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INITIAL WATERSHED ASSESSMENT
WATER RESOURCES INVENTORY AREA 45
WENATCHEE RIVER WATERSHED

Open file Report 95-12

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Initial Watershed Assessment
Wenatchee River Watershed (WRIA 45)

Introduction

This report is the product of a recent initiative by the Department of Ecology (Ecology) to assess the availability of ground and surface water for each watershed within Washington State. This initiative is part of a larger overall effort to make the water rights decision making process more efficient. The watershed assessment process will not only reduce the time needed to make decisions, but also will allow Ecology to make better informed decisions based on a more comprehensive understanding of each watershed. Ecology also believes these reports will be useful to local governments for planning purposes.

The scope of this report was limited to a review of existing information. No new field work or data collection efforts were conducted. The information reviewed includes hydrologic data, water rights data, water quality data, and fisheries data. A bibliography of reports and information reviewed is contained at the end of this report. Much very useful and detailed information is contained in those reports and we recommend that they be reviewed along with this report.

Watershed Description

Area Description

The Wenatchee River drains a portion of the east slopes of the Cascade Mountains in north central Washington within Chelan County. The river flows generally in a southeasterly direction, emptying into the Columbia River at the City of Wenatchee. The Wenatchee River Watershed (WRIA 45) encompasses approximately 1,371 square miles, with 230 miles of major streams and rivers. The watershed originates in high mountainous regions of the Cascade Mountains, with numerous tributaries draining subalpine regions within the Alpine Lakes and Glacier Peak wilderness areas. The Little Wenatchee and White Rivers flow into Lake Wenatchee, the source of the Wenatchee River. From the lake outlet at River Mile (RM) 54.2 the river descends rapidly through Tumwater Canyon, dropping into a lower gradient section in the region of Leavenworth, where Icicle Creek joins the mainstem (RM 25.6). Other major tributaries include Mission, Peshastin, Chumstick and Chiwaukum Creeks, Chiwawa River and Nason Creek. The Wenatchee River Watershed also includes areas on the west side of the Columbia River from the south part of the City of Wenatchee northward to Rocky Reach Dam. Map 1 illustrates the boundaries and major features of the watershed.

Watershed Subbasins

The Wenatchee River Watershed was divided into 18 subbasins. The subbasins are shown in Map 1. Table 1 lists the subbasins, their area and which stream they are a tributary to. The subbasins represent the division of management by Ecology of water resources in the watershed.

Table 1
Wenatchee River Watershed Subbasins

Name		Area		Tributary to:
		(square miles)	(acres)	
1	White River	155.8	99,712	Lake Wenatchee
2	Little Wenatchee River	103	65,920	Lake Wenatchee
3	Lake Wenatchee	20.2	12,928	Upper Wenatchee River
4	Chiwawa River	199.2	127,488	Upper Wenatchee River
5	Nason Creek	105.9	67,776	Upper Wenatchee River
6	Chiwaulkum Creek	50.1	32,064	Upper Wenatchee River
7	Cabin Creek	40.3	25,792	Upper Wenatchee River
8	Chumstick Creek	79.6	50,944	Upper Wenatchee River
9	Icicle Creek	212.7	136,128	Upper Wenatchee River
10	Peshastin Creek	135.3	86,592	Lower Wenatchee River
11	Derby Canyon	24.8	15,872	Lower Wenatchee River
12	Ollala Canyon	9.8	6,272	Lower Wenatchee River
13	Mission Creek	93.3	59,712	Lower Wenatchee River
14	Nahahum Canyon	21.3	13,632	Lower Wenatchee River
15	Warm Springs Canyon	27.6	17,664	Lower Wenatchee River
16	No. 1 & 2 Canyons	39.5	25,280	Lower Wenatchee River
17	Upper Wenatchee River	31.1	19,904	Lower Wenatchee River
18	Lower Wenatchee River	21.4	17,536	Columbia River
	Totals	**1370.9**	**877,376**	

Land Use

The primary land uses within the Wenatchee River Watershed are forestry, wilderness, agriculture, range, residential and recreation. An estimate of land ownership in the watershed is contained in Table 2. An estimate of area in different land uses is contained in Table 3. Table 3 also presents a breakdown of land uses by subbasin. The subbasin definitions used in Table 3 were obtained from a separate study and differ from those described in this study. The area totals in both Table 2 and 3 do not correspond to the area listed in Table 1. The reason is the data in Tables 2 and 3 are only for area tributary to the Wenatchee River. Our study area also includes the west side of the Columbia River from the City of Wenatchee to Rocky Reach Dam. The largest landowner is the U.S. Forest Service with approximately 395,000 acres of forest land or 45 percent of the total watershed area.

The acreage of irrigated farmland in the watershed tributary to the lower Wenatchee River was estimated to be 12,479 acres.

The population of the study area is divided between cities and towns (approximately 56 percent) and unincorporated areas of Chelan County (approximately 44 percent). Table 4 lists 1993 estimates of populations of cities and towns within the study area.

Table 2
Land Ownership in the Wenatchee River Watershed

Ownership	Approximate Area (acres)	Percent of Total
State		
Common School, Indemnity, Escheat	9,000	1.1
Dept. of Wildlife	2,000	0.3
Federal		
National Forest	395,000	49.4
Wilderness	219,000	27.4
BLM	1,000	0.1
Private Ownership	174,000	21.7
Totals	**800,000**	**100**

Source: WDOF, 1990

Table 3
Areas of Different Land Use by Subbasin

Land Use	Area in Acres									
	Peshastin	**Icicle**	**Nason**	**Lake Wenatchee**	**White**	**Chiwawa**	**Chumstick**	**Mission**	**Main Stem**	**Total**
Urban & Built up	0	66	0	0	0	25	4	772	2,076	2,943
Agricultural Land	259	725	0	0	0	296	701	2,011	8,487	12,479
Rangeland	1,844	9,383	1,491	2,333	8,913	1,937	531	1,405	25,895	53,732
Forest Land	82,102	119,532	66,068	60,494	71,757	110,107	48,679	55,408	122,529	736,676
Water	32	1,303	159	197	322	90	0	0	2,868	4,971
Wetland	0	0	82	1,704	3,698	770	0	0	490	6,744
Barren Land	0	0	16	52	0	10	0	7	85	170
Tundra	1,962	5,990	507	0	6,664	2,978	0	0	1,360	19,461
Perennial Snow & Ice	239	198	0	0	8,658	3,647	0	0	0	12,742
Totals	**86,438**	**137,197**	**68,323**	**64,780**	**100,012**	**119,860**	**49,915**	**59,603**	**163,790**	**849,918**

Source: Chelan County Conservation District, 1994

Table 4
Current Population Estimates

Area	1990 Population	1993 Population
Wenatchee, City of	21,839	23,000
Wenatchee rural area	5,634	n/a
Cashmere, City of	2,544	2,585
Cashmere rural area	6,348	n/a
Leavenworth, City of	1,692	1,825
Lake Wenatchee-Plain	1,251	n/a
Leavenworth rural area	1,445	n/a
Wenatchee River Watershed Total	**40,753**	**n/a**
Chelan County Total	**52,250**	**56,000**

Source: Chelan County Conservation District, 1994.

A graph showing the trend in population growth in Chelan County is shown in Figure 1. Population projections through the year 2010 are also shown. Population projections for census division areas within the Wenatchee River Watershed are tabulated in Table 5. The rate of population growth of the entire State of Washington is included on Figure 1 for comparison. The population growth in the county was below the state average until the 1970's, when growth accelerated. The population growth in the period of 1990-1993 was 7.2 percent (1994 Washington State Almanac).

Table 5
Population Growth in Wenatchee River Watershed

Area	Population				
	1970	**1980**	**1990**	**2000[a]**	**2010[a]**
Wenatchee division	23,490	24,058	27,473	32,401	36,816
Cashmere division	6,848	7,885	8,892	10,165	11,300
Leavenworth/Lk. Wen. division	2,622	3,591	4,388	4,519	5,023
Wenatchee River Watershed	**32,960**	**35,534**	**40,753**	**47,085**	**53,139**
Chelan County Total	**41,103**	**45,061**	**52,250**	**59,591**	**66,246**

[a] Projection by Office of Finance and Management
Source: Chelan County Conservation District, 1994

Climate and Precipitation

The Cascade Mountains and the prevailing westerly winds are the dominant climatic factors influencing the watershed. Moist air from the Pacific Ocean uplifts and cools as it moves east over the mountains. Most precipitation occurs in late fall and winter. The Cascade Mountain area is characterized by heavy precipitation, with nearly 150 inches annually and snow accumulations of 25 feet or more at the crest. Winter daily temperatures average 25° F to 40° F (Fahrenheit), with summer temperatures averaging 60° F to 80° F. As air masses move east toward the Columbia Basin, moisture progressively decreases, resulting in arid conditions within the lowermost region of the watershed. In contrast to the mountainous areas, the City of Wenatchee receives 8.5 inches or less of precipitation annually with maximum summer temperatures averaging 95° F to 100° F. Violent summer thunderstorms occur periodically, and can result in flash flood conditions on local watersheds.

Records from three climatological stations (Lake Wenatchee, Plain and Wenatchee) in the watershed show no increasing or decreasing trend in precipitation. Figure 2 illustrates the trends in precipitation over the last 40 to 80 years for the three stations. An analysis of state-wide precipitation trends was performed by Ecology (Barker, 1995). The conclusions from that report was that precipitation in eastern Washington was generally above the average since the 1940's. However, the mid 1970's and late 1980's were both below average. An extended period of below average precipitation also occurred in the 1920's through about 1940.

Water Usage In The Wenatchee River Watershed

Irrigation Water Use

A precise estimate of the area of agricultural land within the Wenatchee River Watershed was not available. However, an estimate of 12,479 acres for most of the watershed was listed in Table 3. This estimate does not include irrigated areas in the City of Wenatchee and areas along the Columbia River within WRIA 45. A review of irrigation district records indicate that approximately 21,500 acres receive water diverted from the Wenatchee River. The additional irrigated area is located on the east side of the Columbia River (East Wenatchee) within Wenatchee Reclamation District boundaries. A listing of irrigation districts located within the Wenatchee River Watershed is contained in Table 6. Table 6 also contains information on their irrigated acreage and approximate water use. The numbers were obtained from Water Conservation Plans for the Icicle and Peshastin Irrigation Districts (Klohn Leonoff, 1992), through a telephone survey and other miscellaneous sources. Data on water use by other private irrigation or ditch companies could not be found.

Table 6
Irrigation Water Use in Wenatchee River Watershed

Name	Irrigated acres	Water Source		Estimated Water Use	
		Name	Subbasin	Peak (cfs)	Annual (ac-ft)
Icicle Irrigation District	4,331	Icicle Creek & tributaries	Icicle	84	24,700
Peshastin Irrigation District	3,305[a)]	Icicle Creek & tributaries	Icicle	22	7,400
		Peshastin Creek	Peshastin	40	12,500
Wenatchee Reclamation District	12,500[b)]	Wenatchee River	Wenatchee	200	64,740
Wenatchee-Chiwawa Irrigation District	1,300[b)]	Chiwawa River	Chiwawa	25	4,725

cfs = cubic feet per second
ac-ft = acre-feet
[a] Includes 1,182 acres in lands served by Gibbs and Tandy Companies canals.
[b] Total acres in district, irrigated acres not available.

Municipal Water Use

The primary municipal water users in the Wenatchee River Watershed are listed in Table 7. This table summarizes the population served (both current and about 20 years in the future), current and future water use, and current permitted water rights. The Wenatchee urban area, which accounts for approximately 50 percent of the Wenatchee River Watershed population, is served by the City of Wenatchee and Chelan County PUD No. 1 using water from a groundwater source near Rocky Reach Dam on the Columbia River. This water source is located on the east side of the Columbia River in WRIA 44. Water rights for this source, the permit for which is held by the city, currently greatly exceed current and projected future demand. Water supply lines from this source may in the future extend up the Highway 2 corridor to serve communities such as Monitor and Cashmere.

Table 7
Municipal Water Use in Wenatchee River Watershed

Name	Population Served		Water Source		Current Water Use		Future Water Use		Current Water Right	
	Current	Future	Name or Type	Subbasin	Peak (cfs)	Annual (ac-ft)	Peak (cfs)	Annual (ac-ft)	Peak (cfs)	Annual (ac-ft)
City of Wenatchee	n/a	n/a	Rocky Reach wellfield	WRIA 44	n/a	n/a	n/a	n/a	66.8[a]	13,277[a]
Chelan County PUD - Wenatchee urban area	8,603	12,029	Rocky Reach wellfield	WRIA 44	4.9	1,840	6.9	2,575	66.8[a]	13,277[a]
Chelan County PUD - Dryden	152	203	Well	Lower Wenatchee	0.25	16	0.29	21	0.33	74
Chelan County PUD - Lake Wenatchee area	950	1,565	Well and Lake	Lake Wenatchee	0.78	208	1.2	342	---[b]	---[b]
City of Cashmere	2,660	3,296	Wenatchee River	Lower Wenatchee	n/a	649	n/a	1,797	n/a	n/a
City of Leavenworth	2,418[d]	3,823	Icicle Creek Groundwater	Icicle Creek Icicle Creek	5.4[d]	1,166[d]	9.1	1,463	5.2[d]	n/a

[a]Shared water supply source in Douglas County (WRIA 44). Water right is held by City of Wenatchee.
[b]Water rights are currently held by many. PUD is exploring options on how to consolidate or seek new rights.
[c]Future is year 2010 to 2012 timeframe.
[d]1991 estimate - from Water System Plan.

Table 8 summarizes, by subbasin, the total system capacity for all public water systems located in the Wenatchee River Watershed. These data were obtained from the Washington State Department of Health database of system facility data for Group A and B systems. Municipal water use data contained in Table 7 is included in Table 8 totals, except for the City of Wenatchee source, which is located outside the Wenatchee River Watershed.

A listing of the individual water systems within each Wenatchee River Watershed subbasin is included in Appendix A. Table A-1 in Appendix A identifies the system location, name, water source, class, and total capacity. Group A water systems serve 15 or more connections or 25 or more people per day for 60 or more days per year. Group B water systems serve fewer connections than Group A systems.

Table 8
Capacity of Public Water Systems

Subbasin		Total Capacity	
		gpm	**cfs**
1	White River	80	0.18
2	Little Wenatchee River	0	0.00
3	Lake Wenatchee	1,060	2.36
4	Chiwawa River	163	0.36
5	Nason Creek	582	1.30
6	Chiwaulkum Creek	60	0.13
7	Cabin Creek	0	0.00
8	Chumstick Creek	158	0.35
9	Icicle Creek	2,800	6.25
10	Peshastin Creek	505	1.13
11	Derby Canyon	10	0.02
12	Ollala Canyon	478	1.07
13	Mission Creek	115	0.26
14	Nahahum Canyon	0	0.00
15	Warm Springs Canyon	29,930	66.82
16	No. 1 & 2 Canyons	102	0.23
17	Upper Wenatchee River	5,795	13.34
18	Lower Wenatchee River	6,015	13.43
	Total	**47,853**	**107.20**

gpm - gallons per minute
Source: Washington State Health Department database for Class A and B systems.

Surface Water

Watershed Hydrology

Hydrology is the study of the occurrence, circulation, distribution and properties of the earth's waters and their reaction to the environment. Water occurs in the form of rain and snow and then circulates as groundwater and surface water. In the Wenatchee River Watershed, precipitation mostly falls as snow and accumulates to create the winter snowpack. The warmer temperatures and rain of spring and early summer melt the snowpack, generating water to supply streamflow. A portion of the melt water, as well as some of the rain water, also infiltrates down through the soil to become groundwater. Later on, this same groundwater discharges to the river and tributaries, and supplies much of the streamflow from late summer through winter. The continual movement of precipitation, surface water runoff, infiltration, surface and subsurface storage, groundwater discharge, and evapotranspiration between the earth and atmosphere is referred to as the hydrologic cycle. An illustration of the hydrologic cycle is shown in Figure 3.

The main surface water feature of the Wenatchee River Watershed is the Wenatchee River, which has its source at Lake Wenatchee. Four large tributaries join together at or near Lake Wenatchee to form the Wenatchee River: the Chiwawa River, White River, Little Wenatchee River, and Nason Creek. The river then flows southeasterly though the Wenatchee Valley and discharges to the Columbia River at Wenatchee. The drainage area of the Wenatchee River is 1,328 square miles. The Wenatchee River Watershed is confined by the Entiat mountains to the northeast, the crest of the Cascade range to the northwest, and the Wenatchee mountains to the southwest. The Wenatchee River Watershed also includes areas along the west side of the Columbia River from Rocky Reach Dam downstream to the south end of the City of Wenatchee. The total watershed area is 1,371 square miles.

Most of the streamflow in the Wenatchee River Watershed originates from several large tributaries in the upper portion of the watershed. Five tributaries - the Chiwawa River, White River, Little Wenatchee River, Nason Creek and Icicle Creek - are the source of over 94 percent of the surface water within the watershed (based on 1992-1993 measurements), whereas their drainage area represents only 58 percent of the total watershed area. Figure 4 shows the relative amount of streamflow that each tributary contributes to the Wenatchee River.

Available Data

Streamflow in the Wenatchee River Watershed has been measured and recorded at many gauging stations located on the Wenatchee River and associated tributaries. In general, measured streamflows from stream gauges in the upper watershed (above Leavenworth) have not been greatly affected by consumptive water usage because the streams drain mostly undeveloped mountainous areas. Water supply for small domestic systems and a single irrigation diversion near Plain are the only uses. Stream gauges that are located near the lower ends of stream basins, particularly on the Wenatchee River and in tributaries below Leavenworth, have measured streamflow that has been affected by water usage for irrigation, water supply, and other activities. This has resulted in reduced streamflow rates and/or modified seasonal runoff patterns. An analysis to determine what the natural streamflow characteristics would be in the absence of human activities has not been conducted on streams in the Wenatchee River Watershed and was beyond the scope of this assessment report. Therefore, the analysis of streamflows is based on data that reflects and incorporates changes caused by historical water usage.

Streamflow gauging stations with continuous historical flow records are summarized in Table 9. The period of record for stations on principal tributaries and for the main stem of the Wenatchee River is fairly good, with continuous records dating as far back as 1929. However, only four gauges are currently operating: three on the Wenatchee River and one on the Chiwawa River. Several stations that were discontinued in the 1970's and/or 1980's have been recently reactivated.

Data on the remaining perennial streams in the lower portions of the Wenatchee River Watershed are very limited. Continuous records on these streams are generally very short and date from many years ago. For example, the only continuous streamflow data available for Peshastin Creek are for the period of 1911-1912. Gauging stations with short and dated records are not listed in Table 9. Recently, many streams were measured on a semi-monthly basis between October 1992 and September 1993 for the Wenatchee River Watershed Ranking Project (Chelan County Conservation District, 1994). That study provides the only available streamflow data on several small tributaries. However, since these data cover only one year in a drought period, when streamflows in the Wenatchee River were only 67 percent of normal, they may not be representative of long-term conditions. It would be difficult to assess the status of current streamflows in these streams using that data. The location of USGS streamflow gauging stations are shown on Map 1.

Reservoirs in the Wenatchee River Watershed that are used for storage of water for irrigation and water supply are listed in Table 10. Reservoir storage in the Icicle Creek subbasin is used to augment irrigation water used by the Icicle and Peshastin Irrigation Districts. Water is released from these reservoirs and diverted into the irrigation canal at Icicle Creek when there is not sufficient streamflow in Icicle Creek and/or Peshastin Creek to meet the Irrigation District's diversion requirements. Water from these reservoirs is also used to supplement the water for the City of Leavenworth and the U.S. Fish and Wildlife Service hatchery located at Leavenworth.

Table 9
Available Recorded Streamflow Data in Wenatchee River Watershed

Name and Location	USGS Gauge	Drainage Area (sq mi)	River Mile (mi)	Period of Record	Upstream Irrigation or Diversions (acres)
Chiwawa River near Plain	12456500*	170	6.2	1936-1949 1954-1957 1991-1995	None
White River near Plain	12454000	150	6.4	1954-1983	None
Wenatchee River below Wenatchee Lake	12455000	273	---	1932-1958	None
Wenatchee River at Plain	12457000*	591	46.2	1910-1979 1989-1995	1,400 acres supplied by lower Chiwawa River
Icicle Creek above Snow Creek	12458000	193	5.8	1936-1971	Regulation by upstream reservoirs for diversion below gauge
Wenatchee River at Peshastin	12459000*	1,000	21.5	1929-1995	6,900 acres of irrigation
Mission Creek above Sand Creek near Cashmere	12461400	39.8	7.0	1958-1971	None
Wenatchee River at Monitor	12462600*	1,301	7.0	1962-1995	200 cfs to Highline Canal plus an additional 9,000 acres of irrigation upstream

* Indicates currently active stream gauge

Table 10
Storage Reservoirs in Wenatchee River Watershed

Name	Location	Subbasin	Primary Purpose	Normal Active Storage (acre-feet)
Colechuck Lake	Colechuck Creek	Icicle	Irrigation	1,240
Eightmile Lake	Eightmile Creek	Icicle	Irrigation	1,610
Klonoqua Lake	French Creek	Icicle	Irrigation	1,920
Square Lake	Prospect Creek	Icicle	Irrigation	500
Snow Lake	Snow Creek	Icicle	Irrigation	n/a
H&H Reservoir #3	E. Fork Mission Creek	Mission	Irrigation Water Supply	27

Source: Ecology (1994)

Average Annual Flows

A summary of historical average annual flows at various locations within the Wenatchee River Watershed is presented in Table 11. This table includes averages of streamflows that were measured over many years at USGS gauging stations, and also streamflows that were measured during October 1992 to September 1993 for the Wenatchee River Watershed Ranking Project. Streamflows were only 67 percent of average in 1992-1993, probably caused by an extended period of below average precipitation that began in the mid 1980's. However, the percentage of streamflow that each tributary contributed to the Wenatchee River during 1992-1993 is very similar to that indicated by the long-term USGS streamflow measurements.

Based on the 1992-1993 streamflow measurements, the five principal tributaries in the upper watershed - the Chiwawa River, White River, Little Wenatchee River, Nason Creek and Icicle Creek - are the source of over 94 percent of the surface water that is discharged from the Wenatchee River. These five tributaries are all located above Leavenworth and represent only 58 percent of the total Wenatchee River drainage area. The White River is the largest in terms of total flow and also has the highest amount of runoff per square mile. The remaining 42 percent of the drainage area, located below Leavenworth, contributed less than 6 percent of the streamflow to the Wenatchee River. Since these estimates are based on streamflows that were measured during an abnormally dry year, they may not be representative of normal or wet years. Relative streamflow contribution from smaller tributaries would probably be somewhat greater during wetter periods because the smaller streams in the lower watershed would be more affected by drought conditions.

Historical annual streamflows for selected stations with long-term records (greater than about 30 years) are shown in Figures 5-8. Data for these stations are tabulated in Appendix B. The graphs

depict the long term trend of annual runoff at various locations on these rivers. Trends in annual runoff are depicted by a straight line calculated using a linear regression analysis. Also shown on these graphs are total annual precipitation at Lake Wenatchee. Comparison of runoff to precipitation can indicate whether streamflow trends are related to climatic trends.

Based on data trends shown in these graphs, the average annual flows on the Wenatchee River at Plain (Figure 8) have increased by about 200 cfs over the past 80 years, and have shown a smaller increase over the past 60 years at the stream gauge located at Peshastin (Figure 5). Although total flow volume fluctuated widely from year to year, extended periods of higher or lower than normal streamflows occurred at several different times during the last 80 years. For example, the mid-1930's to mid-1940's were particularly dry, followed by a wet period that lasted to about 1960. The early 1970's were a wet period, followed by a dry period in the 1980's. These patterns are also illustrated by the annual precipitation graphs plotted above the streamflow graphs. The average annual flow in Icicle Creek (Figure 6) showed an increasing trend for it's period of record (1936-1971). That period coincides with a cycle from a dry period to a wet period. The average annual flow in the White River (Figure 7) showed a decreasing trend for it's period of record (1954-1983). That period coincides with a cycle from a wet period to a dry period.

The trends indicated by the regression analyses are strongly influenced by the period analyzed. Because of that, it is concluded that there has not been a trend of increasing or decreasing flows in the Wenatchee River Watershed.

Table 11
Average Annual Flows in the Wenatchee River Watershed

Location	Drainage Area		Period of Record Streamflows[b]		1993 Streamflows[c]		
	Square Miles	Percent [a]	Average Annual Volume (acre-feet)	Average Flow (cfs)	Annual Volume (acre-feet)	Average Flow (cfs)	Percent of Outflow[d]
TRIBUTARY INFLOWS							
- White River	150	11.5%	589,000	814	434,000	600	27.6%
- Chiwawa River	187	14.4%	353,000	488	236,000	326	15.0%
- Little Wenatchee River	100	7.7%	---	---	242,000	335	15.4%
- Icicle Creek	211	16.2%	451,000	624	340,000	471	21.7%
- Nason Creek	108	8.3%	---	---	197,000	273	12.5%
- Peshastin Creek	133	10.2%	---	---	74,000	103	4.7%
- Mission Creek	82	6.3%	9,800	13.5	7,200	9.9	0.5%
- Chumstick Creek	78	6.0%	---	---	2,900	4.0	0.2%
- Tributary total	1,049	80.6%	---	---	1,533,000	2,122	97.6%
MAINSTEM FLOWS							
- Wenatchee River at Lk. natchee	273	21.0%	950,000	1,314	819,000	1,133	52.2%
- Wenatchee River at n	591	45.4%	1,636,000	2,262	1,093,000	1,513	69.6%
- Wenatchee River at nastin	1,000	76.9%	2,214,000	3,062	1,474,000	2,040	93.9%
- Wenatchee River at nitor	1,301	100.0%	2,337,000	3,231	1,570,000	2,173	100.0%

a Compared to drainage area of Wenatchee River measured at Monitor.
b From USGS for varying periods of record.
c Based on 20 flow measurements between October 1992-September 1993 (Chelan County Conservation District, 1994). Flows for Chiwawa River and Wenatchee River at Plain, Peshastin and Monitor from daily USGS streamflow records for water year 1993.
d Compared to average flow rate of Wenatchee River measured at Monitor.

Monthly Flow Exceedences

To determine how streamflows have varied historically throughout the year, a statistical analysis using recorded daily streamflows was performed. The analysis produces low, median and high flow exceedence probability estimates for incremental dates during the year. Low flow is defined as the 90 percent exceedence probability, and is equal to the flow rate that occurred 9 years out of 10 for a particular period of time. Median flow is defined as the 50 percent exceedence probability, and is equal to the flow rate that occurred five years out of ten. High flow is defined as the 10 percent exceedence probability, and is equal to the flow rate that occurred one year out of ten.

Figures 9-16 present the results of the monthly flow exceedence analysis. The analysis was conducted on four Wenatchee River stream gauges and four tributary stream gauges. The data are also tabulated in Appendix B. The WAC instream flows are also shown on the figures where applicable. WAC instream flows are discussed in the **Water Demand** section.

The flow exceedence curves show the peak annual flows occurring in late May and early June, at the peak of the spring snowpack melt. The lowest annual flows occur in late September and early October prior to the start of the fall rains. Flow rates increase moderately during the mid winter in response to runoff from winter storms and then fall to another low flow period (but not as low as in the fall) in early spring. Flow rates decrease by ten- to twelvefold on average between the times of peak runoff and low flows on the Wenatchee River and most tributaries. Mission Creek experiences an even larger drop (fifteen fold) in flow rate between the spring peak and fall low flow. The volume of runoff on the Wenatchee River for the months of May through July averages 57 percent of the total annual runoff volume.

Streamflow records show that during mid-September, when the lowest flows of the season occur, flow rates in the Wenatchee River remain constant from about Leavenworth to the mouth. Gauging records from Peshastin and Monitor indicate that the flow rate in this reach drops to an annual low of approximately 730 cfs during average flow years and 430 cfs during dry years (50 percent and 90 percent exceedence flows, respectively).

Low Flows

Trends in late summer and fall streamflows do not always correspond to trends in annual flows because the majority of runoff volume occurs during the period of spring runoff. Trends in low flows are best evaluated by examining the historical trend in annual 7-day flows. The 7-day low flow is defined as the average of the seven lowest consecutive flow days in each year.

Historical 7-day low flows with their trends for streamflow stations in the Wenatchee River Watershed are shown in Figures 17-24. Annual average flows are also shown on these graphs to enable comparison of annual average and annual low flow trends. In general, the trend over about the last 80 years at all locations where streamflow records are available is a slight increase in annual 7-day low flows. However, short-term cycles are present within this 80-year period, resulting in periods when streamflows appear to be decreasing. For example, when streamflow records for the period since about 1960 are examined, a slight decreasing trend in 7-day low flows is apparent. This recent trend was caused by relatively high low flows in the 1960's, and very low flows in the late

1970's and late 1980's. When the entire 80-year streamflow record is examined, it could be seen that these recent low flows were very similar in magnitude to low flows that occurred during the late 1930's and early 1940's. As a result, the 1930-1960 period shows an increasing trend in annual 7-day low flows.

In general, the trend in annual 7-day low flows closely match the trend in average annual flows. Therefore, it does not appear that summer streamflows are changing over time any differently than average annual flows. This indicates that the apparent trend in summer low flows could be caused by overall climatic trends, which affects streamflows year-round, rather than by activities such as irrigation withdrawal that consume water only during the summer.

In conclusion, the trend in annual 7-day low flows appears to be largely determined by long-term climatic cycles, with the 1930's and 1980's both representing low points in the cycle. This pattern in streamflows makes it appear that annual 7-day low flows have been decreasing in magnitude over the last 30 years. However, without further analysis of streamflow and water use data, this trend cannot be attributed to anything but the long-term climatic cycle.

Excursions of WAC Instream Flows

Figures 9 - 13 compare instream flows established in Chapter 173-545 WAC to the monthly flow exceedence curves. (WAC instream flows for the Wenatchee River Watershed are discussed in the **Water Demand** section). In general, the instream flow standard lies at about the 50 percent (median) flow exceedence line during late summer and early fall, and below the 90 percent (low) flow exceedence line during the period of spring runoff and extending to about the beginning of August. During August and early September the instream flow standard lies between the 50 percent and 90 percent exceedence line. The Mission Creek plot (Figure 11) shows the WAC instream flows for Mission Creek near Cashmere, whereas the flow data are from a gauge located further upstream. Due to the large difference in drainage area between the two gauges (81.2 square miles and 39.8 square miles, respectively), a conclusion could not be reached by a comparison of instream flows to flow exceedence statistics.

A summary of average monthly and annual WAC instream flow excursions is contained in Table 12. This summary represents a comparison of the WAC instream flows to the total record of available streamflow data. The number of excursions varies considerably from year to year depending on the natural variability of streamflow. Average excursion data for Mission Creek is not shown in Table 12 for the reasons described in the previous paragraph.

Table 12
Summary of Excursions of WAC Instream Flows

Month	Percent of Time Instream Flow Not Met			
	Wenatchee River at Plain	Icicle Creek near Leavenworth	Wenatchee River at Peshastin	Wenatchee River at Monitor
January	19	12	18	21
February	16	12	13	10
March	17	19	10	4
April	7	6	6	3
May	1	2	1	1
June	3	3	1	1
July	12	12	11	8
August	27	33	30	20
September	52	40	57	43
October	41	37	45	37
November	16	23	17	10
December	15	17	18	12
Annual	**19**	**18**	**19**	**14**

The number of excursions from WAC instream flows during the historical streamflow records are shown as a function of time in Figures 25 - 28. The total number of instream flow excursions are shown as both annual and June through September totals. Historical trends calculated using a linear regression equation are also shown. In general, a decreasing trend of instream flow excursions is evident over the last 80 years on the Wenatchee River at Plain and Peshastin, but an increasing trend is apparent over the last 30 years at Monitor. The trends in total annual excursions are decreasing faster than the June-September excursions, indicating that excursions during the winter are becoming less frequent than excursions during the summer.

The difference in the trend of instream flow excursions over the last 80 years versus the last 30 years was also observed in the graphs of trends in annual 7-day low flows. Again, the linear regression trends appear to be influenced by the low flow periods in the 1930's and 1980's. The slope of the trend line, whether increasing or decreasing, depends on whether those historical low flow periods are present in the streamflow record being examined. Although the graph of instream flow

excursions on the Wenatchee River at Monitor (Figure 25) shows a two to three-fold increase in excursions over the last 30 years, this can be attributed to the relatively high streamflow conditions of the 1960's and the relatively low streamflow conditions in the 1980's. The apparent trend would be quite different if a longer streamflow record were available at Monitor. In fact, the late 1930's and early 1940's were considerably worse in terms of instream flow excursions than the mid to late 1980's.

Hydrogeology

Geology

Much of the Wenatchee River Watershed falls within a geologic province known as the Chiwaukum graben, an erosional lowland developed on downdropped sandstone and shale. Areas outside of the Chiwaukum graben generally have bedrock consisting of granitic and metamorphic rocks. These rocks form a complex arrangement of geologic terrains, that are, in places, fractured, folded and faulted.

During the last large scale glaciation, more than 10,000 years ago, the Wenatchee River Watershed was filled with a large valley glacier that extended from the Cascade Crest. The glaciers, and associated features, deposited several different geological units, including:

lacustrine deposits - silts and clay deposited as lake bottom sediments behind glacial ice or moraine dams.
outwash deposits - advancing and retreating glaciers deposit primarily sand and gravel sediments in front of the glacier from glacial meltwater.
till - a very dense, poorly sorted mixture of clay, silt, sand and gravel, deposited directly beneath glacial ice.

These sequences of unconsolidated materials are generally present as valley fill and along valley walls as terraces.

More recently modern rivers have scoured the bedrock and glacial deposits and redeposited them as sand and gravel terraces and plains. A review of well logs, and previous reports indicates that the valley fill and terrace deposits may be more than 150 feet thick in areas.

Aquifer Characteristics

Groundwater in the Wenatchee River Watershed is present in two major flow systems; a bedrock flow system and a surficial flow system present in sediments overlying bedrock.

While many domestic wells within the watershed do penetrate bedrock, yields are generally low, less than one gpm. Some bedrock wells reportedly have yields up to 15 gpm. The bedrock wells are not considered viable sources for significant groundwater development. Many of the domestic wells penetrating bedrock have found reliable sources of water contained in the sandstone. Often a thin zone of relatively high permeability weathered bedrock may be present, that also contains enough water for domestic development. Recharge to bedrock aquifers is derived from direct precipitation on bedrock outcrops, and from overlying glacial deposits.

The alluvial and glaciofluvial outwash sediments, that fill river valleys and depressions in the bedrock, are a source for much of the domestic and public water supply. The nature and extent of these fill materials is highly variable, with reported areas of confined aquifer conditions due to overlying lacustrine silts and clays. Well yields in the fill materials reportedly range from less than

5 gpm to over 100 gpm. Recharge to the aquifers is primarily in the form of precipitation infiltration, surface water infiltration, and recharge from deeper bedrock aquifers. Groundwater flow is likely in a down valley direction. Some localized aquifers, such as those found in smaller drainages above the Wenatchee River Valley, will likely be more affected by increased groundwater usage than the larger aquifers located in the Wenatchee River Valley. This is because recharge is limited by the small basin size and low amounts of precipitation occuring in those drainages.

Several well tests have been performed in the Wenatchee River Watershed, with estimates of transmissivity for bedrock aquifers of about 25 ft^2/day and about 1720 ft^2/day for the sand and gravel fill materials (Golder Associates, 1995).

Groundwater\Surface Water Interaction

Reports indicate that groundwater and surface water interact throughout the watershed, depending on the subarea's morphology. Many of the smaller drainages have aquifers in valley fill that are in direct connection with surface water and the water levels generally respond together. In all cases, interaction between surface water and groundwater within the watershed is largely dependent on the highly variable geologic conditions. Generally, increased withdrawal from groundwater will result in a decrease in recharge to surface water at some point. Ultimately, most all groundwater within the watershed eventually flows to surface water or another aquifer.

Water Demand

Water Rights Permits and Certificates

Since the adoption of the state surface and groundwater codes, the only means of acquiring a Water Right within the state is by filing for, and receiving, a Permit and/or subsequent Certificate from Ecology or one of its predecessors. One exception is allowed under the domestic exemption to the groundwater code (RCW 90.44). For this portion of the report only Permits and Certificates were used.

When a water user or future water user (applicant) expects to use any amount of surface water for any purpose, or in the case of groundwater (well) use more than 5,000 gallons per day for domestic or industrial purposes and/or irrigate more than 1/2 acre; the applicant must file a Water Right Application with Ecology. If Ecology determines that water is available for a beneficial use, that the use will not impair other rights and is not detrimental to public interest, it issues a Water Right Permit, which allows the applicant to proceed with the project. Upon project completion Ecology issues a Certificate documenting the actual perfected, authorized water use.

A summary of Surface Water and Groundwater Rights, Permits and Certificates issued in the Wenatchee River Watershed is contained in Table 13 and are divided by subbasin in Tables 14 and 15. The data in Tables 13 - 15 represent "paper" rights for active Permits and Certificates. Paper rights generally do not give a good indication of actual consumptive use for several reasons including: many permits do not use their full allocation, irrigation usage varies seasonally and yearly depending on weather, domestic usage by individuals is not represented (i.e., exempt groundwater wells) and there may be illegal usage of water.

The historical growth of Water Rights Appropriations in the Wenatchee River Watershed is shown in Figures 29 and 30. The graphs show that appropriations for both surface and groundwater increased steadily during the last several decades, but has leveled out since the early 1980's.

The purpose of use of Water Rights Permits is also summarized in Table 13 and shown graphically in Figures 31 and 32. In terms of annual quantity, about 67 percent of issued surface water rights is for irrigation use, 16 percent is for municipal water supply, and 14 percent is for commercial and industrial use. Groundwater rights issued for irrigation use represents 17 percent of the total groundwater rights, with domestic and municipal water supply, commercial and industrial, and fish propagation all making up the remainder as major groundwater users. Water rights issued for irrigation usage comprise 55 percent of the total quantity of surface and groundwater rights issued in the Wenatchee River.

Maps 2 and 3 illustrate the distribution of Water Rights Permits and Certificates within the Wenatchee River Watershed.

A total of 420 cfs and 81,012 acre-feet in Water Rights Permit and Certificates have been issued in WRIA 45. Of that total, 357 cfs and 61,857 acre-feet are Surface Water Rights and Certificates, and 63 cfs (28,300 gpm), and 19,155 acre-feet are Groundwater Rights and Certificates.

Table 13
Summary of Water Rights Permits and Certificates

Type and Purpose of Use	Qi Instantaneous Rate		Qa Annual Quantity		Permit Holders		Irrigated acres
	cfs	Percent of Total	ac-ft/yr	Percent of Total	Number	Percent of Total	
Surface Water Permits and Certificates							
Comm/Indust.	35	10%	8,561	14%	9	2%	0
Domestic	19	5%	702	1%	302	62%	0
Irrigation	271	76%	41,508	67%	137	28%	32,054
Municipal	26	7%	10,145	16%	9	2%	0
Other	6	2%	941	2%	34	7%	12
Subtotal	**357**	**100%**	**61,857**	**100%**	**491**	**100%**	**32,066**
Groundwater Permits and Certificates							
Comm/Indust.	6.8	11%	1,981	10%	10	3%	0
Domestic	23.3	37%	4,499	23%	244	69%	0
Irrigation	16.3	26%	3,285	17%	81	23%	1,139
Municipal	5.3	8%	2,327	12%	5	1%	0
Other	0.1	0%	686	4%	12	3%	0
Fish Propagation	11.3	18%	6,377	33%	2	1%	0
Subtotal	**63.1**	**100%**	**19,155**	**100%**	**354**	**100%**	**1,139**
Total	**420.1**	**---**	**81,012**	**---**	**845**	**---**	**33,205**

Table 14
Surface Water Rights, Claims and Applications in Wenatchee River Watershed Subbasins

Subbasin		Permits and Certificates			Claims			Applications		
		Qi (cfs)	Qa (ac-ft/yr)	Number	Qi (cfs)	Qa (ac-ft/yr)	Number	Qi (cfs)	Qa (ac-ft/yr)	Number
1	White River	0.9	14	9	3.4	682	5	0.1	n/a	1
2	Little Wenatchee River	1.0	4	3	0.0	0	0	0.0	n/a	0
3	Lake Wenatchee	3.8	239	134	2.0	236	84	0.6	n/a	21
4	Chiwawa River	35.6	4,786	7	32.1	6,408	6	0.7	n/a	1
5	Nason Creek	3.5	693	27	6.8	1,314	35	0.9	n/a	3
6	Chiwaulkum Creek	0.5	0	3	0.4	74	3	0.0	n/a	0
7	Cabin Creek	1.0	0	3	0.0	0	0	0.0	n/a	0
8	Chumstick Creek	8.2	1,148	54	36.4	7,226	99	0.0	n/a	1
9	Icicle Creek	205.4	29,631	23	9.5	1,890	13	8.8	n/a	5
10	Peshastin Creek	1.2	141	16	84.2	16,796	36	0.7	n/a	1
11	Derby Canyon	0.4	81	8	1.1	216	6	0.0	n/a	1
12	Ollala Canyon	7.2	258	21	2.6	472	42	0.1	n/a	1
13	Mission Creek	1.6	49	5	8.5	1,684	24	1.0	n/a	1
14	Nahahum Canyon	1.5	267	26	3.7	686	28	0.7	n/a	3
15	Warm Springs Canyon	14.8	5,724	4	1.8	348	14	0.0	n/a	0
16	No. 1 & 2 Canyons	40.5	9,814	23	6.9	1,330	46	1.7	n/a	5
17	Upper Wenatchee River	9.6	1,333	65	4.8	832	85	0.8	n/a	4
18	Lower Wenatchee River	20.3	5,646	54	403.5	80,598	120	4.3	n/a	7
	Total	357.0	59,828	485	607.7	120,792	646	20.4	n/a	55

Note: Small differences in values between this table and Table 13 are due to incomplete information on section-township-range data in the WRIS database.

n/a = not available - quantities not specified in Applications.

Table 15
Groundwater Rights, Claims and Applications in Wenatchee River Watershed Subbasins

Subbasin		Permits and Certificates			Claims			Applications		
		Qi (gpm)	Qa (ac-ft/yr)	Number	Qi (gpm)	Qa (ac-ft/yr)	Number	Qi (gpm)	Qa (ac-ft/yr)	Number
1	White River	350	22	1	18	4	2	661	n/a	1
2	Little Wenatchee River	0	0	0	0	0	0	0	n/a	0
3	Lake Wenatchee	151	117	4	342	76	38	386	n/a	7
4	Chiwawa River	78	44	2	27	6	3	514	n/a	2
5	Nason Creek	770	159	11	270	82	22	2,555	n/a	6
6	Chiwaulkum Creek	50	1	1	18	6	2	0	n/a	0
7	Cabin Creek	0	0	0	9	2	1	0	n/a	0
8	Chumstick Creek	2,194	523	103	1,215	446	61	250	n/a	7
9	Icicle Creek	5,178	6,381	5	369	136	16	135	n/a	4
10	Peshastin Creek	315	229	3	558	156	50	26	n/a	1
11	Derby Canyon	190	20	3	171	62	9	20	n/a	1
12	Ollala Canyon	445	135	7	720	180	75	99	n/a	1
13	Mission Creek	1,302	639	16	2,556	1,102	42	250	n/a	2
14	Nahahum Canyon	774	345	25	423	166	13	21	n/a	2
15	Warm Springs Canyon	377	152	6	117	32	12	30	n/a	1
16	No. 1 & 2 Canyons	4,645	2,510	10	4,410	1,910	34	181	n/a	2
17	Upper Wenatchee River	3,446	3,054	47	2,232	644	188	3,886	n/a	18
18	Lower Wenatchee River	8,924	4,778	107	13,860	5,096	671	294	n/a	9
	Total	29,188	19,106	351	27,315	10,106	1,239	9,308	n/a	64

Note: Small differences in values between this table and Table 13 are due to incomplete information on section-township-range data in the WRIS database.

n/a= not available - quantities not specified in Applications.

Water Rights Claims

The Claims Registration Act, Chapter 90.14 RCW, sought to document existing surface water and groundwater uses prior to adoption of the State Surface Water Code, Chapter 90.03 RCW, and the State Groundwater Code, chapter 90.44 RCW. These laws were adopted in 1917 and 1945 respectively. During the Claims Registration period, water users completed a long form to claim detailed uses for domestic and irrigation needs, and completed a short form for a single domestic use with up to 1/2 acre for non-commercial lawn and garden.

While the accuracy of the data on some Claims is questionable, the final determination of the validity and extent associated with a Claim registered in accordance with RCW 90.14 ultimately lies with the Superior Court through the general adjudication process provided for by RCW 90.03.110 through 90.03.240. Therefore, for the purpose of this report, the quantities shown on the Claims documents were used. If a Claim did not specify a water quantity, Ecology used the estimates contained in Table 16 below.

Table 16
Estimates Used for Claims Not Specifying a Water Quantity

Use	Groundwater	Surface Water
Single Domestic Use (up to 1/2 acre)	9 gallons per minute (gpm) instantaneous use and two acre-feet annual use	0.02 cubic feet per second (cfs) instantaneous use and two acre-feet annual use
Irrigation (per acre)	9 gpm instantaneous use and four acre-feet annual use	0.02 cfs instantaneous use and four acre-feet annual use

Water Rights Claims received by Ecology for the Wenatchee River Watershed are summarized in Table 17 and are also detailed by subbasin in Tables 14 and 15. Surface Water Claim volumes are much greater than Surface Water Permits volumes. Quantities of Groundwater Claims are less than those for Groundwater Permits in most subbasins, but are still significant.

The distribution of Water Rights Claims in the Wenatchee River Watershed is illustrated in Maps 4 and 5.

Table 17
Summary of Water Rights Claims

Type	Qi Instantaneous Rate (cfs)	Qa Annual Quantity (ac-ft/yr)	Number of Claims
Surface water	608	120,792	646
Groundwater	61	10,106	1,239
Total	**669**	**130,898**	**1,885**

Water Rights Applications

Pending Groundwater and Surface Water Applications are summarized by subbasin in Tables 14 and 15. Fifty-five applications for Surface Water Permits are pending requesting a total of 20.4 cfs (annual quantities are generally not listed in the applications). Most of the Surface Water Applications are located in the Lake Wenatchee subbasins, the Icicle Creek subbasin, and the Upper and Lower Wenatchee River subbasins below Leavenworth. The total quantity of Surface Water Applications is approximately 2 percent of existing permits, certificates and claims.

Applications for Groundwater Permits total 64 for 9,308 gpm (20.8 cfs). Nearly 75 percent of the water requested in the Groundwater Applications is located in the Nason Creek and Upper Wenatchee River subbasins, and is likely associated with domestic water systems. The total quantity of Groundwater Applications is equal to 16 percent of existing permits, certificates and claims.

The distribution of Water Rights Applications in the Wenatchee River Watershed is illustrated in Maps 6 and 7.

Instream Flows

Instream flows were established by rule in 1983 for three reaches on the Wenatchee River, one reach on Icicle Creek and one reach on Mission Creek. The instream flows are set in Chapter 173-545 WAC (included in Appendix C). Future consumptive Water Rights for diversion of surface water from the main stem of the Wenatchee River and perennial tributaries are subject to these instream flows as measured at the appropriate stream gauge, preferably the nearest one downstream. Chapter 173 - 545 WAC also stipulates that Peshastin Creek is subject to a June 15 to October 15 closure for protection of instream values. With few exceptions, these instream flows do not affect water rights that were in existence prior to 1983, single domestic and stockwater use, and nonconsumptive uses that are compatible with the purposes of the instream flows.

Table 18 lists the five stream reaches (called stream management units) affected by the instream flow criteria set in Chapter 173-545 WAC. Control stations are USGS streamflow gauging stations. Instream flow rates for each reach are tabulated in Table 19.

Table 18
WAC Stream Management Units in Wenatchee River Watershed

Control Station	Stream Gage	River Mile	Stream Management Reach
Wenatchee River at Plain	12-457000	46.2	From Plain Road Bridge RM 46.2, to headwaters
Icicle Creek near Leavenworth	12-458500	1.5	From headwaters of Icicle Creek to its mouth
Wenatchee River at Peshastin	12-459000	21.5	From confluence of Derby Creek to Plain Road Bridge, RM 46.2 excluding Derby Creek and Icicle Creek
Wenatchee River at Monitor	12-462500	7.0	From mouth to confluence of Derby Creek, including Derby Creek and excluding Mission Creek
Mission Creek near Cashmere	12-462000	1.5	From Mission Creek headwaters to its mouth

Table 19
WAC Instream Flow Requirements in Wenatchee River Watershed

Month	Day	Instream Flow from WAC (cfs)				
		12-457000 Wenatchee River at Plain	12-458000 Icicle Creek near Leavenworth	12-459000 Wenatchee River at Peshastin	12-462000 Mission Creek near Cashmere	12-462500 Wenatchee River at Monitor
Jan	1	550	120	700	6	820
	15	550	120	700	6	820
Feb	1	550	120	700	6	820
	15	550	120	700	6	800
Mar	1	550	150	750	6	800
	15	700	170	940	11	1040
Apr	1	910	200	1300	22	1350
	15	1150	300	1750	40	1750
May	1	1500	450	2200	40	2200
	15	2000	660	2800	40	2800
Jun	1	2500	1000	3500	28	3500
	15	2000	660	2600	20	2400
Jul	1	1500	450	1900	14	1700
	15	1200	300	1400	10	1200
Aug	1	880	200	1000	7	800
	15	700	170	840	5	700
Sep	1	660	130	820	4	700
	15	620	130	780	4	700
Oct	1	580	130	750	4	700
	15	520	130	700	5	700
Nov	1	550	150	750	6	800
	15	550	150	750	6	800
Dec	1	550	150	750	6	800
	15	550	150	750	6	800

Environmental Assessment

Water Quality

The Wenatchee River is designated *Class AA* (excellent) status by the State of Washington (Standards for Surface Waters, Chapter 173-201A-130 WAC, 1992) from its headwaters to the Wenatchee National Forest boundary near Leavenworth. The remainder of the river, to its confluence with the Columbia River, is designated *Class A* status. This classification requires the Wenatchee to meet or exceed the standards for all designated beneficial uses, including: water supply, stock watering, fish and shellfish, wildlife habitat, and commerce and navigation. Water quality standards have been developed to maintain these beneficial uses. Notably, dissolved oxygen shall exceed 8.0 mg/L; temperature shall not exceed 18.0 degrees Celsius; pH shall be within the range of 6.5 to 8.5; and toxic concentrations shall be below levels which adversely affect water uses, public health, or aquatic biota (as per WAC 173-201A-040 and WAC 173-201A-050). The Wenatchee River Watershed was the subject of the 1994 *Wenatchee River Watershed Ranking Project* by the Chelan County Conservation District. For that study, water quality samples were collected from twenty sites in the watershed from October 1992 to September 1993.

The 303(d) report (Butkus, S., 1994) is a list submitted by the Department of Ecology to the U.S. Environmental Protection Agency (EPA) as required by Section 303(d) of the Clean Water Act. The list contains all those surface water body segments that fail to meet state water quality standards. The Wenatchee River was included on the list because of failures to meet water quality standards including temperature, dissolved oxygen, and pH. Table 20 lists the locations of monitoring stations on the Wenatchee River that experienced non-compliance with state water quality standards.

In addition to the above violations, water quality data collected in 1992 and 1993 for the Wenatchee River Watershed Ranking Project indicate several instances of non-compliance with water quality standards. Dissolved oxygen concentrations dropped below state water quality standards for a Class A river in August/September of both years at one or more sampling locations. Monitored pH levels dropped below the state recommended minimum throughout the sampling period, mainly from December through March. Fecal coliform levels in several tributaries to the Wenatchee (Mission and Chumstick Creeks) greatly exceeded standards. One sample site (Brender Creek) had all samples above the standard of 100 colonies/100 mL, with a maximum sample concentration of 19,900 colonies/100 mL. Samples from several stations exceeded temperature standards in August. The smaller tributaries which have experienced high fecal coliform levels and high temperatures have more intensive land use and are areas of increasing population.

Table 20
Exceedences from Water Quality Standards

Monitoring Station Location	Monitoring Station	Parameters Exceeding Standards	Description of Parameter Exceedence
Wenatchee River at Wenatchee, 1.1 miles from mouth of Wenatchee River.	Ecology ambient monitoring station 45A070	Temperature	3 excursions beyond criteria between 1/1/90 and 1/1/92
Wenatchee River at Wenatchee, 1.1 miles from mouth of Wenatchee River.	Ecology ambient monitoring station 45A070	pH	3 excursions beyond criteria between 1/1/90 and 1/1/92
Wenatchee River near Leavenworth, US Highway 2 bridge.	Ecology ambient monitoring station 45A110	Temperature	3 excursions beyond criteria between 1/1/90 and 1/1/92
Wenatchee River near Leavenworth, US Highway 2 bridge.	Ecology ambient monitoring station 45A110	Dissolved oxygen	3 excursions beyond criteria between 1/1/90 and 1/1/92

Fisheries

Several sources of information were reviewed to identify key fish populations of management concern in the Wenatchee River Watershed. These sources included: 1) the Washington Department of Fisheries' "Washington State Salmon and Steelhead Stock Inventory" (SASSI) database (WDF 1992); 2) the Washington Department of Wildlife's (WDW) "Washington River Inventory System" (WARIS) GIS database; 3) the WDF's "Salmon and Steelhead Production Plan for the Wenatchee River Subbasin" (WDW 1990); and 4) the American Fisheries Society's Pacific salmon "Stocks at Risk" report (Nehlsen et al. 1991). The latter document was prepared as part of the Columbia Basin System Planning program, and was co-authored by the Confederated Tribes and Bands of the Yakima Indian Nation, the Confederated Tribes of the Colville Indian Reservation, and finally the Washington Department of Wildlife. In addition, state instream flow specialists with the Washington Department of Fish and Wildlife were contacted to identify flow-related fisheries issues in the Wenatchee River Watershed.

Species present in the Wenatchee River Watershed are summarized in Table 21. Habitat conditions are also summarized in this table. Based upon the above-named sources, three anadromous fish populations are managed in the Wenatchee River Watershed. These fish populations are:

- Chinook Salmon *(Oncorhynchus tshawytscha)*, spring and summer race;
- Sockeye Salmon *(Oncorhynchus nerka)*; and
- Steelhead Trout *(Oncorhynchus mykiss)*, summer race.

Table 21
Summary of Species Present and Habitat Conditions within the Wenatchee River Watershed

Location	Important Habitat for Species Present	Low Flow	Water Quality	Migration Barriers
White River	Chinook (spring), Sockeye, Bull Trout, Steelhead (summer)	No	Good	impassable falls, high flows
Chiwawa River	Chinook (spring), Steelhead (summer), Bull Trout	No	Good	high gradient, high flows
Nason Creek	Chinook (spring & summer), Steelhead (summer)	Yes	Good	high gradient, high flows
Little Wenatchee River	Chinook (spring), Sockeye, Bull Trout, Steelhead (summer)	Yes	Good	high gradient
Wenatchee River (mainstem)	Chinook (spring, summer & fall), Bull Trout, Sockeye, Steelhead (summer)	Yes	Fair	irrigation diversions, water supply
Wenatchee River (other tributaries to lower mainstem)	Chinook (spring, summer & fall), Steelhead (summer)	Yes	Fair to Poor	irrigation diversions, water supply, impassable falls

A life history bar chart showing the timing of entry, spawning, emergence, rearing and outmigration of the anadromous fish populations in the Wenatchee River Watershed is shown in Table 22.

In addition to those species managed in the watershed, the Wenatchee River contains populations of westslope cutthroat, rainbow trout, mountain whitefish as well as introduced species such as brook trout and golden trout. Tributaries to the Wenatchee are also used by Bull trout *(Salvelinus confluentus)*, a candidate species for the Federal Threatened and Endangered Species List (Hindes, 1994). In Lake Wenatchee, there are five species of salmonids including; sockeye or kokanee, chinook, mountain whitefish, cutthroat trout, and rainbow trout (there are also lake trout in a few other mountain lakes). The WDF has determined that the Wenatchee River Watershed is one of the best salmon producing systems in eastern Washington offering fair to excellent habitat for spawning and rearing (WDF 1990).

Natural barriers such as high gradient tributaries exist within the Wenatchee River Watershed that prevent upstream passage of anadromous fish. For example upstream passage in precluded on the Little Wenatchee River above approximately river mile 7.0 (WDF 1990).

In addition to natural barriers, anadromous fish in the watershed encounter flow patterns typical of the Cascade mountain's eastern slope climates. Streamflows are high during spring and early summer months followed by very low flows during the late summer and early fall, limiting juvenile

salmonid and steelhead habitat during both flow stages. During freshet conditions, low velocity refuge from high flows for juvenile anadromous fish has been replaced by agricultural areas, highways, and other developments that include shoreline armoring and fill in the lower mainstem from Leavenworth to the mouth of the Wenatchee River. In addition to high flow impacts, low flow conditions have been documented by the WDF as a probable major factor limiting juvenile summer chinook and steelhead production in the Wenatchee River during the summer and early fall (WDF 1990).

The Washington Department of Ecology has set instream flow standards for the Wenatchee River. The standards were set through a negotiation process involving Ecology and water user groups. No Instream Flow Incremental Methodology (IFIM) study was conducted to determine optimal flows. The standards set for the Wenatchee River are only applicable to water rights issued after the instream flow standards were established. Therefore, water rights issued before the standards were set are not required to adhere to the Ecology instream flow standards which can result in flows below the established minimum during drought years (WDF, 1990).

It has been determined by the WDF that the dominant factor impacting anadromous fish stocks in the Wenatchee River Watershed is the presence of seven Columbia River Dams downstream of the watershed. These dams limit anadromous fish access to spawning areas and result in stress and physical injury related mortality each year.

Spring Chinook Salmon

The Wenatchee River is one of the few remaining systems above the confluence of the Snake River that supports runs of wild spring chinook. Spring chinook enter the watershed in May and June and migrate upstream to spawn in the mainstem and lower reaches of the Wenatchee River and its upper tributaries, the White, Little Wenatchee, Chiwawa Rivers and Nason Creek. Fish arrive at spawning areas at different times depending on flow conditions in the lower mainstem with arrival time being earlier in low flow years and later during high flow years. The fish spawn in mid-August through early September. Average run size determined during counts conducted in 1991 and 1992 estimated about 4,000 fish (a four year average from 1991 - 1994 was approximately 2,000 fish). Juveniles emerge in spring and rear for about one year before migrating the following spring as four inch smolts.

The Leavenworth National Fish Hatchery supports fish in the Wenatchee River and tributaries in the lower mainstem. The hatchery releases as many as 1.8 million smolts into the Icicle River every year and the juveniles arrive at the mouth of the Columbia River in early May. The average run size for the hatchery is about 4,377 fish. During the late summer and early fall, water quantity and quality problems such as low flows and high temperatures have been reported at the hatchery.

Summer Chinook Salmon

Summer Chinook populations were historically abundant in the mainstem and tributaries of the middle and upper Columbia River drainage, and are still considered healthy in the Wenatchee River Watershed (SASSI, 1992). The majority of the population inhabits the area of mainstem Wenatchee River below Lake Wenatchee. In July, Summer Chinook migrate upstream into the middle and upper Wenatchee River. Fish spawn in the mainstem from late-September through late October. Juveniles emerge from mid-February until about mid-April and remain in the mainstem Wenatchee River for approximately one year before out-migration to the ocean via the Columbia River in April through June. The Summer Chinook return estimate to the Wenatchee River between 1967 - 1987 averaged 12,000 fish; the 1992 estimate was about 6,700 fish for that year (McDonald, 1994).

The major factors which impact summer chinook populations within the Wenatchee River Watershed are barriers to upstream passage, flow conditions, and lack of adequate screening on diversion and intake structures. Summer chinook encounter naturally high gradient tributaries in the Wenatchee River Watershed which prevents upstream passage on the Little Wenatchee River and Icicle Creek above their lower reaches. Reduction in habitat quantity and quality for juvenile and adult fish during both high flow spring conditions and low flow summer and early fall conditions results in annual losses of summer chinook within the Wenatchee River and its tributaries. Additional impacts to the summer chinook population due to inadequate screening facilities on irrigation diversions and intake structures was also reported. However the screens at the diversion of most concern, the Dryden Dam diversion, have been recently upgraded. The performance of the new screens are currently being evaluated by the Bonneville Power Administration, who funded the project. A report will be issued in the near future to address any upgrades that may be needed to optimize the facility.

Steelhead Trout

The Wenatchee River and its tributaries have historically supported productive steelhead trout populations. Although the cause for the reduction of steelhead within the watershed has not been specifically determined, major dams on the Columbia River, commercial fishing pressures, and diversions are likely associated with their decline.

Wenatchee River steelhead were mixed with other upper Columbia River stocks during the Grand Coulee Fish Maintenance Project. During this project, fish from several upper Columbia River watersheds were trapped and released into adjacent watersheds. Population counts of steelhead were historically collected at the Rock Island Dam and included stocks from the Okanogan, the upper Columbia, and 3 other tributaries to the upper Columbia River. The counts conducted in the 1950s averaged 3,722 fish (WDW 1990).

Summer steelhead enter the Wenatchee River Watershed in mid-July and peak in from mid-September through October. Summer steelhead spawn in March through May throughout the Wenatchee River Watershed. Fry emerge during the summer of the same year and rear for one complete year before out-migration to the ocean in the spring.

Steelhead within the Wenatchee River Watershed are a mixed stock. The Wells Salmon and Steelhead Hatchery has planted smolts in the watershed since 1983. Due to the relatively limited number of natural fish identified in the watershed it is believed that hatchery fish have exerted genetic influence on the wild population (WDW 1990).

Sockeye Salmon

Historically, sockeye salmon inhabited several of the lake systems within the mid and upper Columbia River and its tributaries. The development of the mainstem Columbia River hydroelectric projects, and construction of impassable diversions within these watersheds has significantly reduced fish access to spawning areas. Today, Lake Wenatchee and Osoyoos Lake are the only two lakes inhabited by sockeye within this region (WDW 1990).

Sockeye salmon inhabit and spawn in Lake Wenatchee but spawn primarily in the White and Little Wenatchee Rivers located above the lake. Migration up the Wenatchee River begins in late July through early August and continues until fish reach the lake in late August to early September, with spawning beginning in early September and peaking in late September. Average inter-dam run size counts for the ten year period between 1977 - 1986 is about 31, 000 fish. Eggs hatch in the winter or early-spring. Fry emerge in May through June and generally move from the spawning stream into the lake where they rear for one year before out migration (some juveniles remain for up to two additional years) (WDW 1990).

Habitat quality within the Little Wenatchee and White Rivers is considered fair, however, low water temperatures and limited productivity are considered population constraints (WDF, 1990). Similarly, Lake Wenatchee is oligotrophic providing limited primary production within the watershed. Sockeye must compete with the other anadromous species inhabiting the lake, with kokanee proving to be the greatest competitor for food. In addition, bull trout and cutthroat trout as well as other fish species within the lake prey on out-migrating sockeye. Fry emerging from lacustrine redds are particularly susceptible to predation by a number of species. Despite these genetic, environmental, and harvest impacts, the sockeye runs within the Wenatchee River Watershed have maintained genetic viability.

Sockeye were reared at the Leavenworth Fish Hatchery until the facility abandoned propagation in the mid-1960's. Currently, the Chelan County PUD is operating a supplemental program for sockeye. The program rears juvenile fish in net pens within Lake Wenatchee. In addition, the National Marine Fisheries Service (NMFS) has a sockeye program on Lake Wenatchee to determine the feasibility of reintroducing the species to Lake Cle Elum.

Sockeye within Lake Wenatchee support a viable recreational fishery, however, the fishery is closed during years when not enough fish reach the lake. Commercial harvests of Wenatchee sockeye occur primarily in the lower Columbia River. In addition, some ceremonial and subsistence harvests occur within the watershed.

Status of Fish Stocks

Fish population and stock data from the American Fisheries Society (AFS) Threatened and Endangered Fishery Stock Report (Nehlsen et al. 1991) and the Washington State Salmon and Steelhead Inventory (SASSI) were reviewed. The status of stocks in the Wenatchee River Watershed as given in the AFS and SASSI reports is presented in Table 23.

Table 23
Comparison of American Fisheries Society List and Salmon and Steelhead Stock Inventory

Water Body	Stock	AFS Status	AFS Factors	SASSI Status	SASSI Origin	SASSI Type
White River	Chinook Salmon Spring race	*Moderate Risk*	1	Depressed	Native	Wild
Chiwawa River	Chinook Salmon Spring race	No Listing	No Listing	Depressed	Native	Wild
Nason Creek	Chinook Salmon Spring race	No Listing	No Listing	Depressed	Native	Wild
Little Wenatchee River	Chinook Salmon Spring race	No Listing	No Listing	Depressed	Native	Wild
Wenatchee River	Chinook Salmon Summer race	*Special Concern*	1	Healthy	Native	Wild
Wenatchee River	Sockeye Salmon	*Special Concern*	1	Healthy	Native	Wild
Wenatchee River	Steelhead Trout Summer race	*High Risk*	1, 4	Depressed	Mixed	Wild

A description of the headings contained in Table 23 follows.

Water Body

The water body is the river, creek, lake (etc.) that is named in the respective reports as being the place of origin for the identified stock (i.e., where the stock returns to spawn).

Stock

The term stock defines the population of fish that spawn in a particular season and do not breed with other fish that spawn in a different watershed during a different season. These populations contain specific genetic differences that have adapted to the specific characteristics of the water body and season in which they spawn.

AFS Status

The American Fisheries Society has established a list of at high risk (A), at moderate risk (B), or of special concern (C) salmon, steelhead, and sea-run cutthroat trout stocks.

AFS Factors

The American Fisheries Society developed a list of factors that are currently most threatening to the stocks identified in the AFS Status list. The two factors presented in Table 23 are:

1. The present or threatened destruction, modification, or curtailment of stocks habitat or range, as well as mainstem passage and flow problems, and predation during reservoir passage or residence.

4. Other natural or human-created factors affecting the stocks continued existence, such as hybridization, introduction of exotic or translocated species, predation not primarily associated with mainstem passage and flow problems, and competition. This category includes poor ocean survival conditions, as well as, negative interactions with hatchery fish, such as hybridization, competition and disease.

SASSI Status

The WDF Salmon and Steelhead Stock Inventory has established a set of status ratings ranging from Healthy to Extinct. The rating "depressed" presented in Table 23, defines a stock of fish whose production is below levels that are based on available habitat and natural variation in survival rates, but above a level that is likely to result in permanent damage to the stock.

SASSI Origin

Fish Stock origin definitions were developed to attempt to categorize the genetic history of stocks. The assessments of stock origin presented in Table 23 should be considered primary until additional information confirms or refutes the current designations. The definitions of the designations presented in Table 23 are:

1. Native - a stock that has become established outside of its original range.

2. Mixed - a stock that has undergone significant genetic change, hybridization, and/or originated from commingling native and non-native parents.

SASSI Type

This classifications refers to the type of spawning and rearing activity that produced the fish. The definition of the Type presented in Table 23 is:

1. Wild - a stock that is sustained by natural spawning and rearing in the natural habitat, regardless of rearing parentage (includes native).

Water Quality Impacts

Water quality factors which can potentially limit the fish populations in the Wenatchee River Watershed include high summer temperatures, arsenic, and zinc, as well as concentrations of such organo-pollutants as dichlorodiphenyltrichloroethane (DDT) in fish tissues. These problems have been mainly observed in more populated areas of the lower watershed. Besides these factors, water quality can be regarded as good to excellent in the Wenatchee River Watershed. Water quality values in the Wenatchee River Watershed fall within normal ranges for Cascade Range streams. The only water quality problem of concern to salmonid fish in the watershed is warm water temperatures which sometimes exceeds 21°C from July to September during periods of low flow in the lower reaches of the Wenatchee River. In addition, low water temperatures in the winter may also limit salmonid production in the watershed by reducing egg and alevin survival, as well as juvenile survival. The oligotrophic (low nutrient and primary production) nature of water in the Wenatchee River Watershed may also limit salmonid fish production, especially in the more upstream tributaries to river.

Conclusions

The following conclusions can be drawn from the information contained in this report:

- The Wenatchee River Watershed (WRIA 45) encompasses about 1371 square miles. The watershed originates in the Cascade Mountains and extends to the Columbia River. Principal land uses in the Wenatchee River Watershed are forestry, wilderness, agriculture, rangeland, residential development and recreation. Precipitation within the watershed varies from nearly 150 inches per year in the Cascade Mountains to 8.5 inches per year at the City of Wenatchee. Most precipitation occurs in late fall and winter.

- Total annual streamflow in the Wenatchee River averages about 2.3 million acre-feet (measured at the USGS gauging station located at Monitor). A majority of that flow occurs in the spring and early summer from snowmelt runoff.

- There is an estimated 12,479 acres of irrigated area within the portion of WRIA 45 that is tributary to the Wenatchee River. An estimated 21,500 acres of irrigated area is served by water diverted from the Wenatchee River. The additional acreage served is located within the City of Wenatchee and on the east side of the Columbia River in the East Wenatchee area. The volume of water diverted for the 21,500 irrigated acres was estimated to be in the range of 114,000 acre-feet per year. Other land uses such as municipal use much less water than irrigation.

- A total of 420 cfs and 81,012 acre-feet in Water Rights Permits and Certificates have been issued in WRIA 45. Of that total, 357 cfs and 61,857 acre-feet are Surface Water Rights and Certificates, and 63 cfs (28,300 gpm) and 19,155 acre-feet are Groundwater Rights and Certificates. Irrigation is the largest type of water user, with about 67 percent of the volume of the Surface Water Permits and Certificates, but only 17 percent of the volume of Groundwater Permits and Certificates. An additional 1,885 surface water and ground water claims have been registered for a total of 668 cfs and 130,898 acre-feet. There are currently 119 Water Rights Permit Applications on file at Ecology, requesting a total of 41.2 cfs. Most of the Surface Water Applications are located in the Lake Wenatchee, Icicle, Upper and Lower Wenatchee River subbasins. Groundwater Applications are located mostly in the Nason Creek and Upper Wenatchee River subbasins.

- Groundwater resources are present primarily within the sand and gravel valley fill material of the Wenatchee River valley. Aquifers present within the watershed are generally considered to be in hydraulic connection with the surface water bodies, i.e. streams, lakes and rivers. However, insufficient data exists to fully characterize the relationship between surface and ground water within the watershed. Due to the limited nature of surficial aquifers located in smaller drainages above the Wenatchee River Valley, further groundwater development may effect existing wells. Many domestic wells are present in the fractured, weathered, or porous bedrock, but yields are generally too low for large scale development.

- The Washington Department of Ecology has set instream flow standards for the Wenatchee River. The standards were set through a negotiation process involving Ecology and water user groups. No Instream Flow Incremental Methodology (IFIM) study was conducted to determine optimal flows. The standards set for the Wenatchee River are also only applicable to water rights issued after the instream flow standards were established.

- Anadromous fish populations in the Wenatchee River Watershed are both abundant and diverse. This watershed possesses some of the most important anadromous fish resources in eastern Washington.

- Seven Columbia River dams and associated smolt and adult mortality impacts are the dominant factors limiting the production of anadromous fish in the Wenatchee River Watershed from historic levels.

- Rearing habitat for juvenile salmon and steelhead trout may be an important factor limiting production of these fish in the lower Wenatchee River. Rearing habitat for these fish has been reduced due to channelization and bank armoring, which has eliminated much of the shoreline habitat during high flow periods. The shoreline areas serve as important refuge habitat to fish including chinook salmon fry.

- Anadromous fish habitat is limited by extremes in high and low flows which occur throughout the year. Low flows during the late summer and fall may be an important limiting factor to yearling chinook salmon and steelhead trout. The Wenatchee River channel at low flow provides relatively poor cover habitat to rearing anadromous fish.

- Inadequate screening of irrigation diversions may be responsible for some mortality to salmon and steelhead fry in the watershed, however screening problems at the major Wenatchee River diversion at Dryden Dam were recently fixed.

- There is only one small hydroelectric project in the Wenatchee River Watershed. Consequently, impacts to anadromous fish populations by hydroelectric projects located in the watershed are minimal. Future developments of hydroelectric projects and resulting diversions of water in the watershed are not likely because of the important anadromous fish populations present.

- The Wenatchee River Watershed meets Washington State Water Quality Standards in most of the watershed. Water quality problems are evident in smaller drainages such as the Mission and Chumstick drainages. Those drainages also have increasing populations. The Wenatchee River on occasion does not meet water quality criteria for temperature, dissolved oxygen and pH.

Recommendations

The following recommendations for further action are made based on the information contained in this report:

- Prepare detailed water budgets for subbasins or reaches of the Wenatchee River for which Water Rights Permit applications are outstanding and for which water availability issues cannot be resolved with this report. The water budgets should review surface and ground water hydrology, existing uses and instream flows to determine the availability of water.

- Prepare a more in-depth analysis of the available groundwater resources including:

  - A field verification survey of existing wells and approximate groundwater consumption along the Wenatchee River corridor.

  - Develop a network of wells to be used for regular water level measurements to establish long term trends in groundwater availability.

  - Perform aquifer testing to further define aquifer parameters and relationships with surface water and existing users.

- Present instream flow standards for the Wenatchee River were developed through negotiations with state agencies and water users, which were based upon flow frequency records. As a result, relationships between flow and fish habitat are not well quantified in the Wenatchee River drainage. A habitat based method for evaluating flows (e.g., instream flow incremental method) would improve the understanding between present and future flow regimes in the Wenatchee River and habitat quantity and quality.

- Further improvements or replacements of diversion screens and fish bypass systems should be examined as a way a reducing anadromous fish mortality related to water use.

- Reactivate the Mission Creek near Cashmere stream gauge to provide additional data and a means to manage the Mission Creek stream management unit.

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