaries to, but away from, the mainstem Entiat River. There is a sheep allotment in the Tillicum Creek - Gold Ridge area where a band of sheep (1,000 ewes with lambs) grazes each year. This allotment includes land in the Wenatchee River watershed, outside of the Entiat WRIA.

The Potato Creek allotment includes the largest area grazed by livestock within the Entiat watershed. Two permittees are able to graze cattle on several wildland pastures within this allotment. One permittee was allowed to graze 56 cows with calves on pastures in the Mud

Creek drainage. As a result of the 1994 Tyee fire the permittee was notified that cattle would not be allowed to utilize the burned area until certain vegetation and range readiness recovery criteria were met, and was thus granted a temporary 5-year permit on Dinkelman Ridge in 1996 (T. Graham, pers. comm. November 17, 2003). In 2001 the range readiness conditions were met; however, the grazing permit was turned back to the National Forest Service by the permittee and is currently vacant (T. Graham, pers. comm. November 17, 2003). A second permittee is allowed 48 head of cattle with calves in the Crum Canyon and the Bear Gulch/Roaring Ridge areas where he alternates years of use. The operations were/are managed under a modified rest-rotation system of grazing where season of use and/or rest is rotated among several pastures annually.

Grazing on Private Lands

In 1996 the CRMP group used aerial photography interpretation and ground truthing to determine that there were approximately 180 to 200 acres of irrigated private land used for hay production and/or pasture in the subbasin at that time. It was estimated from interviews with various individuals and a count of animals performed the second week of April 1996 (see [Appendix J](#)) that there were between 215 and 250 head of various classes of livestock that may have occupied private lands within the subbasin for at least part of the year.

The 1996 survey estimated that between 145 and 185 of these animals utilized the Entiat River valley bottom; a few other locations were noted as having very limited mainstem river "watering" access. The survey identified three locations where livestock had direct access to the river, which may have had the potential to affect water quality. The study determined there were 12-15 donkeys on about two acres near Saunders Canyon that had unlimited access to the river; between 40 and 60 cows on about five acres near Ringstead Canyon had river access, and a complex of fenced corrals associated with these cows was immediately adjacent to the main river. The 30-40 head of cattle brought onto the Tyee Ranch during the summer each year also had access to the river. Overall, the 1996 mapping showed that many of the pastures from Potato Creek to the river mouth were fenced along the riverfront; with fewer than 2000 feet of river in this 15.5 mile reach open to direct access by livestock.

Of the remaining livestock, 27 head of horses were "on and off" the watershed in the Dick Mesa area north of the river mouth and the town of Entiat. In 1997 there were 60+ head of horses in this area. Entiat tributary drainages with livestock included: Mills Canyon, 12 horses; Roaring Creek, 5 horses; Crum Canyon, 8 horses; and the Mud Creek area above the mouth, 5 horses.

Concern for water quality exists where livestock have direct access to the river (for more information on water quality, see [Chapter 8](#)). The planning group estimated that less than 2000 feet of riverbank was available to livestock from the Potato Creek confluence downstream to the mouth of the Entiat River. Many pastures in this 15.5 mile reach were, and still are, fenced along the river front. Only at two or three of the livestock locations identified in the 1996 study did there appear to be some stream bank stability and water quality implications as a result of private land use by livestock. Water sampling data collected at various locations in the subbasin have shown few fecal coliform excursions

above State standards; data indicated infrequent elevations in Mud and Potato Creeks. Thus, it appears that neither the limited direct access livestock had to the river in the past, nor current land use practices have notably affected water quality in the subbasin.

Recreation

The Entiat River and its tributaries, especially the Mad River, provide users with a wide range of recreation experiences, from developed campgrounds to undeveloped primitive campsites. An extensive road network that ranges from two-lane asphalt roads to single lane dirt trails provides access to recreation within the subbasin. Although a few of the scattered parcels of private lands have trails and roads passing through them, there is little developed recreation associated with private lands in the WRIA. As mentioned in the demography and economics section, the 2000 census reported just over one-third of the residences in the Entiat subbasin were part-time/vacation homes.

Forest Service Recreation Management

Developed Recreation

Most of the developed recreation in the Entiat subbasin is confined to areas along the Entiat River, except for the Pine Flats Campground, which is located along the Mad River. The Entiat RD provides recreational opportunities through 107 family-oriented campgrounds, with all but 11 being fee sites (full-service sites); two observation points; two summer home tracts; and two group reservation sites. Currently, the condition of the Entiat RD's recreation facilities ranges from good to poor.

Over the past decade, recreation on the Entiat RD has increased steadily, with most weekends running over 100 percent capacity and weekday use during July and August at 50 to 60%. The Silver Falls complex is the most popular recreation site, receiving approximately 27,000 campers annually. The National Recreation barrier-free trail at this site receives an additional 6,000 visitors annually.



Figure 3-14 Silver Falls Forest Service campground at Entiat RM 31.

The recreation use level for all National Forest developed campsites in the Entiat valley in 2001 was 80,000 visitor days (T. Graham, pers. comm. 2002). This use estimate was based on campground receipts only and did not include dispersed recreation activities like trail use, fishing, sight seeing, etc.

Recreation Trails

The Entiat RD provides the trail traveler with a wide range of recreation experiences. The District presently manages 292 miles of forest single-track trails. This system is divided into three different management areas: Wilderness Trail System (65 miles), Non-Motorized Trail System (35 miles), and Multiple-Use Trail System (184 miles). There are also 6.5 miles of hiker only trails.

Wilderness trails are closed to all mechanized modes of travel. The main access route into this trail system is from the Entiat River trailhead at Cottonwood via trail #1400. Prior to the Washington Wilderness Act a portion of this trail, from the trailhead to the old wilderness boundary, was unrestricted to motorized vehicle travel.

The Non-motorized Trail System lies primarily near the North Fork of the Entiat River. Prior to the implementation of the 1990 Land and Resource Management Plan, the system was managed as unrestricted, with vehicle travel allowed.

The Multiple-Use Trail System managed by the Entiat RD represents the hub of one of the largest and most unique systems of interconnecting trail networks in the Northwest, consisting of over 235 miles of trails, 184 of which are on the Entiat. This system is primarily used by the motorized recreationists, but is also enjoyed by hundreds of mountain bikers, equestrians, hikers and the occasional llama/goat packer. More than 50% of the use that occurs on the District's Multiple-Use Trail System originates in western Washington. The Upper Mad River area is the most popular destination within this system. The gentle topography of this area and trails with limited exposure to danger make this an attractive family recreation area.

Dispersed Recreation

Currently, the Entiat Ranger District has an estimated 250 dispersed camps scattered throughout the WRIA, 200 of which have been mapped. Extensive impact surveys have been completed for camps in the wilderness. These dispersed areas provide opportunities that are very different from those found in more developed locations. Most camps throughout the District are concentrated around water sources.

Winter Recreation Activities

Winter recreation in the WRIA consists mainly of snowmobiling, with some cross-country skiing. Snowmobiling is one of the Entiat RD's fastest growing recreational activities. Popular groomed routes include Eagle Creek along Entiat Ridge to Sugarloaf Lookout, and from 25 Mile Creek over Shady Pass and down to the Sno-Park located 1/2 mile above the forest boundary sign along the Entiat River Road. Since 1997 additional grooming has occurred on routes near Sugarloaf, Tillicum, Moe Ridge, Gold Ridge and Roaring Ridge. Use varies from area to area, with the highest-use areas occurring along the Entiat Ridge (groomed) and Tyee ridge (ungroomed).

Other Recreation Activities

Other popular activities in WRIA 46 include hunting, fishing, and sightseeing from forest roads and trails. Roads, which were primarily constructed for logging, now serve a variety of purposes including administrative access, public access, logging, and fire control activities.

Wild, Scenic and Recreational Rivers

The USFS, in the Land and Resource Management Plan for the Wenatchee National Forest (USFS WNF 1990a), identified portions of the Entiat River as candidates for potential designation by Congress as part of the National Wild, Scenic and Recreational Rivers system. The Entiat has been determined to exhibit outstandingly remarkable scenic resource values, which makes it eligible for designation. Designation is intended to preserve and protect scenery, recreation, geologic, fish, wildlife, and historical, cultural and ecological resource values within the river corridor. Recreation activities including water sports, viewing scenery, and camping would be enhanced through this designation. River sections proposed for designation include:

- from the headwaters to the Glacier Peak Wilderness boundary (12.5 miles) – wild classification;
- from the Glacier Peak Wilderness boundary to the Cottonwood trailhead (4.0 miles) – scenic classification; and
- from the Cottonwood trailhead to above the confluence with Burns Creek (15.0 miles) – recreational classification.

3.2.4 Demography and Economics

Residential Housing and Population Trends

Past housing development was primarily associated with historic settlement and tied to the growth of the logging/sawmill and orchard industries. Although there were many homesteads and timber claims in the lower tributaries and the mid-Entiat River area, most of these became uneconomical. Landowners often worked elsewhere in or outside of the valley. Some landowners later used the residences associated with their homesteads, although often they were sold to adjacent owners and/or abandoned.

The Chelan-Douglas Health District started tracking septic system installations in the mid 1950s, and all systems approved for installation since 1983 meet system standards. According to the Health District, systems that were installed prior to 1983 are generally in good condition and most early residences were located away from the river and floodplain, thus helping to protect water quality. Only a few of the older systems may not meet today's standards; however, many of these have been and continue to be upgraded to meet septic system standards. Furthermore, valley residents have had a good record of compliance with upgrade requirements.

The Chelan-Douglas Health District reported in 1998 that there were over 300 septic systems in the Entiat valley, over one-half of which were installed between 1993 and 1998. Accordingly, the WRIA has experienced a fairly recent surge in urban population growth and rural part-time/vacation home construction. US Census data showed that the population within the city limits of Entiat remained relatively constant between 1981 and 1990;

however, between 1991 and 2000 it grew by 133%, from 449 to 957 people (US Census Bureau 1991a, 2001a). During the past decade, the rural year-round population within the subbasin portion of the Entiat CCD grew by approximately 11%, from 739 to 829 people (US Census Bureau 1991b, 2001b). Although recent year-round rural population growth occurred at a slower rate than urban population growth, 2000 Census data reported that the number of homes in the rural Entiat subbasin area of the WRIA grew by about 41%, from 278 to 470 units. Of these, 160 (34%) were reported as part-time/vacation homes (US Census Bureau 2001b). For more information about growth trends and future population estimates, refer to Chapter 4, Section 4.1.11.

Figure 3-15 shows the number of well logs submitted to WDOE annually. The surge in the number after 1975 was partially due to the resolution of landline location disputes and litigation in the late 1970s. During the dispute/litigation period, land title companies were not offering title insurance to prospective land purchasers.

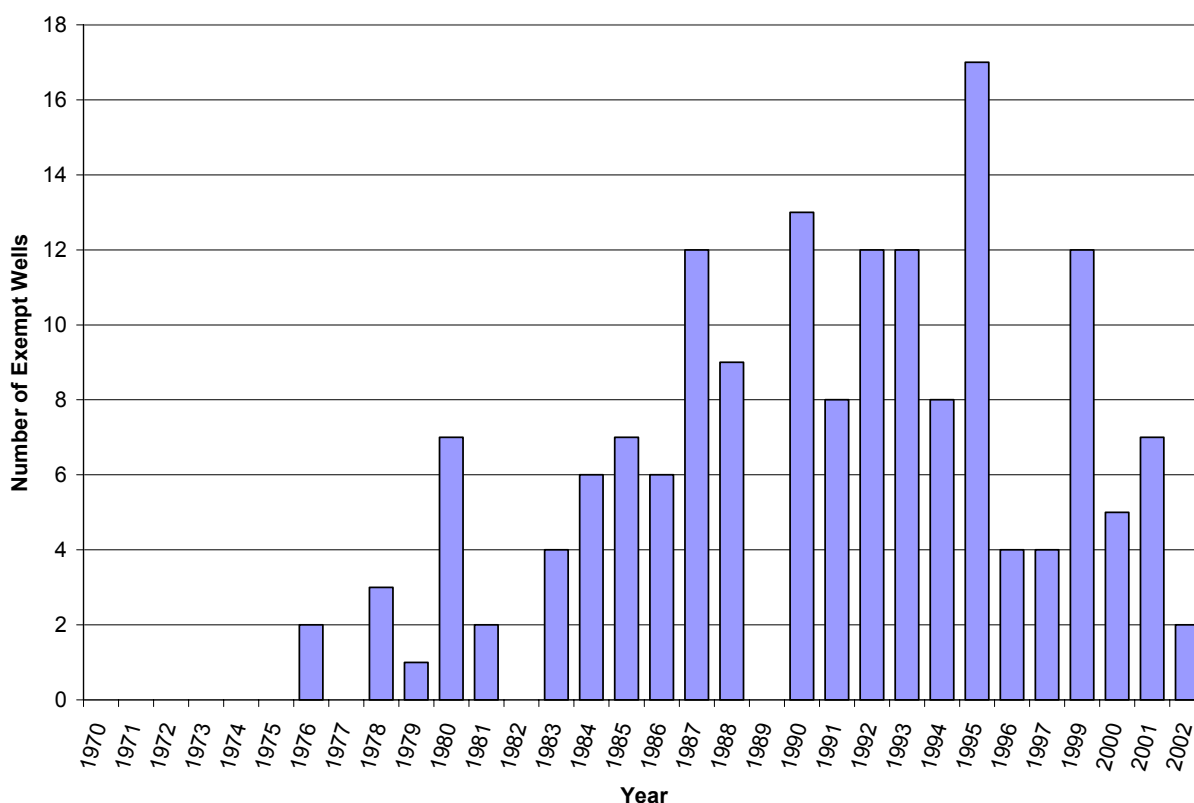


Figure 3-15. Number of exempt well logs submitted annually to WDOE since 1970.

Continued high-density development of private lands near the river on floodplains has the potential to threaten existing water quality (see Chapter 8, Water Quality). Water quality sampling has not indicated non-point source pollution problems related to septic systems or runoff from home sites and other developed areas in the valley, nor has it indicated regular fecal coliform bacteria, nitrate or phosphate level exceedences of State standards. Increasing concern exists regarding accelerated development in flood prone areas. Several parcels have been subdivided for additional home sites, and many new residences have

been/are being built in close proximity to the river on the floodplain and tributary alluvial fans, which have a high risk for inundation by flood flows.

Some citizens view an increase in population as an opportunity for new services. However, they recognize that more people and residences mean more septic systems, which raises important concerns about the long-term health of the river and other fragile environmental systems. Development pressure has increased the level of construction occurring on lands and areas on which earlier residents avoided building. In some locations, development and the removal of riparian vegetation has degraded the condition of streamside areas, promoting bank instability and reducing the ability of these areas to mitigate high flows. Residents have questioned how much additional growth the rural valley area of the WRIA can absorb before it detracts from the quality of life and/or threatens the environment, yet they are generally supportive of promoting additional balanced growth in the city center and its surrounding commercial/industrial area. Development, new land uses, and growth potential in the Entiat WRIA are now regulated to some degree by the Chelan County and City of Entiat Comprehensive Land Use Plans.

Economic Trends

The construction of Rocky Reach Dam in 1960 has been reported as having the greatest cumulative net negative impact on the fiscal situation of the City of Entiat and the Entiat School District (ECONorthwest 2003). The dam flooded a large area of the city's downtown business area and adjacent residential and agricultural land. It has been estimated that the dam's direct and indirect impacts caused the city and the school district to lose millions of dollars in past and projected revenues (revenues that they otherwise would have expected if the dam had not been built) from: property tax, sales tax, real estate excise tax, hotel/motel tax, and from state general-fund education revenue (ECONorthwest 2003).

Additional factors have contributed to poor economic conditions in the WRIA. Washington State Department of Revenue data (see [Figure 3-16](#) on the following page) show that City of Entiat retail sales plummeted over 75% from about 6.5 million dollars a year to less than 1.5 million dollars a year between 1981 and 1982, and that retail sales were essentially stagnant between 1982 and 1992. Local residents indicate stagnancy was caused by setbacks in different sectors of the economy occurring at the same time. The mill at Ardenvoir, which employed up to 100 people, closed in the early 1980s; a manufacturer of specialized sleeper cabs for tractor-trailers also closed its doors. In addition, fruit packinghouses in the Entiat area closed. The Entiat Valley Community Action Plan (Gillis Group 1994), a document developed from the results of a survey of the Entiat community and a canvass of the entire Entiat valley, noted that hard economic times have affected the income level of some residents. Data from the 2000 census showed 9.1% of all families and 14% of individual residents of the City of Entiat fell below the federal poverty level (US Census Bureau 2001a). The poverty level in Entiat subbasin was lower than the level within the city limits.

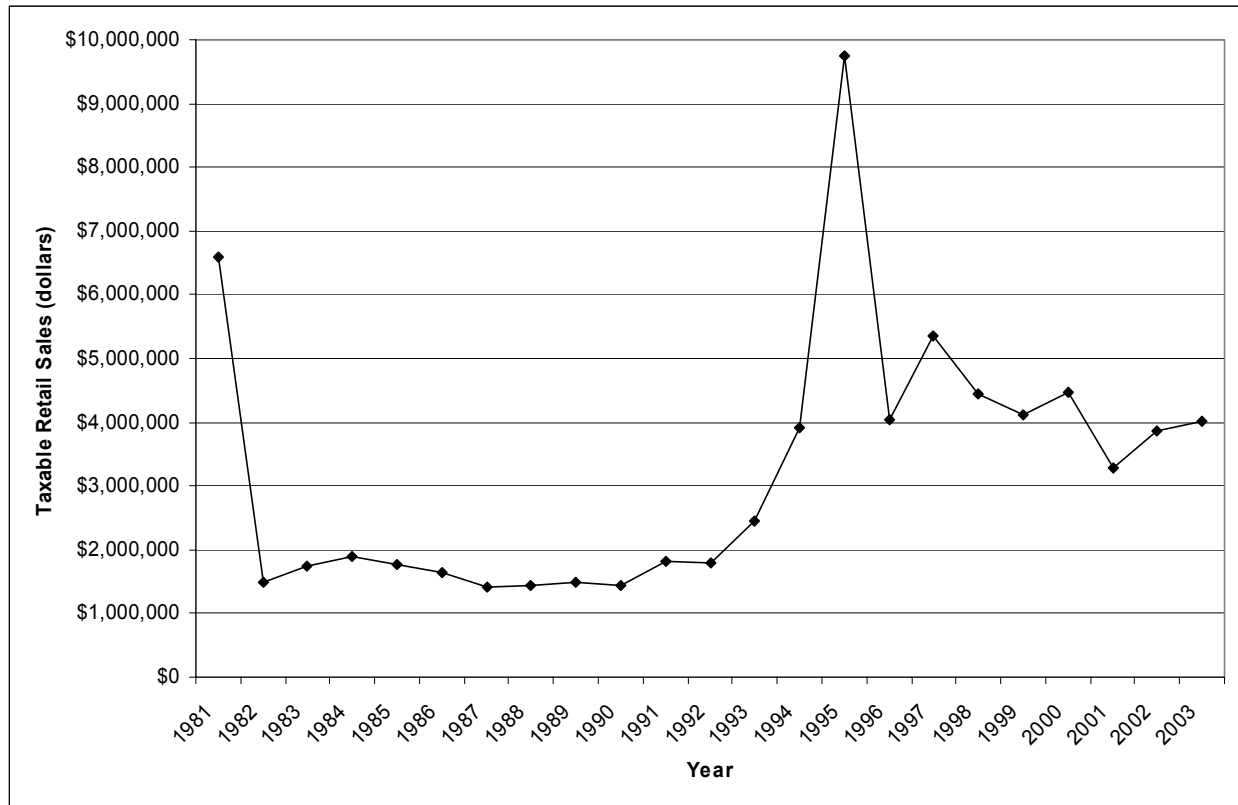


Figure 3-16. City of Entiat taxable retail sales, 1981-2003.

The 1994 Community Action Plan substantiated the continuing importance of the agricultural/orchard community as the most stable, enduring industry in the Entiat WRIA, and contained information about several economic assets and weaknesses of and/or constraints on future economic development efforts in the City and rural area. The Community Action Plan included three key goals to achieve the Entiat's definition of economic success:

- Focus primarily on manufacturing to create year-round jobs that pay a living wage.
- Develop Entiat's town center as a focal point for activity and shopping through strategic actions.
- Preserve the beauty of the Entiat valley through good local planning and cooperative efforts with the County.

The 1994 Action Plan was updated by the Report on the Update of the Community Action Plan and A Vision and Goals for Entiat, Washington (Stewart 1999). Both the 1994 Action Plan and the 1999 update were funded jointly by the USFS Entiat RD and the City of Entiat. The 1999 update report noted that job creation, population growth and economic expansion in the Entiat and the region overall had increased due to new manufacturing and service industry positions throughout the region, and the Entiat area had benefited in particular from the addition of Aeromet America Industries (see Table 3-4 on page 3-32).

Table 3-4. Economic issues identified by 1994 Community Action Plan and 1999 Update Report.

Economic Assets identified in 1994 Report	Additional Assets added by 1999 Report
High quality of life	Completion of the City of Entiat Comprehensive Land Use Plan, which is contributing to sound development and quality residential areas.
Abundant and diverse recreational opportunities	Organization and development of the Columbia Breaks Fire Interpretive Center Foundation.
Located in a growing, prosperous region	
Available local labor force with access to additional workers through the Link bus system	
Pro-active local officials, volunteers and regional organizations	
Close access to medical facilities and other services in Wenatchee and Chelan	
Relatively low cost of living and affordable power rates	
Local people support job creation	
Available industrial land with access to services and transportation	
Economic Weaknesses/Constraints identified in 1994 Report	Additional Weaknesses added by 1999 Report. Asterisk items based on LSC review
Limited local population base and income to support new businesses	Very low tax base, both in sales and property tax, for the City of Entiat.
Lack of a well-defined town center, as a result of the dam, and few local stores/services	*Elements of Growth Management Act
Stiff retail competition from Chelan and Wenatchee	*Regulatory & environmental constraints
Distance from major urban markets	Lack of physical space (see Section 3.2.2,)
Lack of local communication vehicles	
Water rates that are currently higher than in other small communities	
Current housing shortage	
Declining availability of local timber	
Located in an environmentally sensitive area	
Limited planning mechanisms to ensure compatibility and appropriateness of local uses of land	

The 1999 update document reported that several of the aforementioned weaknesses are changing or have already been modified, and that significant population growth and home construction have occurred within the City of Entiat and the Entiat rural area, and these trends are expected to continue. Technological innovations such as the Internet and the potential installation of fiber optic lines by the PUD, coupled with the elimination of long distance charges between the cities of Chelan and Douglas Counties, are making the concern about lack of communication almost obsolete. Finally, land use planning and comprehensive plan development and adoption by the City of Entiat and the County have provided a framework to help plan for and guide growth within the Entiat WRIA.

Refer to Entiat Valley Community Action Plan (Gillis Group 1994) and the Report on the Update of the Community Action Plan and A Vision and Goals for Entiat, Washington (Stewart 1999) for further information on vision and goals; also see the 1996 Columbia Breaks Fire Interpretive Center Foundation Business & Development Plan for more material related to this topic. Refer to the Comprehensive Plan for the City of Entiat, Chelan County, Washington (1997) and the Comprehensive Plan for Chelan County, Washington (2000) for City and County land use policy and planning information, respectively.

3.2.5 Cultural Resources

Native Americans were the first occupants of the Entiat WRIA. The Entiat band of the Moses-Columbia Indians, who lived along the Columbia River and its tributaries between Priest Rapids and Wells Dam, use the word Entiat to name the area around the mouth of the River. Their translated meaning of the word Entiat is “grassy water place” (M.D. Kinkade, pers. comm. 2002). The Entiat WRIA lies within territory ceded by the Yakama Nation in 1855. The traditional Yakama spelling is “Int-yat”, which is described as meaning either a rich and abundant area, or happiness, depending on pronunciation (Johnson Meninick, pers. comm. October 31, 2003). Plants found in dry lithosol areas, wetlands, and other areas within the WRIA are significant to the Yakama Nation for medicinal and other purposes. Salmon continue to be an important natural, spiritual and cultural resource. In addition to ancestral and present use, legendary stories about the Entiat are told by Yakama elders to preserve the history of and respect for areas of cultural significance in perpetuity.

Cultural resources found within WRIA 46 represent a range of artifacts and sites, which may include:

- historic cabins, trails, mines, ditches, railroad grades, emigrant trails, original highway grades, mills, and homesteads;
- historic Forest Service structures including guard stations, lookout towers, corrals, camps, administrative centers, and Depression-era campgrounds and buildings; and
- prehistoric campsites, villages, graves, quarries, pictographs, workshops, trails, rock shelters and religious sites.

As of July 1997, six cultural resource sites have been inventoried on private lands within the subbasin and classified as historic sites on a list maintained by the State Historic Preservation Office. The identification and listing of these sites is in compliance with national and state Historic Preservation laws. Federal law requires federal agencies to do a preliminary cultural survey of any area where ground-disturbing activities take place; the law also applies to activities on private lands where a federal agency is expending federal funds as a cooperator. As of April 2002, approximately 37 sites had been inventoried on National Forest lands within the subbasin. Of the 37 sites, 32 are classified as historic and 5 are classified as prehistoric. Four of the 32 historic properties are listed on the National Register of Historic Places (P. Gadd, pers. comm. 2002). The Badger Mountain lookout ([Figure 3-17](#) on the next page), which was moved to the Columbia Breaks Fire Interpretive Center in the minor Columbia River tributaries portion of the WRIA, and Tyee lookout are both listed on the National Register. The Steliko Ranger Station ([Figure 3-18](#)) is not currently listed but is eligible for listing.



Figure 3-17. Badger Mountain lookout (date unknown).



Figure 3-18. Steliko Ranger Station, circa 1926.

*Photographs courtesy of the National Archives and USFS Wenatchee National Forest Supervisor's Office, Wenatchee, WA.

Visual Resources

Scenic vistas and natural beauty are critical to the quality of life and recreational economy of the Entiat WRIA. The landscape is typical of the Northeast Cascade Mountains. The parallel mountain forms have approximately uniform crest elevations. Rock forms are common, especially on the ridge tops and steep upper slopes where jagged rocky peaks occur and glacier-carved outcrops abound. The physical features of the geology and climate influence the landscape pattern. The most predominant physical geographical features are the naturally established elements of landform. The structure of mountain peaks and the glaciated U-shaped main valley with hanging valley tributaries, often featuring waterfalls, are outstanding.

The change in elevation within the WRIA, from 9,249 feet at the Entiat's headwaters to 713 feet the river mouth, offers a wide range of vegetation from alpine to near desert types. The vegetation is characterized by a wide variety of communities and species, and patterns vary throughout the basin; the landscape is dominated by true fir and hemlock in higher elevations, and pines as elevation drops. Shrubs and grasslands dominate south slopes and lower elevations. Development of human settlement has created a rural feeling in the landscape character of the lower valley where irrigated orchards offer a welcome contrast to the arid grass-shrub hillsides in mid and late summer.

3.3 NATURAL ENVIRONMENT

3.3.1 Climate

Climate in the Entiat WRIA is strongly influenced by orographic effects associated with its location extending from the Columbia River to near the crest of the Cascade Mountains. Climate is discussed below in averages for winter and summer; however, fluctuations outside of average are very common, and extremes may best describe the local climate. Examples of such extremes include temperatures in the 90s and 100s, which may last for several weeks at a time during the summer, and single digit and sub-zero temperatures (occasionally double digit) for short periods during many winters.

Mean annual precipitation can range up to 90 inches in the headwater areas near the Cascade crest to less than 10 inches along the Columbia River. Approximately 50% of the mean annual precipitation falls from October through January, and 75% falls from October through March. Most winter precipitation falls as snow; however, rain is not unusual at some mid- and lower elevations. Cumulative snow depths range from less than 24 inches in lower elevations to nearly 400 inches. Precipitation in July and August, the two driest months, is 5-10% of the annual mean. High intensity, short duration thunderstorms frequently develop over the mountains in the summer, resulting in heavy downpours of short duration in the subbasin. Occasionally these heavy rains produce flash floods. Long-term records (1949-1992) from climatological stations in the surrounding area do not show any definitive increasing or decreasing trend in annual precipitation (Kirk et al. 1995). Refer to Figure 3-19 on the following page for a depiction of annual precipitation ranges estimated for the Entiat WRIA. The isohyet GIS data were derived from PRISM model outputs based on 1961-1990 mean monthly precipitation data (Daly et al. 1994, Daly et al. 1997).

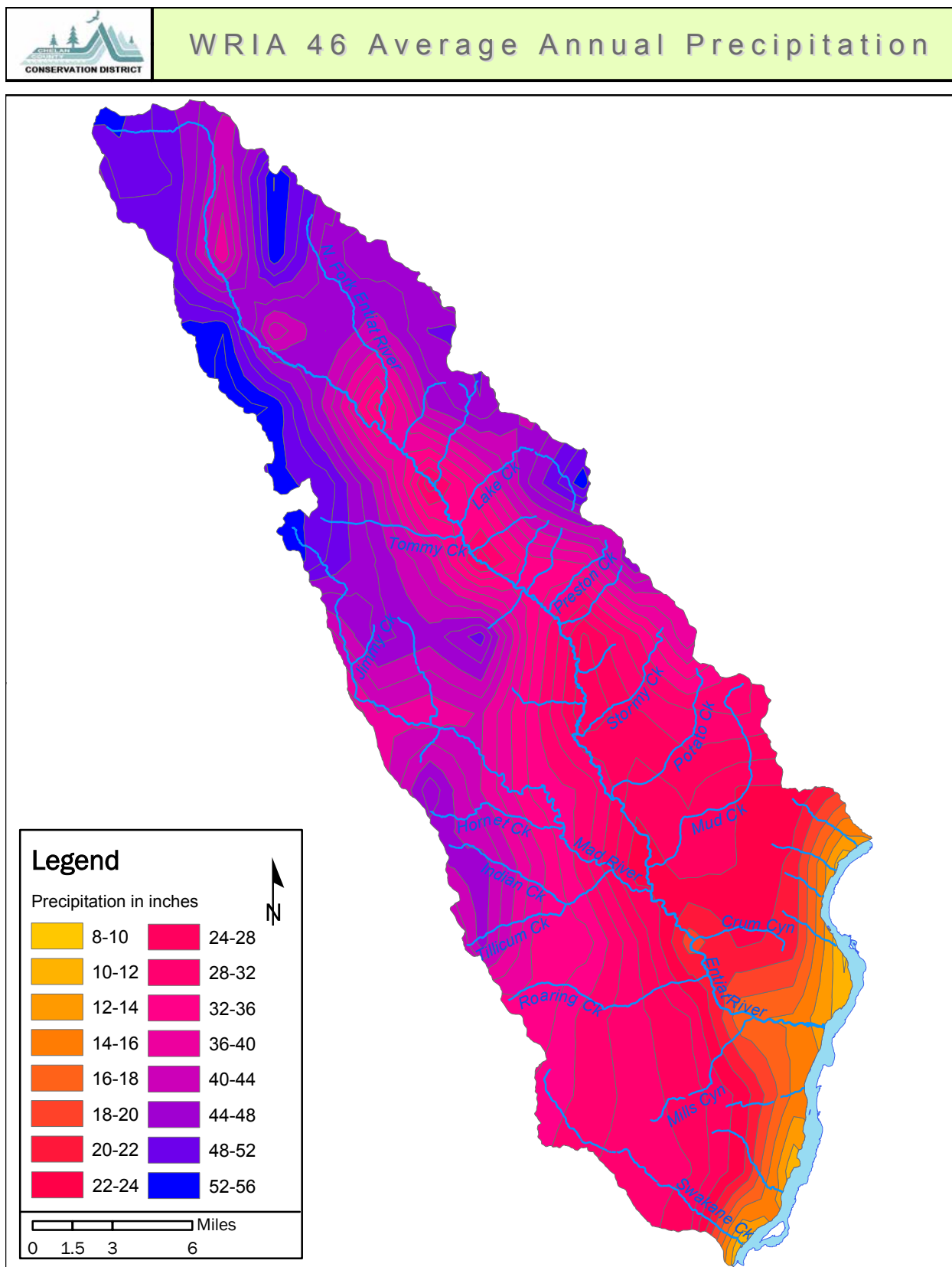


Figure 3-19. WRIA 46 average annual precipitation in inches.

Average daily summer temperatures in the mid-elevations range between 60 and 70 degrees, decreasing to the 50s at higher elevations. High temperatures in the 90s frequently occur in the lower valley during July and August. In winter, storm systems moving east from the Pacific, as well as outbreaks of cold air from the north produce frequent weather changes. During an average winter, temperatures range from the teens to the 40s depending on elevation. The frost-free season is generally mid-May through early October; however, frost in the lower valley has occurred as late as the first week in June. The first frost of the fall is likely to occur about October 1. The average growing season in the agricultural area of the subbasin averages 150 days; the upper valley experiences a shorter growing season due to increased elevation and later departure/earlier onset of frost.

Air Quality

The Entiat valley is classically positioned on the east slope of the Cascade Mountains, where climate and air patterns predispose the valley to periods of air stagnation, especially during the fall and winter. During periods of air stagnation, air contaminants generated at the surface within the valley tend to accumulate, rather than disperse. Pollutants generated within the Entiat “airshed” more readily disperse during times of air movement.

The Entiat airshed is impacted by many forms of outdoor burning, including forest prescribed burning and wildfire, agricultural burning, and residential burning, and is also seasonally affected by residential woodstove use. High levels of air pollution can put visual as well as air quality resources at risk. As population continues to grow and the area becomes more developed it could become increasingly difficult to protect visual resources and air quality.

The WDOE administers an air quality registration and permitting program for commercial and industrial sources of air contaminants. There are no registered sources within the Entiat watershed adjacent the Entiat River, although there are a few regulated sources within the City of Entiat. Although WDOE monitors airsheds across the state, no monitoring data exist for the Entiat airshed. The nearest monitoring site is in the Wenatchee area, where the WDOE has been collecting information since 1998. WDOE has no immediate plans to expand their air monitoring to include the Entiat airshed.

3.3.2 Topography

The Entiat WRIA is characterized by three distinct types of topography. Rolling hills found in the minor Columbia River tributaries area of the WRIA are indicative of an earlier geologic era when streams were downcutting slowly. Steeper topography created by uplifting and the formation of the Cascade Mountains is more commonly found throughout the subbasin. During uplifting, streams became more erosive resulting in narrow incised canyons in the mid to lower valley portions of the subbasin. Soil and bedrock were eroded in these canyons and alluvial fans formed in areas where the streams met the Entiat River floodplain.

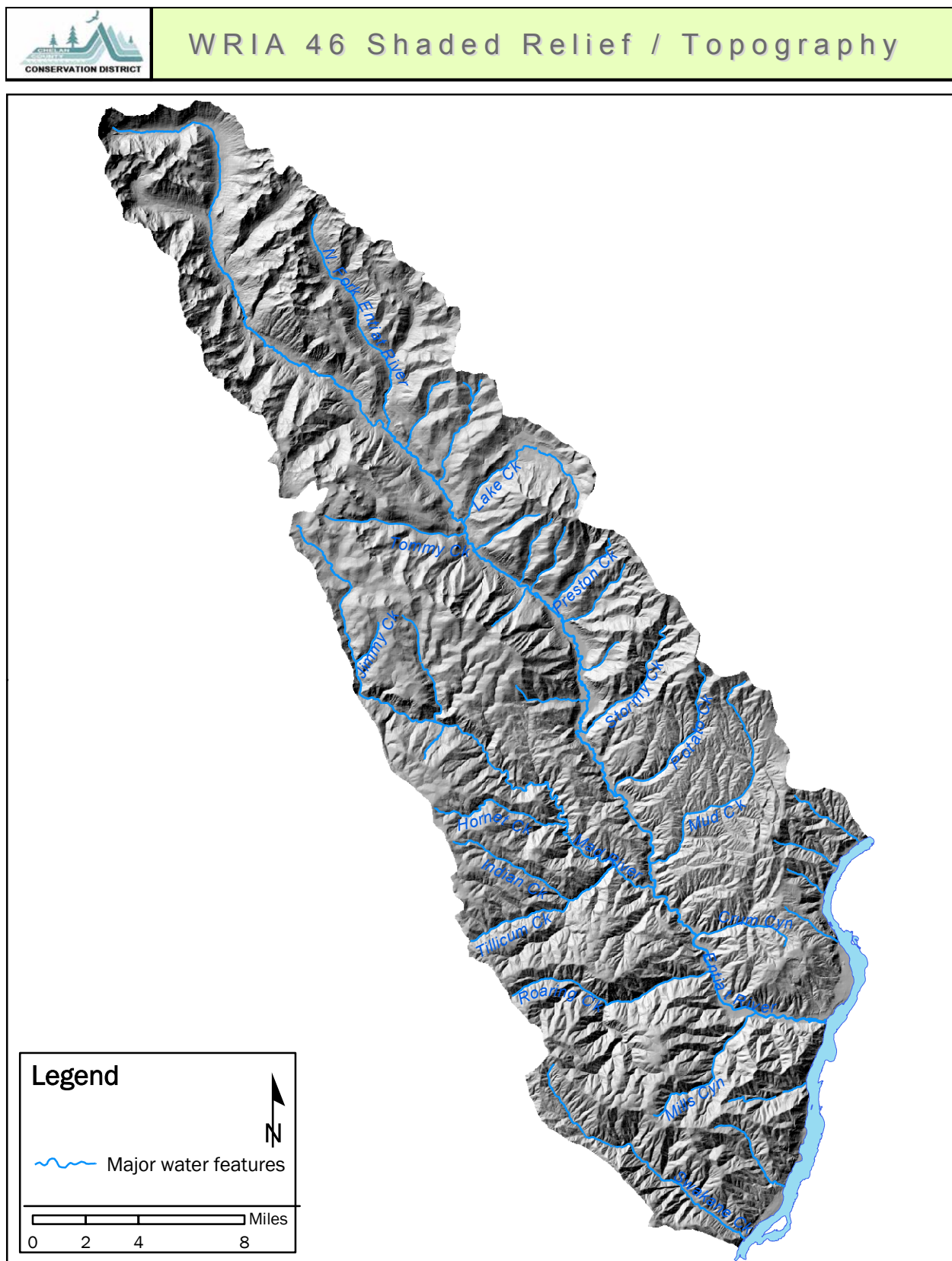


Figure 3-20. WRIA 46 shaded relief / topography.

Most of the topography in the WRIA is the result of alpine glaciation, which significantly affected the upper half of the Entiat subbasin. During the neo-glaciation period a valley glacier that was nearly 25 miles long extended from its source at the headwall of the Entiat watershed to just below Potato Creek, which is marked by a terminal moraine indicating the furthest downstream influence of the glacier on channel geomorphology and bed material. Above the terminal moraine the Entiat valley has a characteristic U-shaped appearance and is covered with glacial till. Glaciation resulted in hanging valleys and a moderately broad floodplain in the mid-Entiat River that contains water-stratified silt, sand, gravel and cobbles.



Figure 3-21. Entiat U-shaped valley created by glaciation, looking northwest near RM 24.

3.3.3 Geology

Geology in WRIA 46 is characterized as being composed primarily of metamorphic schist and gneiss, intrusive granodiorite, and quartz diorite. The Chelan and Entiat Mountain ranges consist of rugged angular forms indicative of hard rocks, predominantly quartz diorite and granodiorite, with lesser amounts of schist and gneiss. More resistant dikes of rhyolite porphyry traverse some areas. Mt. Maude and Seven Fingered Jack are massive quartz diorite formations, while Spectacle Butte is part of an exposed quartz diorite/gneiss pluton.

Major geologic formations include Swakane Gneiss, Chiwaukum Schist, and Mt. Stuart Granodiorite. Swakane Gneiss is the oldest and is composed of medium grained gneiss, coarse amphibolite schist, and many small stringers of pegmatite and mylonite. Chiwaukum Schist contains foliated rocks ranging from phyllite to fine gneiss. Mt. Stuart granodiorite consists of medium to coarse-grained gray granodiorite containing abundant biotite and some hornblende. This formation is often highly weathered where exposed.

The Entiat WRIA includes at least two outcrops of Columbia River basalt. The northernmost outcrop is located in the Dick Mesa area about one mile northwest of the City of Entiat. The Dick Mesa basalt cap is covered with a layer of loess very similar to Palouse Loess deposits

found to the southwest. The southern outcrop, called the Tenas Basalt, is located west of Rattlesnake point near the head of the south fork of Tenas George Canyon. The readily observable part of the Tenas Basalt is on the east end of the Entiat Ridge. It reappears in several places along the Entiat Ridge and into the head end of Roaring Creek, especially at Prairie Springs and the junction of Dinkelman ridge and the Entiat Ridge. The Tenas Basalt soil cap is associated with the natural weathering of the exposed basalt. The presence of local basalt dikes might suggest local extrusions, but the presence of loess on Dick Mesa may indicate a relationship to the Miocene lava flows from the southwest. Both basalt deposits are mini-aquifers with several springs seeping out at or near their contact with bedrock.

Glacier Peak, a currently inactive volcano that lies 14 miles west of the headwaters area of the WRIA, has covered most of the area with volcanic ash and pumice thrown from within it at different intervals over the past 12,000 years. Prevailing winds carried pyroclastic debris east; hence, the amount and type of deposition is related to topographic aspect and distance from Glacier Peak. The pumice and ash deposits are deepest on north and east facing slopes, and in some places they are deep enough to obscure the underlying bedrock.

3.3.4 Land Type Associations⁴

Land Type Associations (LTAs) are defined by geomorphic process expressed by landforms (topographic characteristics), geology and potential natural vegetation groups. LTAs express patterns of similar geomorphic processes and conditions, which in turn help explain unique landscape level ecological and hydrological processes such as erosion and sedimentation, soil productivity, riparian/stream channel function, and natural disturbance regimes.

The USFS completed an ecological land unit inventory of the Wenatchee, Okanogan and Colville National Forests in 1999, in which 134 unique LTAs were identified and mapped. LTA information and data pertaining to percent fine sediment in substrate gravels were used to stratify the WRIA into three broad, landscape-level analysis zones: Transport, Transitional and Depositional. [Figure 3-22](#) on page 3-42 depicts the extent of these zones within the WRIA, as well as USFS Entiat RD fine sediment sampling sites. Although distinct transport/transitional/depositional reaches lie within these three zones, more detailed geomorphic assessment work is needed to clearly classify/delineate reach-level processes.

Transport Zone

The upper part of the WRIA, which includes the mainstem Entiat from its headwaters to Entiat Falls, contains strongly glaciated land types. This zone has high subsurface water storage capacity favorable for vegetative growth and regulated baseflows. Coarse and fine sediment and large woody debris are recruited by a naturally high occurrence of debris flows. Fine sediment (diameter <1 mm) is transported through this zone with minimal deposition. The management effects in this zone have been relatively minor, with the exception of dispersed recreation, localized grazing, and trail impacts.

⁴ Information on land types and soils was condensed from the Watershed Assessment Entiat Analysis Area, Version 2.0, Wenatchee National Forest (USDA Forest Service 1996), which includes information from all of the sources discussed.

Transitional Zone

The mainstem from Entiat Falls to the confluence with McCrea Creek lies within this zone, which exhibits characteristics of both transport and depositional zones, as influenced by glaciation. It is not unusual for a transitional zone to have characteristics of both transport and depositional zones. What may be somewhat atypical of the Entiat's transitional zone is that it contains an expansive depositional zone known as the "stillwater" area where glacial alluvium has accumulated and resulted in low gradient, meandering river channels composed of fine bed elements such as silts, sand, and small gravels. Above and below this reach are higher gradient Rosgen B and F-type channels, characteristic of transport reaches. This expansive depositional area places constraint on the channel length one might otherwise expect to be "transitional" throughout the mid-elevations of the WRIA.

Depositional Zone

The depositional zone characterizes the lower part of the Entiat WRIA, an area of non-glaciated mountain slopes dissected by stream down-cutting. Sediment deposition is a dominant process within this zone, and periodic floods generated from high intensity, convective storms are a significant transport mechanism. Fine sediments from steep hill slopes, swales and high gradient channel reaches are transported by surface erosion and debris flows and deposited along floodplains and alluvial fans during these events. A cycle of fill and scour occurs naturally along low gradient reaches within this zone. Recent wildfires have affected a large portion of this area (e.g., Crum, Dinkelman, and Tyee fires). Historic and current management influences in this zone are primarily wildfire and fire suppression; logging and associated road construction; grazing and agricultural development; riparian channel alterations from roading; housing development and fire/flood rehabilitation. Erosion and compaction of surface soils have reduced soil moisture holding capacity and productivity in many areas.

Table 3-5 provides a simplified summary of hazard interpretations for the LTAs found in the Entiat WRIA above and below the Potato Creek moraine.

Table 3-5. Land Type Associations, hazard interpretations, and associated risk levels.

LTA Hazard	Risk Level Above Moraine	Risk Level Below Moraine
Surface erosion	high	high
Debris slide	high	moderate
Sediment delivery	high	high
Soil compaction	low/moderate	high
Soil moisture stress	low	high
Surface runoff	high	moderate
Subsurface water storage	high	moderate
Regulation of stream flow	high	low/moderate

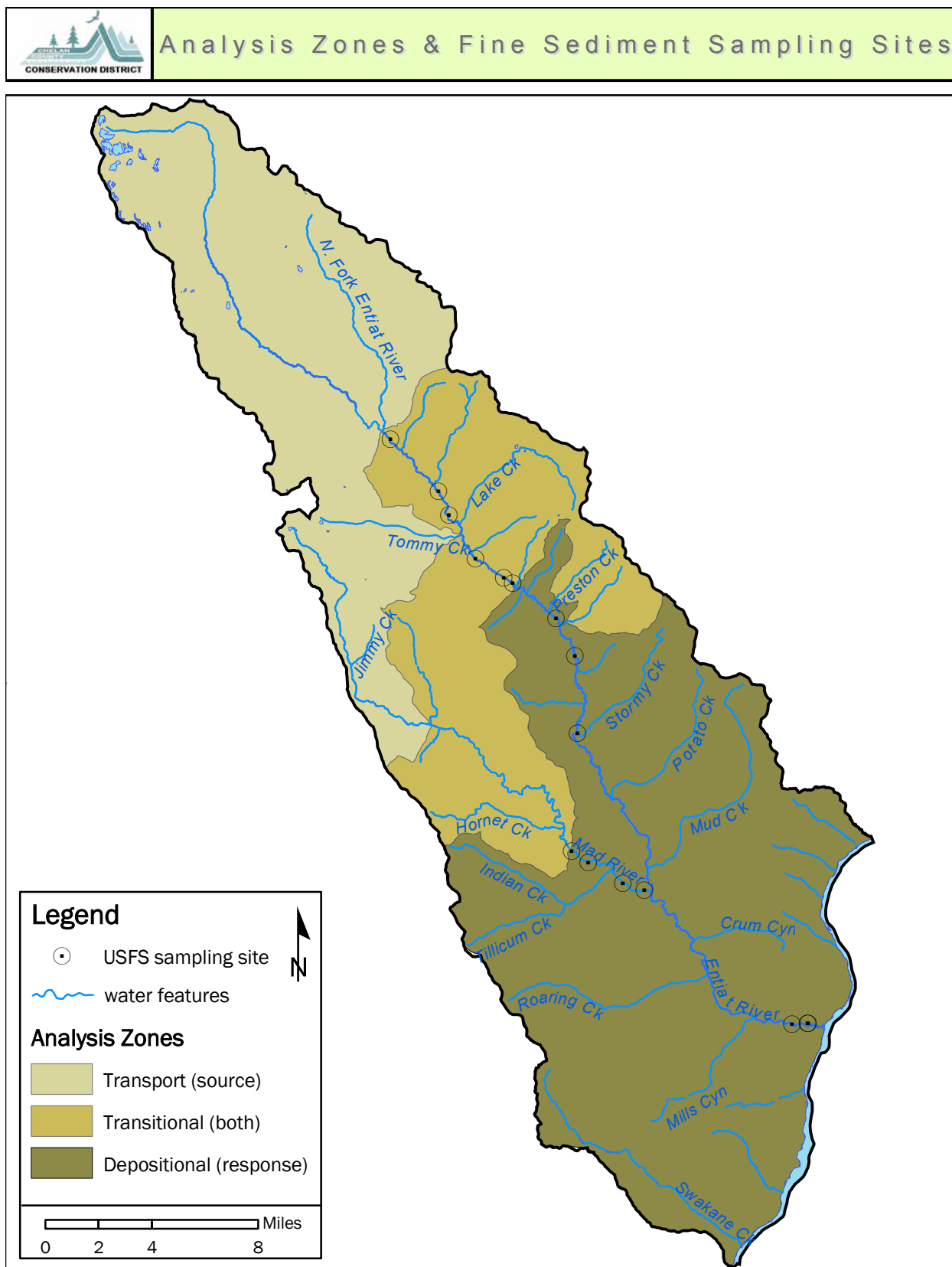


Figure 3-22. WRIA 46 land type association analysis zones and fine sediment sampling sites.

3.3.5 Soils and Prime Farmlands

Soils

Soils within the WRIA have been described in several reports. The earliest soil survey, “Soil Survey of Chelan Area, Washington, Parts of Chelan and Kittitas Counties” (SCS 1969), included private lands near the mouth of the Entiat River to approximately RM 10. In 1976 the USFS published a soils management report for the Entiat area, “Soils on Forest Service Lands” (USFS WNF 1976). The Soil Resource Inventory for the Wenatchee Forest incorporated information from the earlier Entiat area survey and report. The Soil Conservation Service, in cooperation with the US Forest Service, conducted a soil survey that mapped soil types on National Forest System and private lands, titled Soil Survey of Cashmere Mountain Area, Washington, in parts of Chelan and Okanogan Counties (SCS 1990).

Soils in the Entiat are generally highly erodible due to widespread deposits of volcanic ash and pumice or loess at the surface. Sediment delivery rates are typically high, primarily as a result of steep slope and high stream densities. Flooding and debris flows are significant transport processes for both sediment and organic material. Management disturbances such as grazing, tractor yarding and roading generally accelerate natural erosion and sediment delivery hazards on sensitive soils. Once fine-textured soils at the surface are disturbed, certain climatic conditions and coarse-textured sub-soils can create an environment that limits the amount of soil moisture available for vegetative growth.

Prime Farmlands

When the National Environmental Policy Act (NEPA) became law, it was recognized that the nation’s farmlands, forestlands, rangelands and wetlands were being converted to other uses. There was a concern that continued conversion of these lands would impair the ability of the United States to produce sufficient food, fiber and wood to meet domestic needs. As a result of the NEPA and direction by the Secretary of Agriculture, the NRCS defined classifications for important farmlands and published rules in the Natural Register to be used to bring agency programs into compliance with the Act and the direction of the Secretary.

Important farmland classes include Prime Farmland, Unique Farmland, and Additional Farmland of Statewide Importance. All three classes have criteria that include landform, physical and chemical characteristics of soil and moisture. Prime farmlands have the most stringent criteria, with unique farmland being somewhat less notable but important for high value crops. The third class is for land that is of statewide importance to a specific state.

The Soil Conservation Service, as part of a 1969 survey that covered lands from the mouth of the river to one-half mile above Crum Canyon, designated approximately 1336 acres in the Entiat WRIA as “prime farmlands if irrigated” (SCS 1969). The Cashmere Mountain Soil Survey (SCS 1990) identified an additional 633 acres of prime farmlands in the WRIA, for a total of 1969 acres. Lands designated as prime farmlands include orchard land, but not all orchards fall within this designation. Lands other than orchard land, including pasture or land not managed for crops or livestock, are also included in the prime farmland

designation. The 1969 SCS survey also identified approximately 1111 acres as “farmlands of unique importance” and about 232 acres as “farmlands of statewide importance”.

3.3.6 Vegetation

Vegetative Groups

Vegetation in the Entiat WRIA has been described over the years using a variety of methods. For example, one characterization emphasized vegetation important to grazing animals and identification of suitable range areas for range management analyses, while another characterization emphasized timber management interests by identifying stands with high commercial value.

The USFS identified vegetative groups on federal lands in the WRIA that had similar disturbance regimes. An approach comparable to that taken by Agee (1994) was used to delineate vegetation groups based on structure, general characteristics of the vegetation, tree species presence and tree canopy density. Designations also reflected a similarity in fire frequency and, to some extent, fire intensities and soil characteristics. The vegetative groups identified in the Watershed Assessment Entiat Analysis Area (USFS WNF 1996) are summarized below. Refer to the Synthesis Summary Tables section in [Chapter 2](#) for additional vegetative information and USFS management strategies for these groups.

Shrub/Steppe

This dry plant community is dominated by shrubs, grasses, or both (see Figure 3-23 on the following page). Tree canopy cover is less than 10 percent and tree species are ponderosa pine or sometimes Douglas-fir. Common and dominant shrubs are bitterbrush and sagebrush. Common grasses are bluebunch wheatgrass, junegrass, Sandberg's bluegrass, and bottlebrush squirreltail. In the Entiat, this group is found below the forest margin or on drier sites within forested areas at elevations of less than 4,500 feet.

Open Forest

This group is found mostly at lower elevations on relatively dry sites, commonly with grass or shrub understories similar to the Shrub/Steppe Group. Typical tree canopy cover is 10-50% with grass/shrub cover of 10-90%. Ponderosa pine and Douglas-fir are the dominant tree species, with grand fir on some sites. These stands are essentially a transition between the shrub/steppe below and the closed forest above at elevations of less than 4,500 feet.

Closed Forest

Closed forest communities exhibit tree canopy covers of over 50%, with various understory species (see Figure 3-24). This group is typically found at elevations between 1,500 and 4,000 feet; it may occur on north slopes at lower elevations and southerly aspects in the subalpine zone. Climax tree species are either Douglas-fir or grand fir; however, ponderosa pine and to a lesser extent lodgepole pine may temporally dominate some areas as a result of fire occurrence and frequency. This group combines fairly dry stands with relatively low site productivity and moist closed forest with fairly high site productivity.



Figure 3-23. Shrub/steppe vegetation in the lower Entiat valley.



Figure 3-24. Typical closed forest near the Shady Pass Road junction (RM 30).

Closed Subalpine

This group is typified by more than 50% tree canopy cover and various understory species. Communities are found between 4,500-6,000 feet, although this group can be found at lower elevations in cold air drainage areas and on north slopes. The predominant climax tree species in this group in the Entiat is subalpine fir, and lodgepole pine is the typical seral tree stand dominant.

Open Subalpine/Alpine

Open forest/park land interspersed with subalpine and alpine meadows typifies this group. Stands are generally open (canopy <50 percent) except in small clumps. Understory composition is commonly low shrubs, forbs, and graminoids. Conditions are often cold and snowy at the typical elevation range of this group (4,500-7,500 feet, with most over 6,000 feet). Common trees are subalpine fir, Englemann spruce, whitebark pine, and subalpine larch. Mountain hemlock may be present, but has limited distribution in the Entiat.

A summary of USFS Entiat Ranger District vegetative group acreages is provided below.

Table 3-6. Summary of vegetative groups found within the USFS Entiat Ranger District.

Vegetation Type	Acres	Percent
Shrub-Steppe	36,777	13.7
Open Forest	48,925	18.3
Closed Forest	109,936	41.0
Sub-alpine Forest	20,966	7.8
Open Subalpine	49,941	18.7
Non-vegetation (rock and/or water)	1,190	0.5
Total	267,735	100

Noxious Weeds

Several species of noxious weeds are found on both public and private lands within the Entiat WRIA. The most common noxious weeds include Dalmatian Toadflax, Canada thistle and Knapweeds, which are abundant in several locations throughout the WRIA. Knapweeds are especially prevalent along roads and other disturbed areas such as construction sites, gravel pits, utility and transportation corridors, as well as previously cultivated and/or semi-abandoned croplands and pastures. Some livestock pastures are heavily infested. Noxious weeds identified in the Entiat WRIA by the Chelan County Weed Control Board and others include:

Spotted Knapweed
Russian Knapweed
Diffuse Knapweed
Yellowstar Thistle
Canada Thistle
Perennial Sow Thistle
Musk Thistle
Scotch Thistle

Scotch Broom
Jointed Goatgrass
Eurasian Watermilfoil
Rush Skeletonweed
Common Crupina
Puncture vine
Purple Loosestrife
Dalmatian Toadflax

Spotted Catsear
Perennial Pepperweed
St. Johnswort
Longspine Sandbur
Tansy Ragwort
Oxeye Daisy
Wild Four o'clock

Proposed, Threatened, Endangered and Sensitive Plants

State and federal agencies maintain lists of proposed, threatened, endangered and sensitive plant species that occur or may occur within WRIA 46. It is estimated that less than 50% of the WRIA has been surveyed, thus it is likely the lists are incomplete. The data included in [Table 3-7](#) and in [Appendix K](#) are maintained by state and federal agencies. Status classifications for some of the same plants may differ, depending on agency criteria.

Table 3-7. Endangered, threatened and sensitive plant species and occurrence in WRIA 46.

Scientific Name	Common Name	Occurrence	State Status	Federal Status
<i>Astragalus arrectus</i>	Palouse milk-vetch	documented	sensitive	R-6
<i>Astragalus sinuatus</i>	Whited's milk-vetch	may occur	endangered	SOC
<i>Carex buxbaumii</i>	Buxbaum's sedge	documented	sensitive	R-6
<i>Carex proposita</i>	Smoky mountain sedge	documented	sensitive	R-6
<i>Chaenactis thompsonii</i>	Thompson's chaenactis	documented	sensitive	R-6
<i>Cypripedium fasciculatum</i>	Clustered lady's slipper	documented	sensitive	R-6, SOC
<i>Delphinium viridesens</i>	Wenatchee larkspur	may occur	threatened	R-6, SOC
<i>Hackelia hispida</i> <i>var. disjuncta</i>	Sagebrush stickseed	documented	sensitive	R-6
<i>Hackelia venusta</i>	Showy stickseed	may occur	endangered	R-6, endangered
<i>Iliamna longisepala</i>	Longsepal globemallow	documented	sensitive	R-6
<i>Nicotiana attenuata</i>	Coyote tobacco	documented	sensitive	R-6
<i>Orobancha pinorum</i>	Pine broomrape	documented	sensitive	R-6
<i>Petrophytum cinerascens</i>	Chelan rockmat	may occur	threatened	R-6, SOC
<i>Sidalcea oregana</i> <i>var. calva</i>	Oregon checker-mallow	may occur	endangered	R-6, endangered
<i>Silene seelyi</i>	Seely's silene	may occur	threatened	R-6, SOC
<i>Trifolium thompsonii</i>	Thompson's clover	documented	threatened	R-6, SOC

R-6 – Designates plant species listed as sensitive by the USFS Region 6 Regional Forester.

SOC - Designates plant species listed as Species of Concern by the USFWS.

Documented occurrence data: P. Camp, BLM 8/26/97; T. Lillybridge, USFS 10/09/97; M.G. Miller, USFWS 1/03/00.

3.3.7 Wetlands

Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (Cowardin et al. 1979). Wetlands vary widely due to regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Wetlands typically include swamps, marshes, bogs and similar areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year.

The USFWS National Wetlands Inventory (NWI) is the best existing information on wetlands in WRIA 46. Table 3-8 provides a summary of the primary wetland systems and subsystems found within the WRIA. NWI data do not include all forested or seasonal wetlands, due to the mapping method used (high altitude aerial photography analysis). Wetlands are also dynamic, with plant communities and boundaries changing over time due to natural and human disturbances; thus, the accuracy of NWI data is limited. For more information about NWI data and wetlands codes/habitats, refer to the following links:

http://www.fws.gov/stand/standards/dl_wetl.html

http://wetlands.fws.gov/Pubs_Reports/Class_Manual/class_titlepg.htm (Cowardin report)

An accurate assessment of historic and current wetlands distribution within the WRIA is difficult due a lack field data. The NRCS has collected some on the ground data during wetlands surveys, and the WDOE's Shorelands Environmental Assistance program staff also collects wetlands data within the WRIA. Information from the NRCS and WDOE will eventually be used to update the digital NWI wetland maps and data layers. A comprehensive, detailed inventory of wetland resources in the Entiat WRIA would provide information about the location of various wetland habitats and help identify potential restoration/enhancement areas.

Table 3-8. Primary wetland systems and subsystems found within WRIA 46.

NWI Code	Definition	Approximate Acreage ⁺
L10W	Lacustrine, limnetic, open water	2412
L2UB	Lacustrine, littoral, unconsolidated bottom	23
L2US	Lacustrine, littoral, unconsolidated shore	6
PEM	Palustrine, emergent	514
PFO	Palustrine, forested	334
POW	Palustrine, open water	71
PSS	Palustrine, shrub-scrub	546
PUSC	Palustrine, unconsolidated shore	4
R30WH	Riverine, upper perennial, open water	414
R3USA	Riverine, upper perennial, unconsolidated shore	93
U	Upland	301,223
	Total	305,640

⁺ Acreages generated using digital USFWS NWI GIS data.

3.3.8 Wildfire

As stated previously, large wildfires have always occurred in WRIA 46 due to its relatively dry hot climate, low summer precipitation, and the occurrence of summer and fall lightning storms. Over 60 % of the Entiat WRIA has been affected by large, stand-replacing wildfires that occurred in the 24 years from 1970-1994. [Figure 3-25](#) on page 3-50 shows some of the effects of the 1994 Tyee Fire, which burned thousands of acres in the WRIA.

Natural fire events have had an important influence on natural resources in the WRIA, including vegetation types and patterns. Stand replacing fires in particular have affected wildlife and wildlife habitat. Some of the recent wildfires were followed by high intensity

storms, resulting in mud and debris flows that affected channel and riparian condition, aquatic habitat and water quality. Mud and debris flows also occurred historically, as evidenced by alluvial deposits at the mouths of most streams and canyons in the Entiat and Mad River watersheds.

Table 3-9 was developed from a timeline included in the Watershed Assessment, Entiat Analysis Area (USFS WNF 1996). Data for fires that occurred prior to 1888 are not readily available.

Table 3-9. Stand replacing fire occurrence and estimated acreages.

Year	Fire Name	Estimated Size (acres)
1888	Mad River	?
July 31, 1910	Signal Peak	2,560
August 31, 1914	Burns Creek	600
1925	Mad River Spectacle Butte Borealis Ridge	1500+ 600 500
1928	Coal Oil Fire	600
1941	Larch Lakes	400
1958	Entiat Fire	6,500
June 29, 1961	Tenas George	3,750
1962	Forest Mt.	520
August 26, 1966	Hornet Creek	1,520
August 5, 1968	Harris Mill	1,210
July 7, 1970	Mills Canyon	933
August 24, 1970	Entiat/Slide Ridge Gold Ridge	49,200 16,100
August 24, 1976	Crum Canyon	9,000
September 4, 1988	Dinkelman	53,000
July 4, 1990	Dick Mesa	1,151
July 24, 1994	Tyee	135,170
September 2001	Tommy Creek	640



Figure 3-25. Area where 1994 Tye fire crossed the main Entiat road near Roundy Creek (background).

3.3.9 Hydrology

Hydrologic processes in the Entiat WRIA result from interactions among weather, climate, geology, soils, topography, vegetation, and an array of disturbance processes. Although disturbances from human activity include: grazing, roads, domestic/agricultural development, timber harvest, fire suppression, beaver control, recreation and government flood/fire rehabilitation work, natural disturbance processes dominate in the WRIA. These include: historic episodes of uplifting, glaciation, volcanism, earthquakes, high intensity storms, flooding, windstorm and wildfire. Wildfire has been the most notable natural disturbance process in recent years. Disturbance processes are described in more detail elsewhere in this document and in the Watershed Assessment, Entiat Analysis Area (USFS WNF 1996).

As described earlier, climate and topography create a wide range in annual precipitation. The capture, storage and release of precipitation control many of the WRIA's physical and biological processes. A large portion of the annual precipitation falls as snow and accumulates to form the winter snowpack. Warm spring temperatures and rain release water accumulated in snowpack as runoff. Thus, snowmelt is the dominant source of streamflow and groundwater in the Entiat WRIA. Occasional, large frontal and convective storms in the spring, summer and fall may increase flow or cause flooding.

Meltwater and precipitation in the WRIA can take several routes in the hydrologic cycle, including:

- evaporation from the soil and other surfaces
- use and transpiration by vegetation
- infiltration into the soil and shallow, sub-surface storage and transfer
- infiltration, deep percolation, storage and transfer in the Entiat aquifer
- streamflow discharge fed by groundwater and surface runoff, and
- groundwater discharge through the Entiat River aquifer to the Columbia River aquifer.

The routing of rain and meltwater is dependent on the physical characteristics of the soil. Surface infiltration rates, percolation rates and soil moisture storage are critical parameters that help determine runoff characteristics and plant water availability. These parameters vary by soil type and are subject to alteration by disturbance, as illustrated by these local examples:

- A reduction in infiltration rates may occur following a high intensity fire if a hydrophobic or water-repellent layer forms near the soil surface, which increases the potential for concentrated surface runoff, erosion and fine sediment delivery to streams. Infiltration rates return to normal over time as the hydrophobic layer is broken down.
- Loss of vegetation following wildfire reduces the amount of water previously used by plants, leading to increases in soil moisture that eventually translate into greater stream flows. This phenomenon was notable in affected portions of the Entiat after the major fire events of 1970, 1988 and 1994.
- Past human disturbances have had a detrimental effect on the soil's water conveyance and retention characteristics in many areas (USFS WNF 1996). In some areas, ground-disturbing activities (e.g., site conversions, grazing, roading, tractor yarding) have caused soil compaction, which decreases infiltration rates. Slope excavation for roads or other developments may intercept shallow sub-surface flows, increasing surface runoff and altering soil moisture distribution patterns. Over-grazing by domestic animals in the WRIA at the turn of the century may have contributed to surface soil changes that reduced soil moisture storage and increased soil moisture stress.

Annual water yield from the Entiat WRIA varies considerably from year to year. Steep topography, relatively short drainage length, pinnate drainage structure, and other factors promote a rapid mainstem flow response time to runoff and a wide range between peak flows and low flows in the lower Entiat River. Mean volume produced from 1951-1958 by the Entiat subbasin (419 sq. mile drainage area), as recorded at the mouth by the Entiat at Entiat gage, was 367,379 acre-feet. Mean annual volume recorded at the same site for the period 1970-1976 was 528,275 acre-feet, indicating a 44% increase in yield during the period following the 1970 fires (USDA 1979). Mean annual runoff recorded upstream at the Entiat near Ardenvoir gage (203 sq. mile drainage area) for the period 1957-1999 was 283,527 acre-feet, with an annual high of 451,140 acre-feet in 1972 and a low of 178,970 acre-feet in 1973.

Table 3-10 summarizes mean annual runoff in cfs recorded at the Entiat at Entiat and Entiat near Ardenvoir USGS gages, and details the extremes in runoff experienced after large fire

events and/or as a result of natural fluctuation in precipitation and runoff. A comparison between the gages shows approximately 75% of the mean annual runoff for the entire Entiat subbasin originates from an area just less than 50% of its total drainage area. Sustained runoff from the upper watersheds is critical to the maintenance of flows in the lower reaches of the Entiat River. The Mad River contributes approximately 32% of total surfacewater runoff to the Entiat River during the low flow period. Although no modeling has been conducted, changes in water yield resulting from past timber harvest activities are considered to be relatively minor when compared to natural variation caused by climate changes or large wildfire events.

Table 3-10. Select streamflow parameters for the Entiat River recorded at two USGS gages.

Parameter	Flow (cfs) at USGS gage Entiat at Entiat (RM 0.5)*	Flow (cfs) at USGS gage Entiat near Ardenvoir (RM 18)**
Mean annual flow range	275-800	175-621
Peak annual flow range	1,100-10,800	900-6,800
7-day mean low flow range	45-120	36-90

* Drainage area 419 sq. mi.; Period of record 1911-1925 & 1951-1958.

** Drainage area 203 sq. mi.; Period of Record 1961-1991.

Figure 3-26 shows the annual runoff volume in acre-feet recorded by the Entiat near Entiat (Keystone) and Entiat near Ardenvoir mainstem gages.

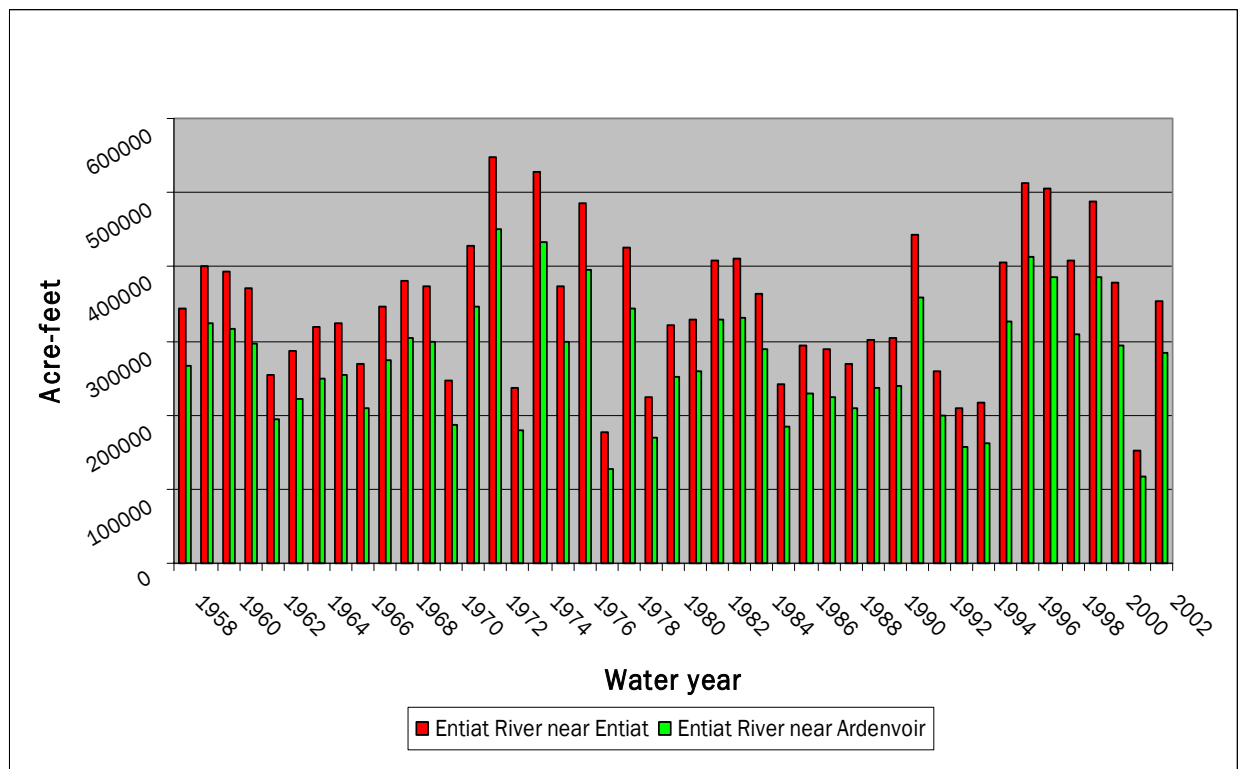


Figure 3-26. Annual runoff (ac-ft) recorded at the Entiat near Entiat and Entiat near Ardenvoir USGS gages, 1957-2002.

Mean monthly runoff data for the Entiat subbasin are indicative of a snowmelt dominated system, and the alluvial and glacially derived sediments in the valley bottoms are the primary storage for groundwater in the Entiat subbasin. A pattern of high elevation snowmelt, aquifer recharge, and the gradual release of groundwater defines streamflows in the Entiat subbasin. Snowmelt influences on peak flows in lower elevation tributaries (e.g., Mud Creek) can begin as early as February; however, the vast majority of the annual runoff typically occurs during the period between early May and mid-July when mid to upper elevation snowmelt reaches its peak. Groundwater movement into the Entiat River and its tributaries from late summer through the winter helps sustain streamflows for the remainder of the year. This exchange of water between sub-surface and surface flows is a function of the height of the water table in relation to the channel.

High flows in the Entiat subbasin commonly result from either rapid spring snowmelt, large storms (1948 and 1972), including warm rain-on-snow events, or high intensity convective storms. Post-fire flooding triggered by one of these mechanisms is a frequent disturbance process. Since 1970, flooding has followed most major fires in the subbasin. The 1972 flood was a drainage-wide event resulting from a large frontal storm combined with the late melt of a record snow pack. The Preston Creek debris torrent that occurred during this event originated from lands burned in 1970. The Crum/Ringsted/Byrd Canyon floods of 1977, the Dinkelman/Mills/Roaring flood of 1989, and the Potato Creek and Oklahoma Gulch floods of 1997 were all post-fire responses triggered by short duration, high intensity convective storms.

Past experience has shown that there are several periods of flood risk following wildfire, all related to the ability of the soil profile to handle water. The first high-risk period is the summer/fall immediately after the fire when lack of vegetation/ground cover and potential for hydrophobic conditions make the affected area highly susceptible to rapid runoff and erosion from thunderstorms or heavy frontal systems. Another high-risk period occurs in the first spring/summer following the fire when ground cover and vegetation are just beginning to recover. During this period, soil moisture storage is being recharged at a relatively rapid rate since water use by plants has been significantly reduced. A later high-risk period is the second spring/summer period following the fire. At this point, although vegetation and ground cover are on the way toward recovery, soil moisture storage is now at an unusually high level due to a post-fire reduction in vegetative growth and transpiration. Increased surface runoff may occur due to the reduced infiltration capacity of saturated or nearly saturated soils. In addition, the potential exists for mass erosion (e.g., debris slides) to occur in sensitive areas.

Average daily streamflow data for the 1997 water year (a relatively “wet” water year) and 2001 (a relatively “dry” water year) are compared in Figure 3-27 on page 3-54. The data from 1997 show both the effects of an above average precipitation year and the yield increase from recently burned areas.

While much attention has been focused on fire-related flood events in the Entiat WRIA, the potential for flooding always exists, given the right conditions. A key element to consider is the land’s capability to distribute water. Any weather event that produces meltwater or precipitation that exceeds the land’s storage ability may result in a “flood” event.

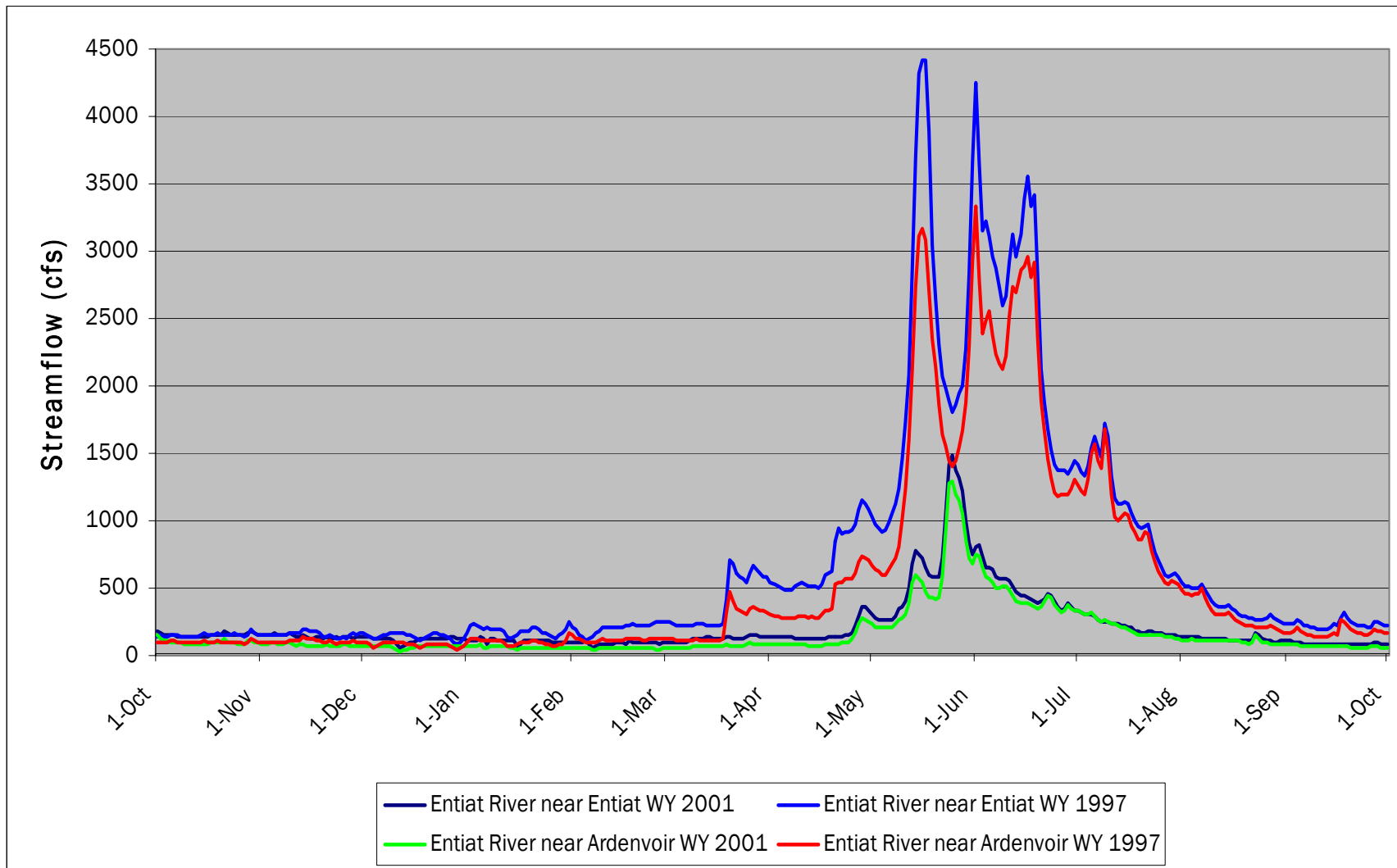


Figure 3-27. Comparison of daily mean streamflows as recorded at USGS gages Entiat near Entiat and Entiat near Ardenvoir, WY 1997 and 2001.

For example, frozen ground can reduce infiltration rates and result in concentrated overland flow and flooding. The most significant flood in recent history (June 1948 regional flood - approximately 10,800 cfs) occurred not after a significant fire, but as a result of heavy rains and the rapid melt of a record snow pack. Flood events in 1956, 1972 and 1974 were also the result of heavy spring rains that accelerated snowmelt and runoff.

Flood events help to shape and rejuvenate landscapes and transport materials to downstream reaches (e.g., gravels for spawning areas, soil for floodplain areas, and woody debris for habitat diversity). Development on alluvial fans and floodplains ignores the risks associated with flood-prone areas (see Figure 5 in the [Entiat River Inventory and Analysis](#)). Most of the past, post-flood rehabilitation work conducted in the Entiat focused on channel clearing and bank armoring, which in turn degraded aquatic habitat and instream values.

Refer to [Chapter 4](#), Water Quantity, for much more information on the history of gaging in the Entiat subbasin, streamflows, groundwater/surface water interactions, and the Entiat valley alluvial aquifer. See [Chapter 7](#), Habitat, for more information on aquatic habitat, riparian condition and historical changes to channel geometry.