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INITIAL WATERSHED ASSESSMENT
WATER RESOURCES INVENTORY AREA 47
CHELAN WATERSHED

Open File Technical Report 95-13

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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, geological data, water well log 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 Chelan Watershed (WRIA 47) drains a portion of the east slopes of the Cascade Mountains in north central Washington within Chelan County. The primary feature of the watershed is Lake Chelan, which at 50 miles long and nearly 1,500 feet deep is the largest and deepest lake in Washington. The watershed encompasses approximately 1047 square miles, including 924 square miles that are tributary to Lake Chelan and 123 square miles that drain directly to the Columbia River. The watershed extends from deep within the North Cascade Mountains to the Columbia River at the edge of the Columbia Plateau. Less than 4 percent of the watershed is developed, primarily in the Chelan and Manson areas adjacent to the lower end of Lake Chelan and along the Columbia River near Chelan Falls. North Cascades National Park, Lake Chelan National Recreation Area and Glacier Peak Wilderness occupy most of the upper watershed above the upper end of the lake. The small towns of Stehekin, Holden Village and Lucerne are the only populated areas in the upper basin. The Chelan Watershed is shown on Map 1.

Lake Chelan lies within an elongated fjord basin formed during the Pleistocene glacial period. The lake was formed by an alpine glacier originating in the Cascade Range to the west. The Okanogan Lobe of the Cordilleran ice sheet, which advanced over the Columbia Plateau, blocked the meltwater from the alpine glacier and formed a dam, creating Lake Chelan. Physical characteristics of Lake Chelan are summarized in Table 1.

Table 1
Lake Chelan Physical Data

Maximum depth	1,486 feet
Average depth	474 feet
Total storage volume	15.5 million acre-feet
Active storage volume	676,000 acre-feet
Watershed drainage area	924 square miles
Lake surface area	52.1 square miles
Length	50.4 miles
Average width	1.0 mile
Maximum elevation	1,100 feet
Hydraulic retention time	10.5 years
Average outflow	1.48 million acre-feet/year

Source: Kendra and Singleton (1987)

Watershed Subbasins

The Chelan River watershed was divided into 7 subbasins. The subbasins are shown in Map 1. Table 2 lists the subbasins, their area and which stream they are tributary to. The subbasins represent the division of management by Ecology of water resources in the watershed.

Table 2
Chelan Watershed Subbasins

	Name	Area (square miles)	Tributary to
1	Lake Chelan	732.2	Chelan River
2	Antoine Creek	72.9	Columbia River
3	Swanson/Cooper Gulch	80.8	Lake Chelan
4	Chelan Butte	29.6	Lake Chelan and Columbia River
5	Bear Mountain	39.5	Lake Chelan
6	First Creek	34.6	Lake Chelan
7	Twenty Five Mile Creek	57.4	Lake Chelan
	Total	**1,047**	

Land Use

Undeveloped forests are the primary land use in the Chelan Watershed, occupying about 90 percent of the total area. Most of the forested lands are managed or owned by the U.S. Forest Service and the National Park Service. Only four percent of the Chelan Watershed is currently developed, with the uses shown in Table 3. The primary land use in developed areas is orchard agriculture. The incorporated area of the largest city in the watershed, the City of Chelan, covers approximately five square miles (Harper-Owes, 1989).

Table 3
Existing Land Use Within the Chelan Watershed

Land Use	Area (square miles)	Percent of Total
Lake Chelan	52	5.6
Other Water Bodies	2	0.2
Forested Public Lands	772	83.6
Forested Private Lands	63	6.8
Agriculture – Orchard	18	2.0
Agriculture – Non- Orchard	12	1.3
Residential	2	0.3
Roadways	2	0.2
Commercial and Public Buildings	<1	0.0
Total	**924**	**100.0**

Source: Harper-Owes 1989. This land use survey excludes WRIA subbasin areas that drain directly to the Columbia River.

The total resident population within the Chelan Watershed in 1990 was approximately 7,400. Table 4 summarizes the 1990 population estimate for different areas in the watershed. However, the population within the watershed is characterized by rather large seasonal changes, resulting from fluctuations in the farm labor force, tourism, recreation, and mobile living patterns of retired persons. Many of these seasonal residents were not included in the U.S. Census estimates.

Table 4
Population in Chelan Watershed

Area	1990 Population
Chelan, City of	2,969
Chelan rural, south shore	1,238
Chelan Falls area	295
Chelan area, other	447
Manson district	2,309
Stehekin district	124
Chelan WRIA Total	**7,382**
Chelan County Total	**52,250**

Source: Chelan County Conservation District 1994.

Nearly all of the population resides within the lower Chelan Watershed. A smaller population center also occurs in the Town of Manson. Comparatively few individuals live within upper areas of the basin, and the combined resident population within the Stehekin, Lucerne, and Holden region was estimated at approximately 124. The population of the upper area of the watershed also increases during summer months.

A graph showing the trend in population growth in Chelan County is shown in Figure 1. The population growth of the entire Washington State is included on Figure 1 for comparison. Population growth in the county was below the state average until the 1970's, when the rate of growth accelerated. The population growth in the period of 1970-1990 was 27 percent, and from 1990-1993 was 7.2 percent (1994 Washington State Almanac). Population projections for Chelan County through the year 2010 are shown in Figure 1 and are summarized in Table 5.

Total population within the Chelan Watershed is predicted to increase by 26 percent over the 1990-2010 period, with nearly all of the increase in population occurring in the lower Lake Chelan area. This rate of increase is very similar to what was experienced during the 1970-1990 period, when population increased by 30 percent.

Table 5
Population Growth in Chelan Watershed

Area	Population				
	1970	**1980**	**1990**	**2000**	**2010**
Chelan division	3,962	4,434	4,949	5,751	6,393
Manson division	1,607	1,861	2,309	2,474	2,750
Stehekin division	90	131	124	147	164
Chelan WRIA Total	**5,659**	**6,426**	**7,382**	**8,372**	**9,307**
Chelan County Total	**41,103**	**45,061**	**52,250**	**59,591**	**66,246**

Source: Chelan County Conservation District (1994).
Projections by Office of Finance and Management.

Climate and Precipitation

The climate of the Chelan Watershed is characterized by hot, dry summers and mild to severe winters. Precipitation and temperature vary widely depending on the elevation and proximity to the Cascade Mountains. Locally, Lake Chelan is also a moderating influence on temperatures.

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 Mountains area experience heavy precipitation, with 150 inches annually and snow accumulations of 25 feet or more at their crest. As air masses move east toward the Columbia Basin, moisture progressively decreases, resulting in arid conditions within the lowermost region of the watershed. In the City of Chelan, the average precipitation is 11 inches per year. Winter daily temperatures average 25 degrees to 40 degrees Fahrenheit, with summer temperatures averaging 60 degrees Fahrenheit to 80 degrees Fahrenheit. The average maximum temperature for July is 86.4 degrees Fahrenheit, and the average maximum temperature in January is 19.8 degrees Fahrenheit. Summer thunderstorms occur periodically, and can result in flash flood conditions on local watersheds.

Records from two climatological stations (Stehekin and Chelan) in the watershed show a slight increasing trend in precipitation. Figures 2 and 3 illustrate the trends in precipitation over the last 30 to 60 years for the two 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 except for a period in the mid 1970's. An extended period of below average precipitation occurred in the 1920's through about 1940.

Water Usage In The Chelan Watershed

Irrigation Water Use

The portion of the Chelan Watershed that is tributary to Lake Chelan contains approximately 19,200 acres of agricultural area, of which an estimated 11,520 acres are irrigated orchards. About 60 percent of that acreage (6,919 acres) is contained within irrigation districts. A listing of the districts located within the Chelan Watershed is contained in Table 6. Table 6 also contains information on their irrigated acreage and approximate water use. All irrigation districts obtain their water directly from Lake Chelan or from taps on hydroelectric penstocks that carries most of the lake's outflow. In the past, the Lake Chelan Reclamation District obtained irrigation water from a canal that diverted several small tributaries above the east shore of the lake to Antilon and Wapato Lakes. That system was abandoned in 1976 when the irrigation system was replaced by a 110-mile pipe system that pumps irrigation water directly from Lake Chelan. The area of agricultural development located along the Columbia River but still within the watershed (east of Lake Chelan) was not found.

Table 6
Irrigation Districts in Chelan Watershed

Name	Irrigated acres	Water Source	Water Use	
			Peak (cfs)	Annual (ac-ft)
Lake Chelan Reclamation District	5,931	Lake Chelan	94	18,335
Chelan Falls Irrigation District	361	Lake Chelan	10	n/a
Chelan River Irrigation District	381	Lake Chelan	n/a	n/a
Isenhart Irrigation District	246	Lake Chelan	4.5	n/a

n/a = not available
cfs = cubic feet per second
ac-ft = acre-feet

Municipal Water Use

The primary municipal water users in the Chelan Watershed are listed in Table 7. This table summarizes the population served (both current and estimated for about 20 years in the future), current and future water use, and current permitted water rights. In addition to water rights permitted to these users, Ecology and Chelan County PUD No. 1 in 1992 agreed to make an

additional 20,000 acre-feet of water available for use by others within the Chelan Watershed. (This agreement is included as Appendix A). These water rights will be transferred from the PUD's existing water right certificate for the Lake Chelan hydroelectric power plant.

Table 8 summarizes, by subbasin, the total system capacity for all public water systems located in the Chelan Watershed. The data was obtained from a Washington State Department of Health database of Group A and B water systems. Municipal water use data contained in Table 7 is included in the Table 8 totals.

A listing of the Group A and B water systems within each Chelan Watershed subbasin is included in Appendix B. Table B-1 in Appendix B 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.

Hydroelectric Power Water Use

Nearly all of the water that flows out of Lake Chelan is used for electrical power generation at the Chelan Falls Power Plant. The primary control of discharge from Lake Chelan is through the hydroelectric turbines in the power plant. Water that flows through the power plant discharges to a tailrace channel that empties into the Columbia River. In general, the power plant is operated to maintain the elevation of the lake at maximum pool during the summer recreation season.

Chelan County PUD No. 1, which owns the power plant, has a non-consumptive water right for 4,000 cfs instantaneous withdrawal for the hydroelectric power plant. As discussed in the section titled **Water Rights Applications**, the PUD has a right to an annual use of an unspecified quantity of water. A 1992 agreement with Ecology allows transfer of up to 20,000 acre-feet per year of the PUD's annual allocation for the Chelan Falls Power Plant to new consumptive use water rights within the Chelan Watershed.

Table 7
Municipal Water Use in Chelan Watershed

Name	Population Served		Water Source		Current Water Use		Future Water Use		Water Right	
	Current	Future	Name or Type	Subbasin	Peak (cfs)	Annual (ac-ft)	Peak (cfs)	Annual (ac-ft)	Peak (cfs)	Annual (ac-ft)
Lake Chelan Reclamation District	n/a	n/a	Lake Chelan	Lake Chelan	--- [a]	--- [a]	--- [a]	--- [a]	--- [a]	--- [a]
Chelan County PUD No. 1 – Chelan Falls	295	371	Groundwater	Chelan Butte	0.34	93	0.38	118	1.1	300
Chelan County PUD No. 1 – South Shore and other areas within the Lake Chelan basin[b]	1,238	2,040	Lake Chelan	Lake Chelan	0.96	270	1.45	450	n/a	n/a
City of Chelan	3,959	12,852	Lake Chelan	Lake Chelan	8.1	1,360	16.5	4,316	3.78[c]	896[c]

[a] Municipal supply by Lake Chelan Reclamation District, which serves the Manson area, is included in irrigation amounts in Table 6.

[b] The South Shore system is a future satellite system of the PUD, consolidating existing private systems. Water use numbers shown are for existing private systems.

[c] Ecology granted preliminary permits for an additional 2,400 acre-feet/year and 6.2 cfs in 1992 (City of Chelan 1993).

n/a – not available

Table 8
Capacity of Public Water Systems

Subbasin		Total Capacity	
		gpm	**cfs**
1	Lake Chelan	3,822	8.5
2	Antoine Creek	7,722	17.2
3	Swanson/Cooper Gulch	13,889	30.9
4	Chelan Butte	1,403	3.1
5	Bear Mountain	266	0.6
6	First Creek	277	0.6
7	Twenty Five Mile Creek	396	0.9
	Total	**27,775**	**61.9**

gpm = gallons per minute
Source: State of Washington Health Department (1995).

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 Chelan Watershed, precipitation mostly falls as snow and accumulates to create the winter snowpack. Average annual precipitation varies widely in the watershed, from as much as 150 inches per year at the crest of the Cascade mountains to 11 inches per year in the City of Chelan. Precipitation at the head of the lake at Stehekin is approximately 35 inches per year. A majority of the annual precipitation in the Chelan Watershed falls in the winter and remains as snow. After remaining for several months as winter snowpack, the spring melt releases the water between April and July. The presence of a deep and high elevation snowpack along the Cascade mountains accounts for a long snowmelt period. 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 rivers 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 4.

The majority of the surface water inflow to Lake Chelan originates from two tributaries that flow into the upper end of the lake – the Stehekin River and Railroad Creek. These two streams supply 75 percent of the lake's inflow. Smaller tributaries to Lake Chelan include Fish, Prince and Twenty-Five Mile Creeks.

Nearly all of the outflow from Lake Chelan is diverted through a penstock for hydroelectric power production at the Chelan Falls Power Plant, owned by Chelan County PUD No. 1. The relatively small dam at the outlet was constructed in 1927, causing the lake to rise by approximately 21 feet. Although Lake Chelan is operated as a storage reservoir for power production, the lake level is generally maintained at full-pool during the peak recreational season (June through September). The water level of Lake Chelan can then drop by up to 21 feet during the winter before the spring runoff begins. In general, discharge from the lake is held at a constant 2,000 cfs. However, during spring runoff the average flow rises to approximately 4,000 cfs and during dry years the flow can drop to below 200 cfs during late winter. The rate of outflow can also drop during late summer in order to maintain the lake level at a constant elevation for recreational usage. Water that does not go through the power plant flows through a spillway and down the relatively short Chelan River to the Columbia River. Discharge from the power plant flows directly to the Columbia River through a tailrace canal.

A detailed yearly water budget for Lake Chelan was prepared for the Lake Chelan Water Quality Assessment Project (Harper-Owes, 1989), and is summarized in Table 9. The water budget was based on streamflow and precipitation data that was collected between December 1986 and November 1987 and then adjusted to reflect long-term conditions. Average annual inflow to Lake Chelan is estimated to be approximately 1.6 million acre-feet, equivalent to a constant flow of approximately 2,200 cfs. The Stehekin River accounts for 65 percent of the total inflow to the lake, Railroad Creek contributes 9 percent, and other smaller tributaries contribute another

21 percent. Precipitation that falls directly on the lake contributes 4.4 percent of the inflow, or approximately 70,000 acre-feet per year.

Table 9
Lake Chelan Water Budget

Component	Annual Quantity		
	Average Volume (acre-feet)	Average Flow	Percent of Total
INFLOWS			
- Stehekin River	1,023,321	1,415	65.2%
- Railroad Creek	147,532	204	9.4%
- Upper basin tributaries	316,759	438	20.2%
- Lower basin tributaries	9,329	12.9	0.6%
- Stormwater runoff	3,254	4.5	0.2%
- Agricultural drains	651	0.9	0.0%
- Direct Precipitation	69,427	96	4.4%
- Total Inflow	**1,570,056**	**2,171**	**100.0%**
OUTFLOW			
- Chelan River	1,487,612	2,057	94.7%
- Irrigation Withdrawal	15,910	22	1.0%
- Evaporation	66,534	92	4.2%
Total Outflow	**1,570,056**	**2,171**	**100.0%**

Source: Harper-Owes, 1989

Total irrigation withdrawal was estimated at about 1 percent of the total outflow, or approximately 16,000 acre-feet per year. Upon review of the water budget, we noted that the estimate of irrigation withdrawals was probably low. Other sources have estimated that 11,520 acres of orchards exist in the watershed. Based on an average water application rate of 3 acre-feet of water per year per acre of orchard, a better estimate of irrigation withdrawals would be 34,560 acre-feet per year, or 2.2 percent of the total outflow from Lake Chelan. An estimate of domestic consumption can also be made by multiplying the population of the watershed by the average annual water use compiled by water districts. Using an average of 250 gallons per day per person (derived from Table 7) and a population of 7,382 (Table 4) the average annual domestic water usage is estimated to be approximately 2,060 acre-feet per year, or 0.1 percent of the total outflow from Lake Chelan.

Available Data

Streamflow in the Lake Chelan basin has been measured and recorded at gauging stations located on the Stehekin and Chelan Rivers and Railroad Creeks. Streamflow gauging stations with continuous historical flow records are summarized in Table 10. The stream gauge on the Chelan River at Chelan includes flow through the hydroelectric turbines, flow over the spillway, and irrigation water that is diverted from the penstocks above the turbines. The period of record for discharge from Lake Chelan is very long, dating back to 1903.

Table 10
Available Recorded Streamflow Data in Chelan Watershed

Name and Location	USGS Gauge	Drainage Area (sq mi)	River Mile (mi)	Period of Record	Upstream Irrigation or Diversions
Stehekin River at Stehekin	12,451,000*	321	1.4	1926-1995	None
Railroad Creek at Lucerne	12,451,500	64.8	---	1927-1957	None
Chelan River at Chelan	12,452,000*	924	---	1903-1995	Regulated for hydropower; 11,520 acres of irrigation

* Indicates currently active stream gauge

Data on the remaining perennial streams in the Chelan Watershed are very limited. The water budget analysis summarized in Table 9 provides an indication of the contribution of the ungauged streams in the watershed to Lake Chelan. Areas in the Chelan Watershed that don't flow into Lake Chelan – the entire Antoine Creek subbasin and parts of Chelan Butte and Bear Mountain subbasins – are arid and contribute very little surface water to the watershed.

Storage reservoirs in the Chelan Watershed are listed in Table 11. Lake Chelan provides a tremendous amount of storage, principally for hydroelectric power production but also for municipal, domestic, and irrigation water supply. Two other reservoirs are owned by Lake Chelan Reclamation District and were formerly used for irrigation supply. However, in 1976 the District converted their irrigation and domestic water supply to Lake Chelan and the lakes are now used for recreation and wildlife enhancement.

Table 11
Storage Reservoirs in Chelan Watershed

Name	Location	Subbasin	Primary Purpose	Normal Active Storage (acre-feet)
Antilon Lake	Johnson Creek	Swanson-Cooper Gulch	Recreation	1,920
Lake Chelan	Chelan River	Lake Chelan	Hydropower	676,000
Wapato Lake	Manson	Swanson-Cooper Gulch	Recreation	2,000

Source: Ecology 1994.

The location of streamflow gauging stations are shown on Map 1. Monthly average flows for the stations listed in Table 10 are tabulated in Appendix C.

Average Annual Flows

Historic average annual flows at the three streamflow gauging stations (Stehekin and Chelan Rivers and Railroad Creek) are shown in Figures 5-7. The data are also tabulated in Appendix C. Average annual flows for the gauging stations are summarized in Table 12. Figures 5-7 depict the long term trend of annual runoff at the gauging stations. Trends in annual runoff are depicted by a straight line calculated using a linear regression analysis. Also shown on the graphs are total annual precipitation at Stehekin. Comparison of runoff to precipitation can indicate whether streamflow trends are related to climatic trends.

Based on data trends shown in the graphs, it is concluded that average annual flows in Lake Chelan have not changed significantly over the period of streamflow gauging. The slight increasing or decreasing trends shown on these graphs are very small and show no consistent pattern from gauge to gauge. The apparent increasing trend for Railroad Creek is caused by a relatively short period of record that started in the abnormally low flow years of the 1930's and ended in the relatively high flow years of the 1950's. Precipitation over this period, as measured at Stehekin, has a very slight increasing trend.

Table 12
Average Annual Flows
at Primary Gauging Stations

Station	Average Annual Flow	
	(cfs)	(ac-ft/yr)
Stehekin River at Stehekin	1401	1,013,000
Railroad Creek at Lucerne	202	146,000
Chelan River at Chelan	2042	1,477,000

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 5 years out of 10. High flow is defined as the 10 percent exceedence probability, and is equal to the flow rate that occurred 1 year out of ten.

Figures 8-10 present the results of the monthly flow exceedence analysis. The analysis was conducted for the three stream flow gauging stations. The data are also tabulated in Appendix C.

The flow exceedence curves show the peak annual flows occurring in early June, and minimum annual flows occurring in late winter. Snowpack melt extends from April through July, augmented by the deep and high elevation snowpack in the North Cascade mountains. Flow rates decrease by thirteen to fifteen-fold on average between the times of peak runoff and minimum flows on the Stehekin River and on Railroad Creek.

Flows recorded at the Chelan River gauging station include the combined discharge from the hydroelectric power plant, the Chelan Dam spillway, and irrigation withdrawals from the power plant penstocks. Since nearly all water flows through the power plant, very little or no streamflow in the Chelan River channel exists except during periods of spill. Therefore, Figure 7 actually represents discharge from Lake Chelan and not flow in the Chelan River.

Low Flows

Trends in late summer and fall streamflows (low flows) 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 Stehekin River and Railroad Creek are shown in Figures 11 and 12. Annual average flows are also shown on these graphs to enable comparison of annual average and annual low flow trends. In general, the trend in annual 7-day low flows closely match the trend in average annual flows. Therefore, low streamflows are not changing over time any differently that average annual flows. Low flows for the Chelan River are not shown because most discharge from Lake Chelan flows through the hydroelectric power plant.

Excursions of Instream Flows

Instream flow restrictions have not been placed on any streams within the Chelan Watershed.

Hydrogeology

Geology

The generalized geology of the Chelan area consists of bedrock geology overlain by sequences of unconsolidated to semi-consolidated glacial, fluvial, colluvial, and lacustrine deposits of silt, sand and gravel.

The bedrock geology is composed primarily of granitic and metamorphic rocks. These rocks form a complex arrangement of geologic terrains, that are, in places, highly fractured, folded and faulted. The bedrock forms the mountain ridges around Lake Chelan. Many of the knolls adjacent to Lake Chelan are a reflection of the underlying bedrock. The fractured and sometime weathered rocks can contain water and can yield it to wells and springs, but these yields are generally low.

During the last large scale glaciation, more than 10,000 years ago, the entire Chelan drainage was filled with a large glacier that extended from the highlands of the Cascades to the west, and ended with the deposition of the moraine under the town of Chelan that holds back the current lake. As the glacier melted it deposited sequences of silt, sand, gravel, and cobbles. These sequences of unconsolidated materials are generally present as valley fill and along valley walls as terraces. Several different geological units comprise the fill deposits, including:

lacustrine deposits – silts and clays deposited as lake bottom sediments behind glacial ice 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.

More recent processes have deposited additional sequences of fill material:

loess – widespread wind deposited silts, generally only 3 to 5 feet thick at the surface

fluvial deposits – primarily sand and gravel, possibly reworked glacial deposits, that modern rivers and streams deposit in drainages throughout the watershed.

lacustrine – modern lake, including Lake Chelan, deposits of silt and clay.

colluvium – loose mixture of rock and soil that occur at the base of slopes.

A review of well logs, and previous reports indicates that the valley fill and terrace deposits may be more than 200 feet thick in areas, but in most areas are generally less than 50 feet thick.

Aquifer Characteristics

Generally speaking, there are two major groundwater flow systems; a bedrock flow system and a surficial flow system present in sediments overlying bedrock. The groundwater flow directions are generally toward Lake Chelan and down basin toward the Columbia River. Harper-Owes (1989) indicate that there does not appear to be flow reversal from Lake Chelan to the groundwater in response to seasonally fluctuating lake levels.

While many domestic wells within the watershed do penetrate bedrock, yields are generally low, and are not considered viable sources for significant groundwater development. Depths of wells penetrating bedrock vary from 100 feet to more than 400 feet. Often a thin zone of relatively high permeability weathered bedrock may be present that contains enough water for domestic development. Recharge to the bedrock flow system is in the form of direct precipitation and snowmelt, and likely through the overlying surficial flow system.

Groundwater within the Chelan Watershed is also present in the sediments that fill valleys and depressions in the bedrock. Generally, the outwash, fluvial, and colluvium sediments are conductors of water, while the lacustrine and till deposits restrict the movement of groundwater. Well yields in the fill materials reportedly range from less than 10 gpm to over 100 gpm. Recharge to aquifers is primarily in the form of rainfall infiltration and snowmelt during spring and early summer. In addition, some groundwater recharge occurs as a result of irrigation on the lower terraces in the Manson area. Some localized aquifers, such as those found in smaller, higher elevation drainages at the south end of Lake Chelan, will likely be more affected by increased ground water usage than larger aquifers lower in the watershed. This is because recharge is limited by the small basin size and low amounts of precipitation occurring in those drainages.

Several pump tests have been performed in the Chelan Watershed, with estimates of hydraulic conductivity for bedrock aquifers of about 1×10^{-3} to 1×10^{-8} cm/sec and about 1×10^{-2} to 1×10^{-5} cm/sec for the silt, sand, and gravel fill materials (Harper-Owes, 1989).

Groundwater\Surface Water Interaction

Reports indicate that groundwater and surface water interact throughout the watershed, depending on the subarea's morphology. Interaction between surface water and groundwater within the watershed is largely dependent on the highly variable geologic conditions. Generally, the groundwater is flowing toward the major surface water bodies, and increased groundwater withdrawal will result in decreased recharge to surface water bodies.

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 Chelan Watershed is contained in Table 13 and are divided by subbasin in Tables 14 and 15. These data represent "paper" rights for active permits and certificates. They also represent rights for consumptive uses only. Non-consumptive uses such as hydroelectric power diversions are not shown in the tables. 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 consumptive use Water Rights appropriations in the Chelan Watershed is shown in Figures 13-14. The graphs show that the appropriation rate for both surface and groundwater was very low until the 1960's and then rose rapidly. Appropriation rates remained high until only recently.

The purpose of use of Water Rights Permits is also summarized in Table 13 and shown graphically in Figure 15. Water rights issued for irrigation make up the largest consumptive use of water in the Chelan Watershed, comprising 59 percent of the total annual quantity and 59 percent of the total instantaneous rate of Surface and Groundwater Rights issued. Fish propagation is the second largest use, followed by municipal and domestic water supply.

The majority of surface water rights issued are for irrigation use, representing 79 percent of the total annual quantity and 63 percent of the total instantaneous rate. Municipal and domestic water supply make up the remaining surface water rights. Groundwater Rights issued for fish propagation make up a large percentage of the total groundwater rights with 68 percent of the total annual quantity and 35 percent of the total instantaneous rate. The place of use for those rights is the hatchery at Wells Dam along the Columbia River. Groundwater rights issued for irrigation use represents 24 percent of the total annual quantity and 38 percent of the total instantaneous rate. Domestic water supply uses comprise only 8 percent of the total annual

quantity of groundwater rights. In addition to these consumptive water rights, Chelan County PUD No. 1 holds a non-consumptive surface water right for 4,000 cfs for the Chelan Falls Power Plant. The power plant uses all of the water that flows from Lake Chelan with the exception of the water used consumptively for irrigation, domestic and municipal use and water directed through the spillway of the plant. As previously discussed 20,000 acre-feet per year has been made available for transfer from the permit for the hydropower plant to future permits for consumptive uses.

Maps 2 and 3 illustrate the distribution of Water Rights Permits and Certificates within the Chelan Watershed. It should be noted that a number of Surface Water and Groundwater Permits and Certificates are located in areas along the Columbia River that are not tributary to Lake Chelan. An estimate of the total volume of Water Rights Permits and Certificates for areas tributary to Lake Chelan only was made. Table 16 summarizes the estimate. It is estimated that Permits and Certificates for an instantaneous rate of 293.2 cfs and an annual water use of 35,900 acre-feet have been issued in the portion of the watershed tributary to Lake Chelan.

Table 13
Summary of Water Rights Permits and Certificates for Consumptive Uses

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	2.7	1%	46	0%	3	0%	0
Domestic	108.8	32%	2,943	7%	531	73%	1
Irrigation	216.5	63%	32,083	79%	158	22%	18,075
Municipal	10	3%	5,400	13%	4	1%	0
Hydropower	n/a[a]	n/a	n/a	n/a	n/a	n/a	n/a
Other	5	1%	65	0%	36	5%	6
Subtotal	**343.1**	**100%**	**40,537**	**100%**	**732**	**100%**	**18,081**
Groundwater Permits and Certificates							
Comm/Indust	0.3	0%	169	1%	2	2%	0
Domestic	19.7	27%	1,886	8%	81	74%	0
Irrigation	27.5	38%	6,011	24%	19	17%	1,494
Other	0.0	0%	2	0%	3	3%	0
Fish Propagation	24.8	35%	16,487	68%	4	4%	0
Subtotal	**72.3**	**100%**	**24,556**	**100%**	**109**	**100%**	**1,494**
Total	**415.4**	**---**	**65,093**	**---**	**841**	**---**	**19,575**

a Hydropower is a non-consumptive use and therefore is not included in this summary. However, a portion of Chelan County PUD No. l's hydropower water right is available for transfer to new consumptive use permits.

Tables 14
Surface Water Rights, Claims and Applications in Chelan Watershed Subbasins[a]

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	Upper Lake Chelan	19.0	365	79	6.6	1,242	52	6.0	n/a	4
2	Antoine Creek	23.4	1,710	38	7.5	1,456	27	18.0	n/a	3
3	Swanson/Cooper Gulch	238.4	30,856	300	23.6	4,444	191	18.0	n/a	19
4	Chelan Butte	38.8	5,344	93	9.3	1,742	74	69.3	n/a	7
5	Bear Mountain	7.4	1,185	42	6.7	1,294	27	1.0	n/a	2
6	First Creek	6.5	825	135	16.7	3,130	135	0.9	n/a	7
7	Twenty Five Mile Creek	9.1	250	44	0.5	68	23	0.0	n/a	0
	TOTAL	342.6	40,536	731	70.9	13,376	529	113.1	n/a	42

[a] Consumptive use permits only. Chelan County PUD No. 1 has a non-consumptive right for the Chelan Falls Power Plant for 4,000 cfs instantaneous withdrawal.

n/a – information not available – not included on Applications.

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

Table 15
Groundwater Rights, Claims and Applications in Chelan 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	Upper Lake Chelan	18	5	3	792	320	20	16	n/a	1
2	Antoine Creek	29,368	23,706	52	567	210	30	7,621	n/a	5
3	Swanson/Cooper Gulch	1,258	264	30	2,034	808	67	3,206	n/a	24
4	Chelan Butte	1,926	500	9	549	226	11	0	n/a	0
5	Bear Mountain	181	53	10	252	96	9	110	n/a	3
6	First Creek	90	14	3	153	46	13	170	n/a	2
7	Twenty Five Mile Creek	45	12	2	0	0	0	0	n/a	0
	TOTAL	32,886	24,554	109	4,347	1,706	150	11,123	n/a	35

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

Table 16
Estimate of Water Rights Permits, Certificates and Applications
for Areas Tributary to Lake Chelan and the Columbia River

Area	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
Tributary to Lake Chelan									
Surface Water	289.1	35,515	667	59.5	11,224	455	94.9	n/a	38
Groundwater	4.1	385	44	7.2	1,270	106	7.6	n/a	27
Total	293.2	35,900	711	66.7	12,494	561	102.5	n/a	65
Tributary to Columbia River									
Surface Water	54.0	5,022	65	11.4	2,152	74	18.2	n/a	4
Groundwater	68.2	24,171	65	2.5	436	44	17.2	n/a	8
Total	122.2	29,193	130	13.9	2,588	118	35.4	n/a	12

n/a – not available - quantities were 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 17 below.

Table 17
Estimates Used for Claims Not Specifying a Water Quantity

Use	Groundwater	Surface Water
Single Domestic Use (up to 1/2 acre)	Nine 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)	Nine 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 Chelan Watershed are summarized in Table 18 and are also detailed by subbasin in Tables 14 and 15. Surface water claim volumes total 13,376 acre-feet, or about 33 percent of the surface water permits volumes. Quantities of groundwater claims total 1,706 acre-feet and are greater than those for groundwater permit volumes in about one-half of the subbasins.

The distribution of Water Rights Claims in the Chelan Watershed is illustrated in Maps 4 and 5. Table 16 provides an estimate of Water Rights Claims for areas tributary to Lake Chelan. It is estimated that Claims for 66.7 cfs instantaneous rate and 12,494 acre-feet annual use exist in areas tributary to Lake Chelan.

Table 18
Summary of Water Rights Claims

Type	Qi Instantaneous Rate (cfs)	Qa Annual Quantity (ac-ft/yr)	Number of Claims
Surface Water	70.9	13,376	529
Groundwater	9.7	1,706	150
Total	**80.6**	**15,082**	**679**

Water Rights Applications

Pending Groundwater and Surface Water Applications are summarized by subbasin in Tables 14 and 15. Forty two applications for Surface Water Permits are pending requesting a total of 113.1 cfs. Most of the applications are for diversions from Lake Chelan along the South Shore and in the Manson area. The diversion rate associated with these applications is equal to 33 percent of currently issued surface water rights permits and certificates for non-consumptive uses.

Future applications to withdraw surface water from Lake Chelan will benefit from a 1992 agreement from Ecology and Chelan County PUD No. 1 that makes an additional 20,000 acre-feet of water available for use by others within the Chelan Watershed. The new Water Rights will be transferred from the PUD's existing Water Right Certificate for the Chelan Falls hydroelectric power plant. In that permit, issued in 1925, the annual quantity of appropriation was not specifically quantified, except that it was subject to existing rights in effect at the time. The 1992 agreement resolved a dispute on the quantity of existing rights and reservations, which was determined to be 45,000 acre-feet per year. Also, at the request of the PUD, a total of 20,000 acre-feet that was authorized under their Certificate was made available for transfer to others. The 20,000 acre-feet can be transferred after the 45,000 acre-feet per year has been allocated. The agreement sets the maximum amount of water that will be available for allocation from Lake Chelan at 65,000 acre-feet per year.

Applications for Groundwater Permits total 35 for 11,123 gpm (24.8 cfs). A large percentage of the applications (7,621 gpm, or 69 percent of the total) are located in the Antoine Creek subbasin, probably for withdrawal from the Columbia River aquifer. Another large quantity (3,206 gpm) is located in the Swanson/Cooper Gulch subbasin. In total, Groundwater Applications are equal to 34 percent of the currently issued Groundwater Rights Permits and Certificates. It is not clear from a reading of the agreement between Chelan County PUD No. 1 and Ecology if Groundwater Permits are subject to the quantity limitations described in the agreement.

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

Environmental Assessment

Water Quality

Lake Chelan is the major body of water in the watershed and the largest natural lake in Washington. The lake is 55 miles long, with an average width of 1.5 miles. There are two major basins within the lake, the larger Lucerne basin (1486 feet deep) and the southern Wapato basin (400 feet deep). Lake Chelan has been the object of two recent studies, including the 1989 Department of Ecology report: *Lake Chelan Water Quality Assessment*, and the 1991 Lake Chelan Water Quality Committee (City and County of Chelan, Chelan County Public Utility District, and Lake Chelan Sewer District and Reclamation District) report: *Lake Chelan Water Quality Plan*. The Lake Chelan Water Quality Plan involved the monthly monitoring of ten lake stations in each of the two lake basins from December 1986 through November 1987. Twenty-three groundwater wells were monitored in selected areas of the lower watershed believed to be influenced by agriculture and septic system inputs. In addition, fourteen fish tissue samples were collected for chemical analysis. Results of these studies are discussed below.

Lake Chelan is currently ultraoligotophic (very low nutrient inputs and concomitant low organic productivity). The water clarity, aesthetic quality, and low pollutant levels of the lake appear to be in relatively stable condition. Lake Chelan is designated Lake Class status by the State of Washington (Standards for Surface Waters, Chapter 173-201A-130 WAC, 1992). This classification requires the lake to meet or exceed the standards for all designated characteristic 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, temperature, and pH shall not diverge from natural conditions; fecal coliform levels shall not exceed 50 colonies/100 mL; 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 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. Lake Chelan was included on this list because of failures to meet water quality and fish tissue standards including pH, 4,4'-DDE, and PCB-1254. The chemical contaminant excursions are for edible fish tissue samples based on a 1992 Ecology report for the Washington State Pesticide Monitoring Program. A summary of exceedences from water quality standards is listed in Table 19.

Potential water quality problems in the lake have been recognized. Wastewater inputs from the growing near-lake population, malfunctioning septic systems (on-site systems), and boat sewerage disposal and storage have been identified as issues to be addressed and managed for the future. This is especially a concern in the southern basin of the lake near the city of Chelan where bacterial concentrations have exceeded drinking water standards. The relatively shallow southern end of the lake is the most densely developed area, as well. Increasing development also increases the inputs of oil and grease, nutrients and chemical contaminants from stormwater runoff. Construction activities have the potential to impact water quality if not managed. Activities occurring within the watershed such as timber harvest and grazing have the potential to input nutrients from soil erosion Agricultural pesticides used in the area may enter the lake

(note the chemical exceedences in Table 19) and agricultural drainage has been shown to contribute nutrients and sediment to the lake (Lake Chelan Water Quality Committee, 1991). Finally, mine tailings and drainage from the abandoned Holden Mine are a concern because of heavy metal loading to the lake. The Forest Service initiated a clean-up program in 1989.

The Department of Ecology's 1989 Water Quality Assessment for Lake Chelan found that 10 to 25 percent of total phosphorous and total nitrogen loading to the lake resulted from human activities. This percentage is relatively high considering that only 4 percent of the 924 square mile drainage area is developed. Groundwater monitoring indicated that total soluble nitrogen rates in the orchard areas adjacent to the lake exceeded state drinking water standards of 10 mg N/L.

Table 19
Exceedences from Water Quality Standards

Monitoring Stations Location	Monitoring Station or Source	Parameters Exceeding Standards	Description of Parameter Exceedance
Lake Chelan	Wash State Pesticide Monitoring Program	4,4'-DDE	excursions beyond criteria of edible fish tissue samples.
Lake Chelan	Wash State Pesticide Monitoring Program	PCB-1254	excursions beyond criteria of edible fish tissue samples.
Outlet of Lake Chelan at Chelan, 4.8 miles from mouth of Chelan River.	Ecology ambient monitoring station 47A070	pH	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 Chelan 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 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 the WDF. In addition, biologists with the Washington Department of Fish and Wildlife were contacted in order to identify fisheries issues related to flow in the Chelan Watershed.

Based upon these sources, the only anadromous fish population managed in the Chelan Watershed is fall chinook salmon (*Oncorhynchus tshawytscha*). In addition to fall chinook, Lake Chelan contains populations of kokanee (*Oncorhynchus nerka*) and rainbow trout (*Salmo mykiss*). Although these species are present, fish production is generally considered low in the watershed due to oligotrophic conditions within the Lake Chelan (Ecology, 1989).

Fall Chinook Salmon

The fall chinook stock in the Chelan Watershed is distinct based on geographic isolation. Fall chinook migration occurs in July and August as fish move up Lake Chelan into headwater tributaries. Information regarding spawning areas is very limited. However, fish have been observed spawning in Company Creek which is a tributary to the Stehekin River. No average runsize distribution information is available for fall chinook in the Chelan Watershed. Typical mature fish are approximately three to five years old and weigh on average between 7 and 15 pounds with some adults reaching as much as twenty pounds. The current naturally sustained population is an introduced mixture of hatchery fish released from a variety of stocks in the Columbia River and Puget Sound systems. Continued production is provided through a cooperative net-pen program started in 1989 -1990. (SASSI, 1992)

Fish population and stock data form the American Fisheries Society (AFS) Threatened and Endangered Fishery Stock Report (Nehlsen et al. 1991) was reviewed and contains no listings for this watershed. The Washington State Salmon and Steelhead Inventory (SASSI) presents the status of stocks in the Chelan Watershed and is summarized in Table 20.

Table 20
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
Chelan River	Chinook Salmon Fall race	No Listing	No Listing	Healthy	Non-Native	Wild

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.

SASSI Status

The WDF Salmon and Steelhead Stock Inventory has established a set of status ratings ranging from Healthy to Extinct. The rating "healthy" presented in Table 20, defines a stock of fish with production levels consistent with the carrying capacity of the watershed.

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 20 should be considered primary until additional information confirms or refutes the current designations. The definition of the designation presented in Table 20 is:

1. Non-native - a stock that has been introduced to an area outside of that stock's original range.

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 20 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

Naturally oligotrophic conditions limit food availability and thus fish production within Lake Chelan. Water quality factors which could be potentially impact fish populations in the Chelan River Watershed are pesticides residues and PCB's; high concentrations of 4, 4'-DDE and PCB-1254 have been found in tissues of fish sampled in Lake Chelan. In addition, pH criteria have been exceeded at the outlet to the lake above the mouth of the Chelan River (Ecology, 1989). Otherwise, water quality conditions in the watershed should be considered good to excellent, since much of the upper watershed is located in wilderness areas or within the boundaries of North Cascades National Park.

Potential Flow Impacts and Recommended Instream Flows

According to instream flow specialists with the Washington Department of Fish and Wildlife, instream flows are not an important issue in the Chelan Watershed. This is because most of the Chelan River is inundated by Lake Chelan. Fall chinook salmon and summer steelhead from the Columbia River only migrate a short distance into the lower Chelan River (WARIS database). Lake Chelan begins above a dam located 4.3 miles upstream the Chelan River from the confluence with the Columbia River. The upper Chelan River above Lake Chelan is located within the Lake Chelan National Recreation Area, Glacier Peak Wilderness, and North Cascades National Park. No known diversions occur in the upper Chelan River because of it's geographical location and protected status. Consequently, no instream flows have been proposed for the Chelan Watershed by Ecology.

Conclusions

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

- The Chelan Watershed (WRIA 47) encompasses about 1047 square miles. The watershed originates in the North Cascade Mountains and extends to the Columbia River. Principal land uses in WRIA 47 are forestry, wilderness, agriculture, rangeland, residential development and recreation. Precipitation within the watershed varies from about 150 inches per year in the North Cascade Mountains to 11 inches per year at the City of Chelan. Most precipitation occurs in late fall and winter as snowfall, and melts in spring and summer. The primary surface water feature of the watershed is Lake Chelan, which is the largest and deepest lake in Washington.

- There is an estimated 11,520 acres of irrigated area within WRIA 47 that is tributary to Lake Chelan. The volume of water diverted for the 11,520 irrigated acres was estimated to be about 34,560 acre-feet per year. Municipal and domestic water use was estimated to be about 2,060 acre-feet per year. Estimates of irrigated acreage and domestic water use in the part of the watershed lies east of Lake Chelan (along the Columbia River) were not available.

- Total annual streamflow in the Lake Chelan system averages about 1.5 million acre-feet (measured at the USGS gauging station located at Chelan).

- A total of 415 cfs and 65,093 acre-feet in Water Rights Permits and Certificates for consumptive use have been issued in WRIA 47. Of that total, 343 cfs and 40,537 acre-feet are Surface Water Rights and Certificates, and 72 cfs and 24,556 acre-feet are Groundwater Rights and Certificates. Irrigation is the largest type of water user, with about 79 percent of the volume of the Surface Water Permits and Certificates, but only 24 percent of the volume of Groundwater Permits and Certificates. An additional 679 Surface Water and Groundwater Claims have been registered for a total of 81 cfs and 15,082 acre-feet. There are currently 77 Water Rights Permit Applications on file at Ecology, requesting a total of 138 cfs. Most of the applications are for diversions from Lake Chelan along the South Shore and in the Manson area.

- Of the Water Rights Permits and Certificates issued in the Chelan Watershed, it was estimated that 711 permits for an instantaneous use of 293 cfs and annual quantity of 35,900 acre-feet are for areas tributary to Lake Chelan. Of the Claims, it was estimated that 561 were registered for a total of 67 cfs and 12,494 acre-feet for areas tributary to Lake Chelan.

- Groundwater resources are present primarily within sand and gravel valley fill material, with limited bedrock aquifer capabilities. Aquifers present within the subbasins flow toward, and 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 subbasins. The potential exists for further development in surficial or fill aquifers, but due to the limited nature of the aquifers, effects on other wells can be expected. Many domestic wells are present in the fractured, weathered, or porous bedrock, but yields are generally too low for large scale development.

- Anadromous fish, including fall chinook salmon and steelhead trout, only migrate a short distance up the Chelan River from the Columbia River. Migration is blocked above this point, while most of the Chelan River is inundated by Lake Chelan. For these reasons, anadromous fish are not considered to be an important issue in this basin by state agencies. Landlocked chinook salmon are present in Lake Chelan and spawn in the upper Chelan River; populations of these fish are considered to be healthy.

- Overall, water quality can be considered to be very good to excellent in the Chelan Watershed. The major impact of water quality on fisheries in this watershed can be attributed to the oligotrophic (low nutrient and primary production) nature of water in Lake Chelan.

- Instream flows are not an important issue to fish populations in the upper drainage because no water is presently diverted from the upper Chelan River system, and it is unlikely that water will be diverted in the future because of the protected status of this watershed.

Recommendations

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

- Prepare detailed water budgets for subbasins in the Chelan Watershed 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 and existing uses 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 around the Chelan and Manson areas.

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

  Perform aquifer testing in the Chelan and Manson areas (the location of most of the Groundwater Applications) to further define aquifer parameters and relationships with surface water and existing users.

- The management recommendations contained in the *Lake Chelan Water Quality Plan* should be carried out to ensure water quality in Lake Chelan.

- Because streamflows are not considered an issue to fish populations in the Chelan River basin, no recommendations are necessary concerning flow and water diversion impacts on fishery resources.

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FIGURES

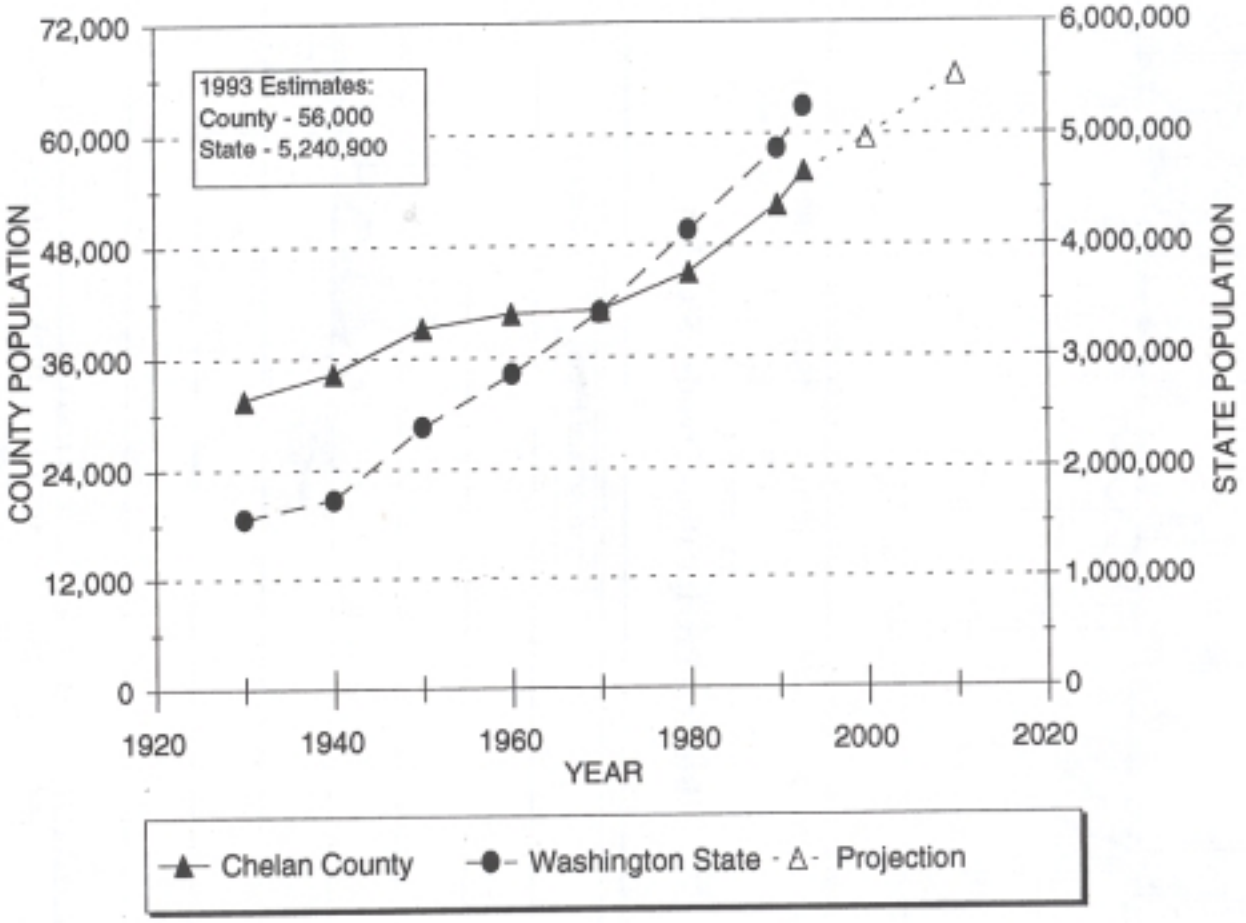


Figure 1
Population Growth in Chelan County

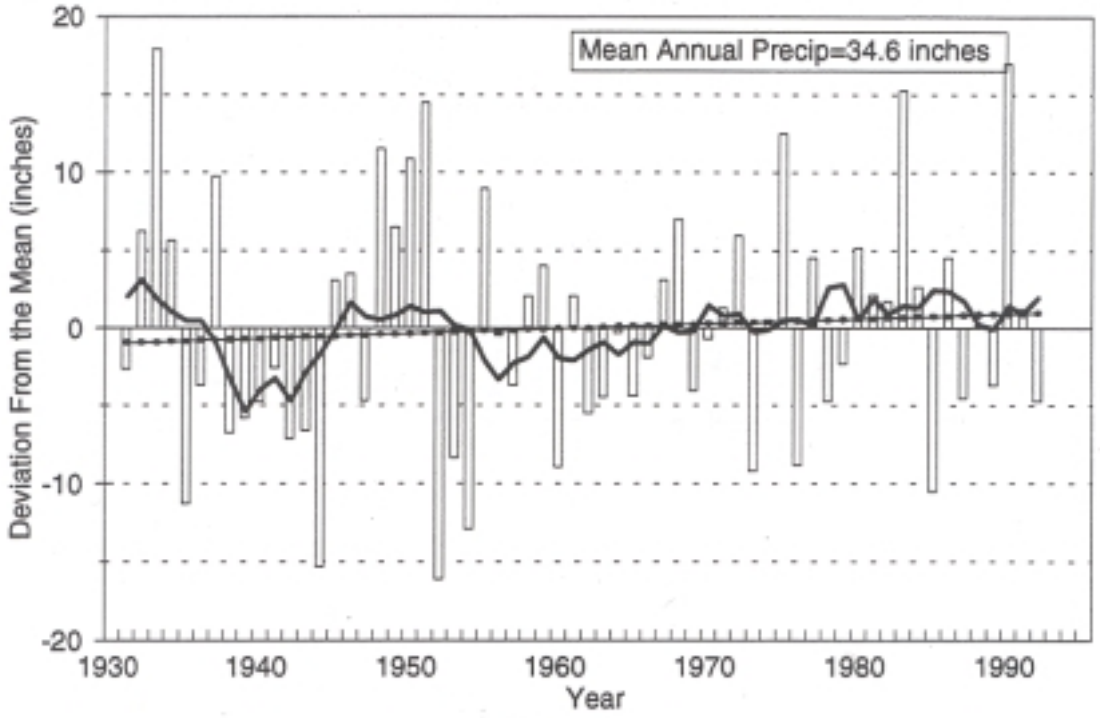


Figure 2
Historical Precipitation Trends - Stehekin

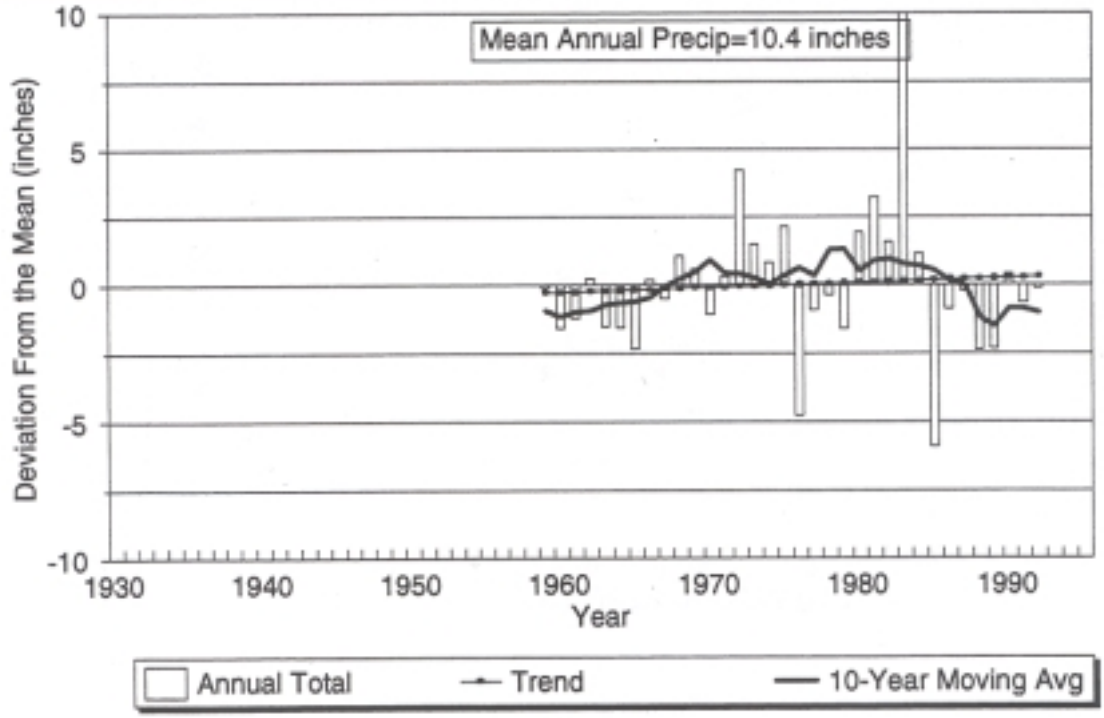


Figure 3
Historical Precipitation Trends - Chelan

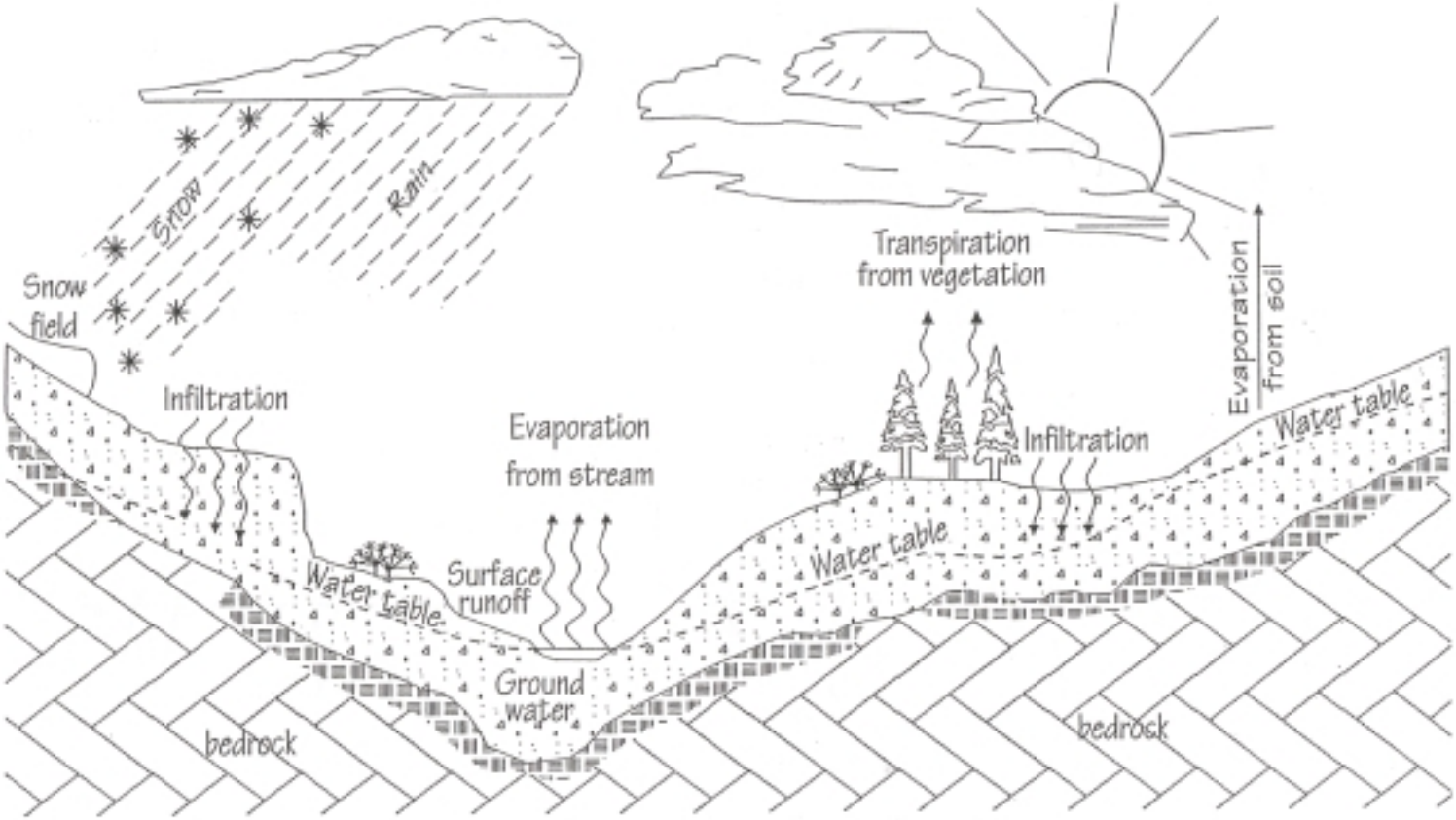


Figure 4
The Hydrologic Cycle
Chelan Watershed

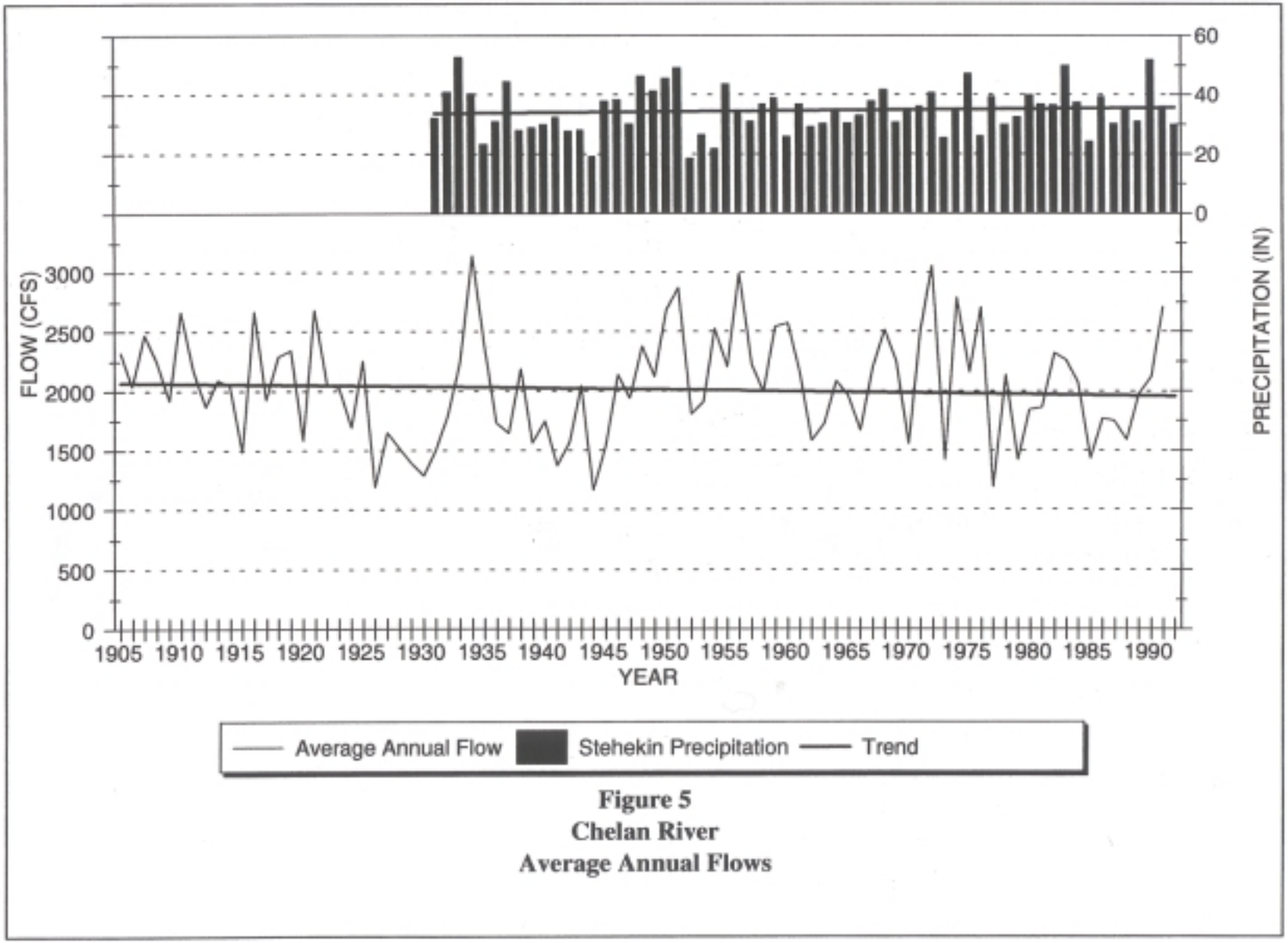


Figure 5
Chelan River
Average Annual Flows

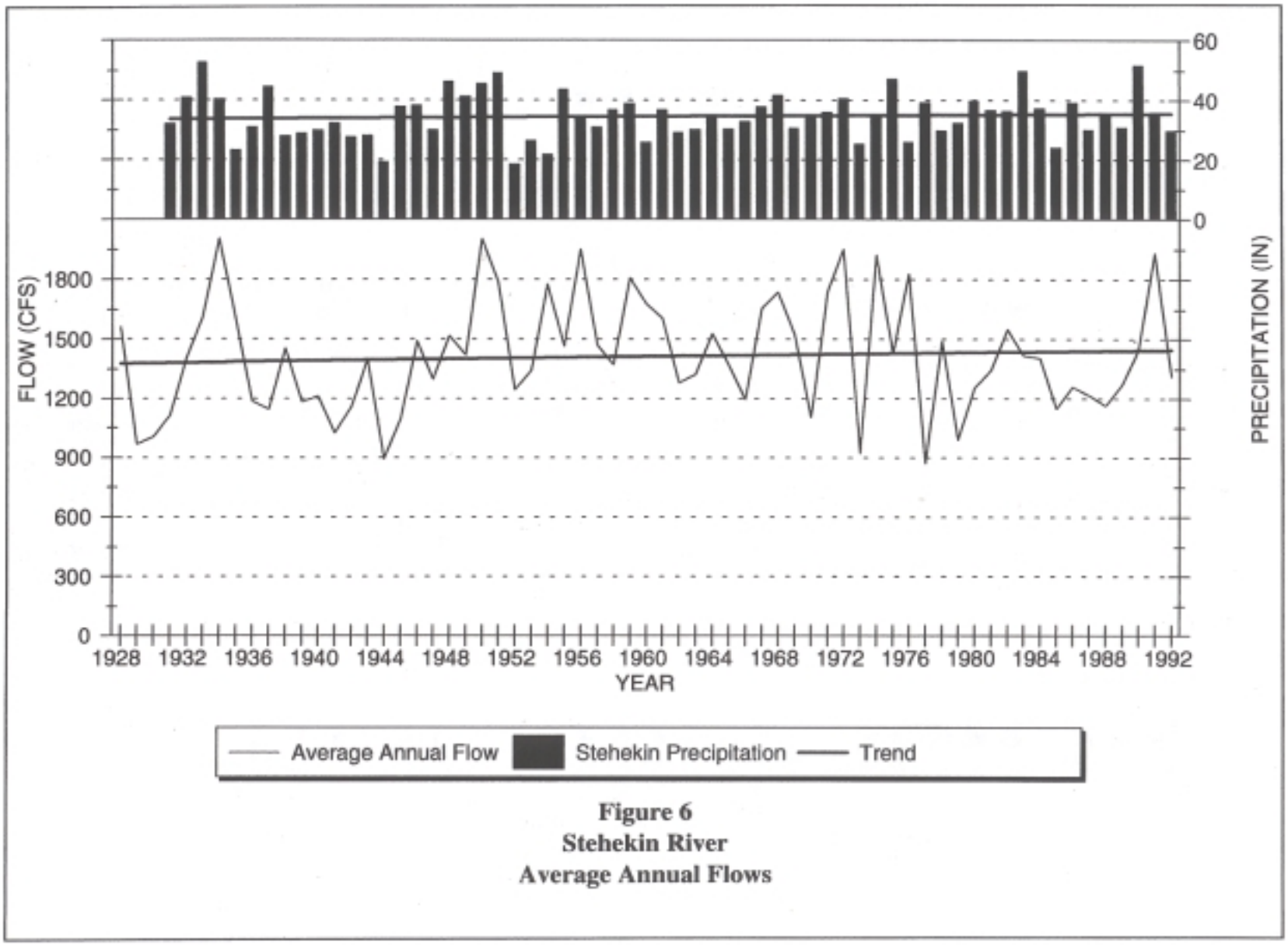


Figure 6
Stehekin River
Average Annual Flows

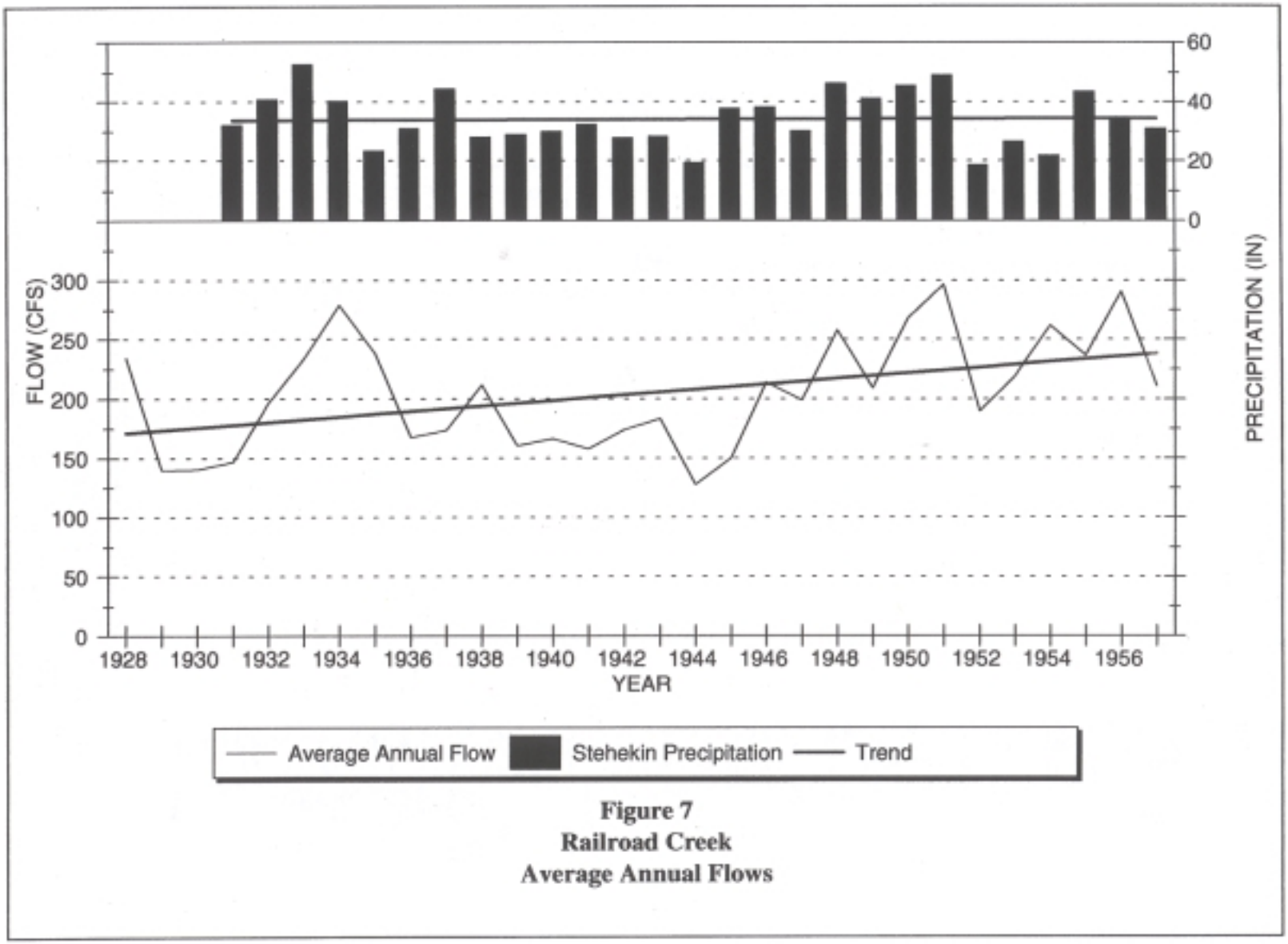


Figure 7
Railroad Creek
Average Annual Flows

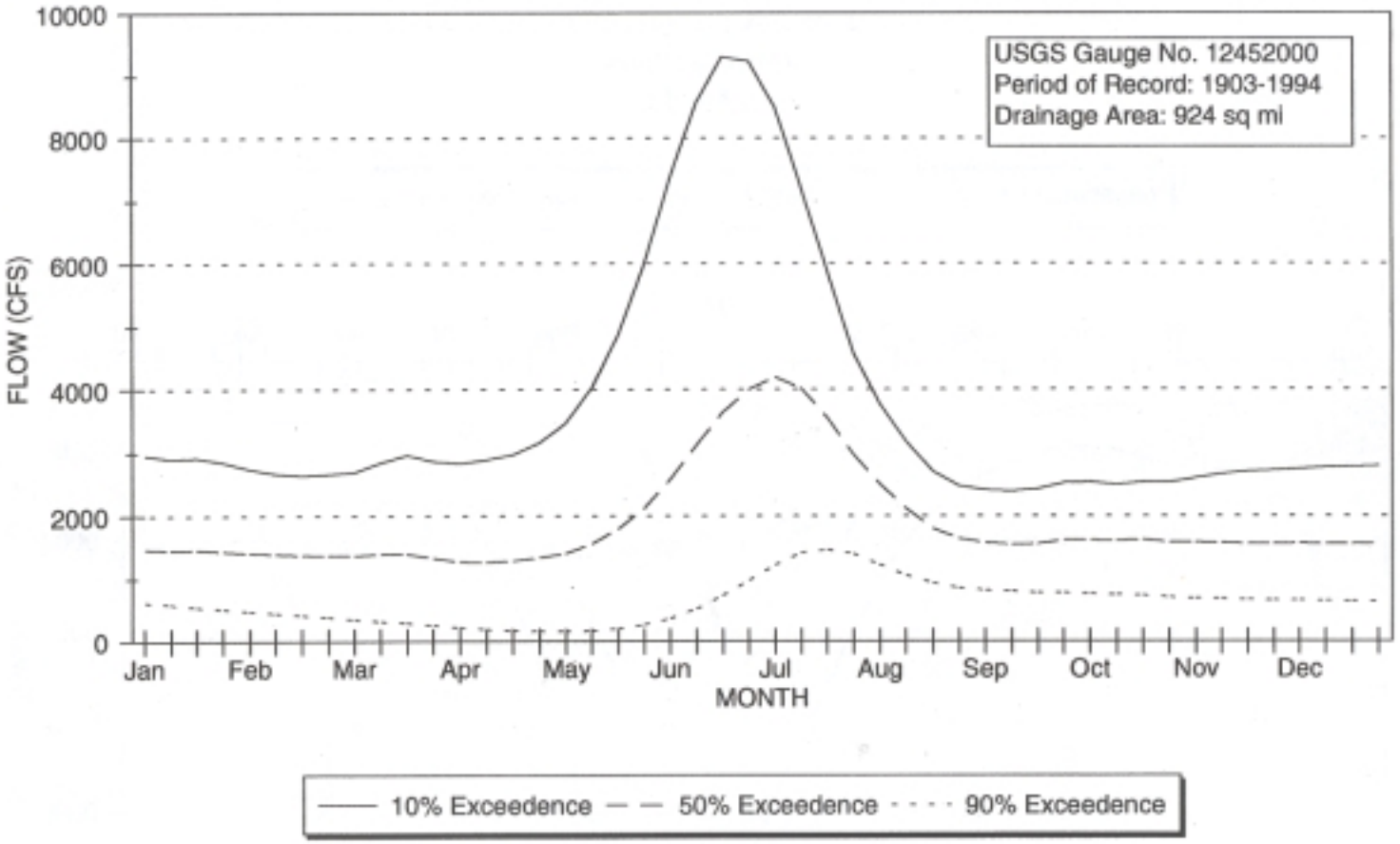


Figure 8
Chelan River
Monthly Flow Exceedence

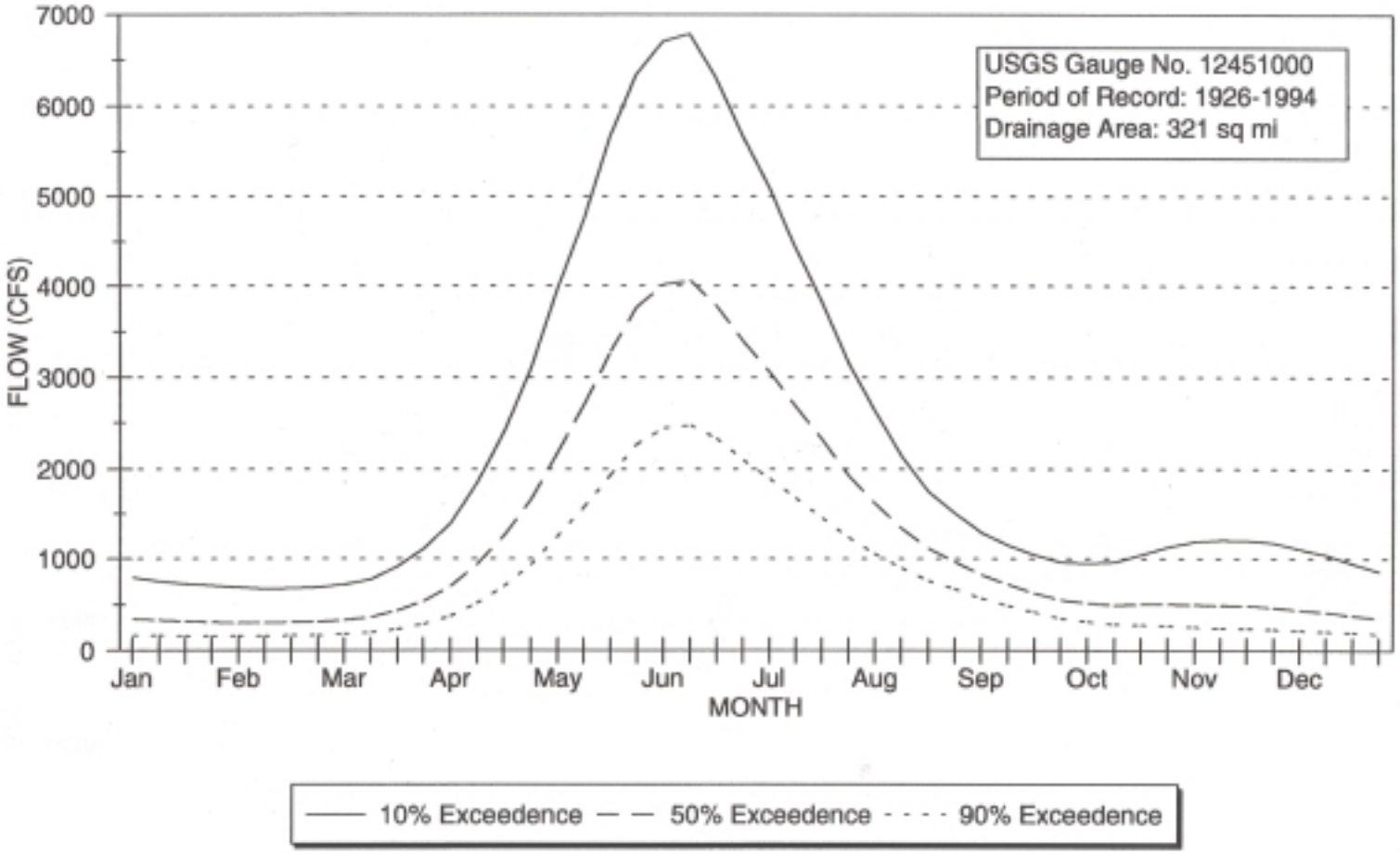


Figure 9
Stehekin River
Monthly Flow Exceedence

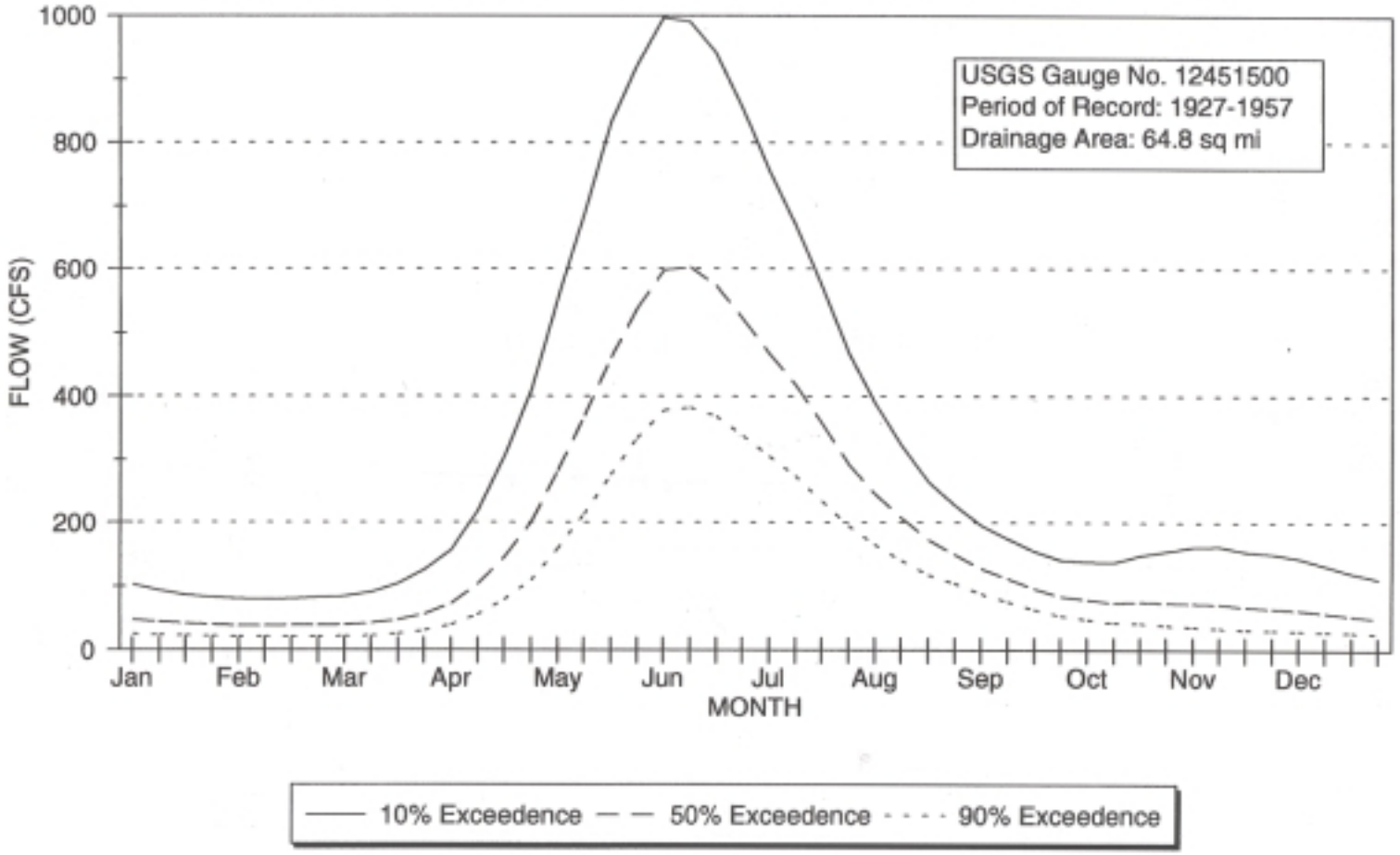


Figure 10
Railroad Creek
Monthly Flow Exceedence

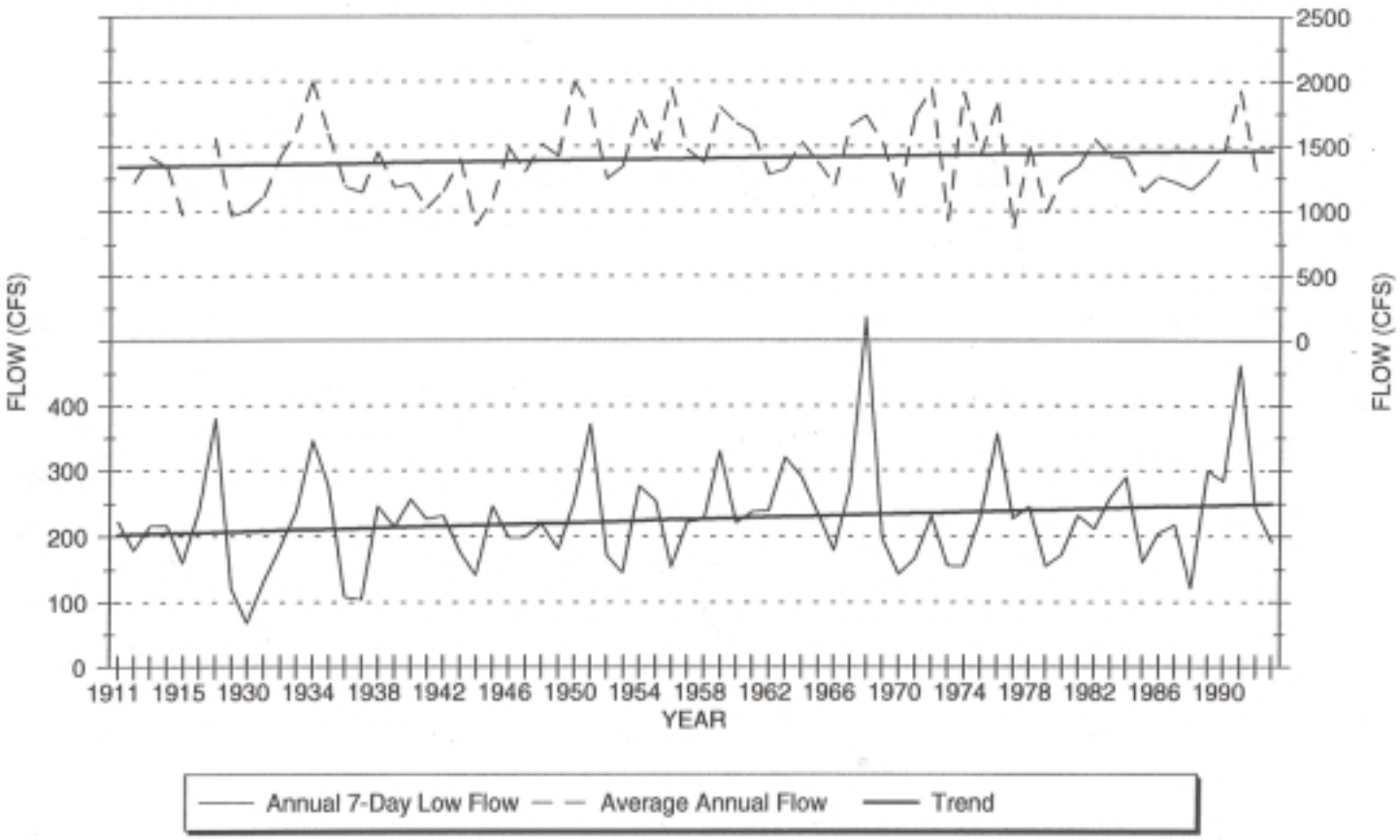


Figure 11
Stehekin River
Historical Annual and 7-Day Low Flows

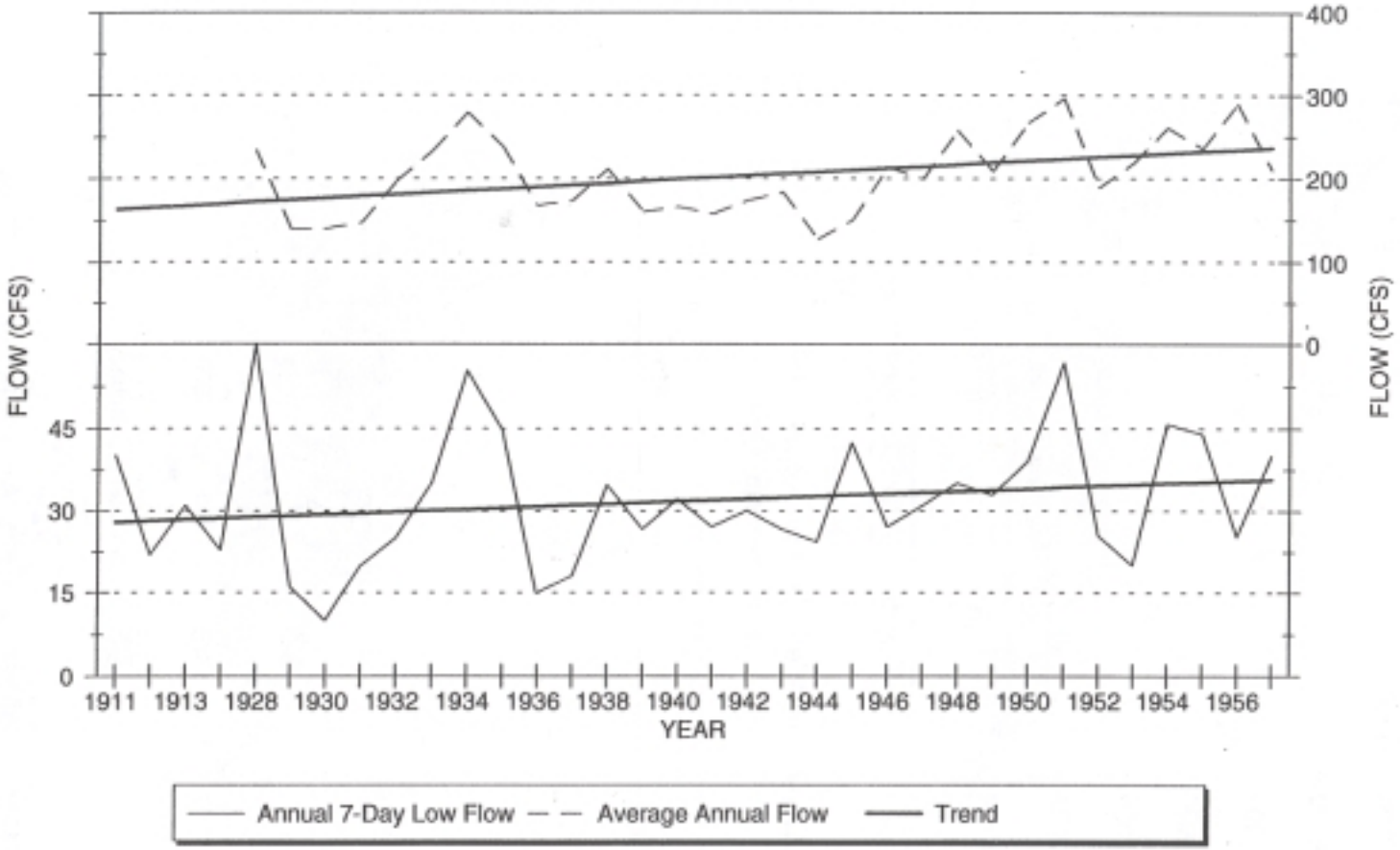


Figure 12
Railroad Creek
Historical Annual and 7-Day Low Flows

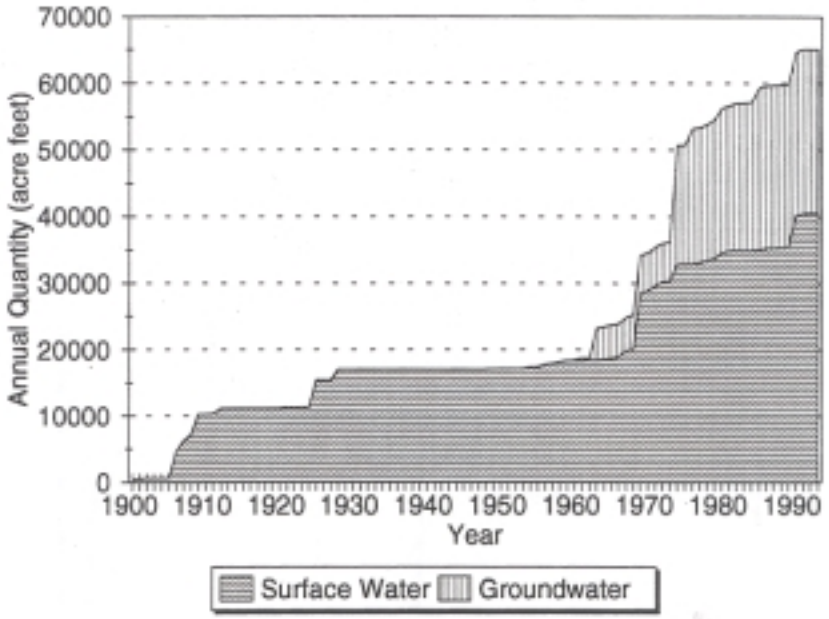


Figure 13
Historical Growth of Water Rights Appropriations in Chelan Watershed
Total Annual Quantity

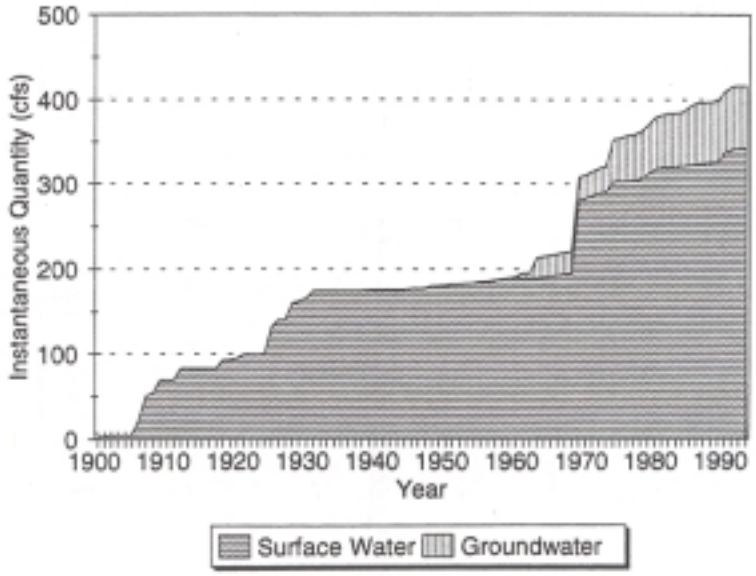


Figure 14
Historical Growth of Water Rights Appropriations in Chelan Watershed
Total Instantaneous Rate

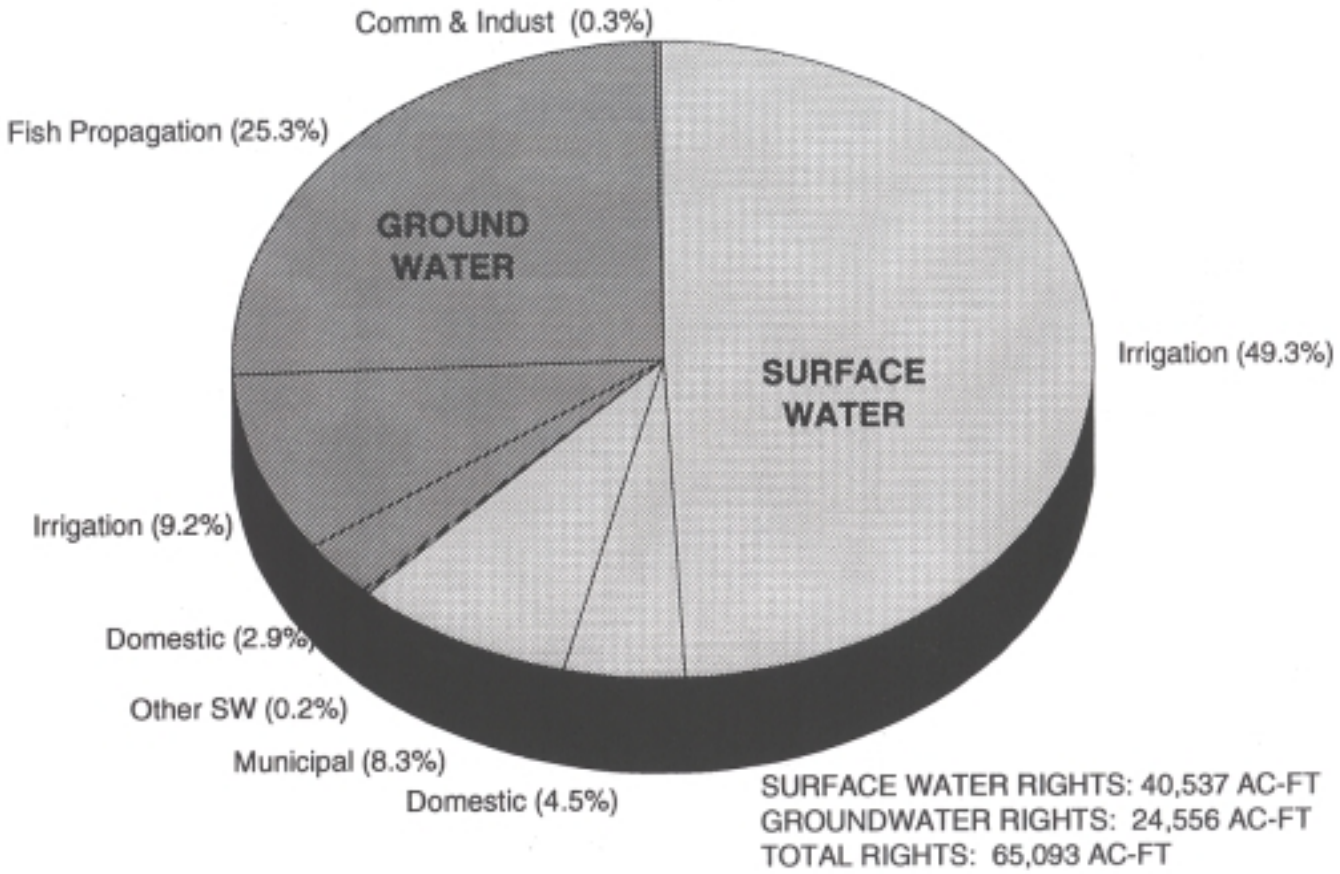
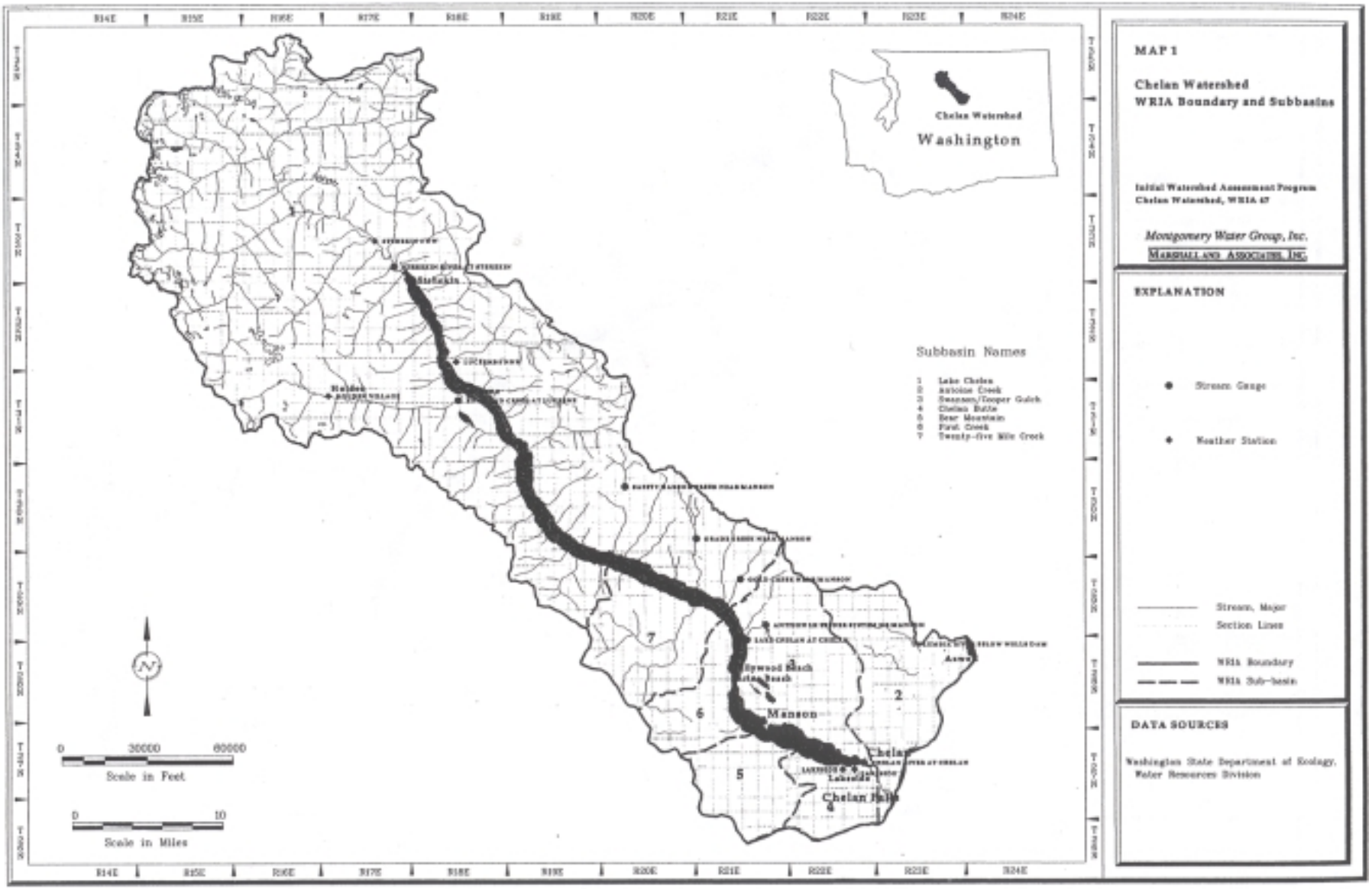


Figure 15
Water Rights in Chelan Watershed
Total Annual Quantity

MAPS



MAP 1

Chelan Watershed
WRIA Boundary and Subbasins

Initial Watershed Assessment Program
Chelan Watershed, WRIA 47

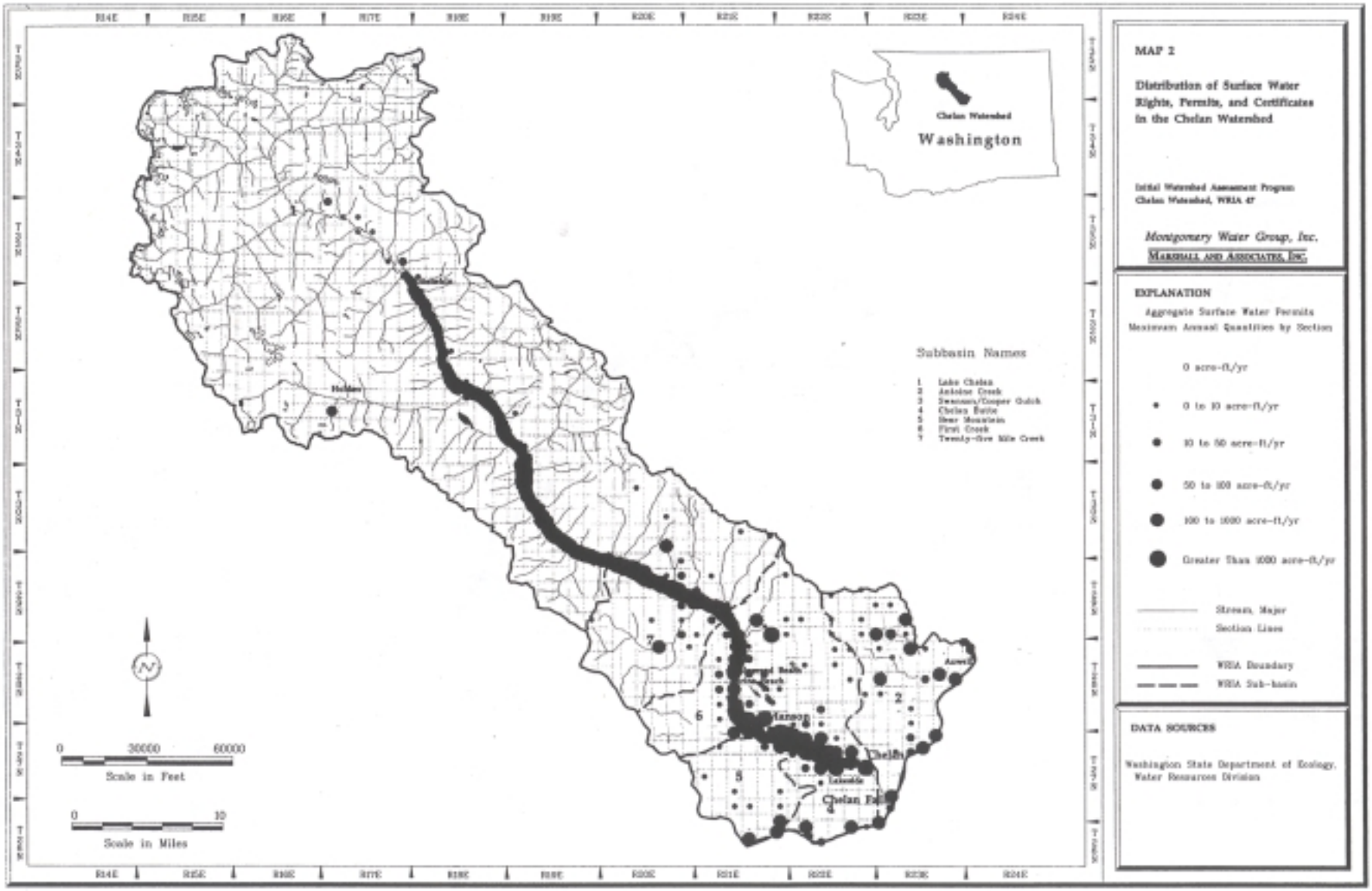
Montgomery Water Group, Inc.
MARSHALL AND ASSOCIATES, INC.

EXPLANATION

- Stream Gauge
- Weather Station
- Stream, Major
- Section Lines
- WRIA Boundary
- WRIA Sub-basin

DATA SOURCES

Washington State Department of Ecology, Water Resources Division



MAP 2

Distribution of Surface Water Rights, Permits, and Certificates in the Chelan Watershed

Initial Watershed Assessment Program
Chelan Watershed, WRIA 47

Montgomery Water Group, Inc.
MARSHALL AND ASSOCIATES, INC.

EXPLANATION

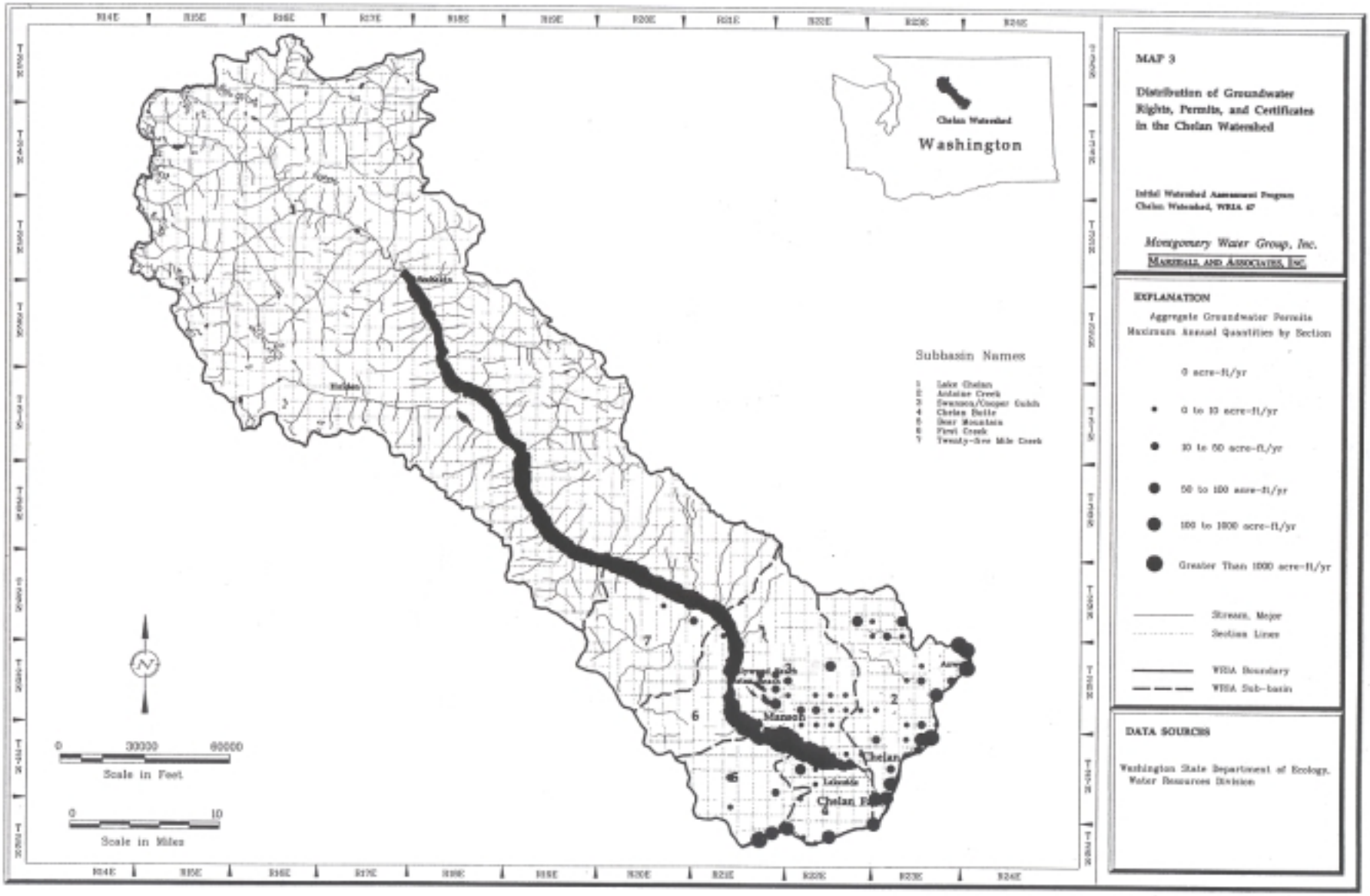
Aggregate Surface Water Permits
Maximum Annual Quantities by Section

- 0 acre-ft/yr
- 0 to 10 acre-ft/yr
- 10 to 50 acre-ft/yr
- 50 to 100 acre-ft/yr
- 100 to 1000 acre-ft/yr
- Greater Than 1000 acre-ft/yr

Stream, Major
Section Lines
WRIA Boundary
WRIA Sub-basin

DATA SOURCES

Washington State Department of Ecology, Water Resources Division



MAP 3

Distribution of Groundwater Rights, Permits, and Certificates in the Chelan Watershed

Initial Watershed Assessment Program
Chelan Watershed, WRIA 47

Montgomery Water Group, Inc.
MARSHALL AND ASSOCIATES, INC

EXPLANATION

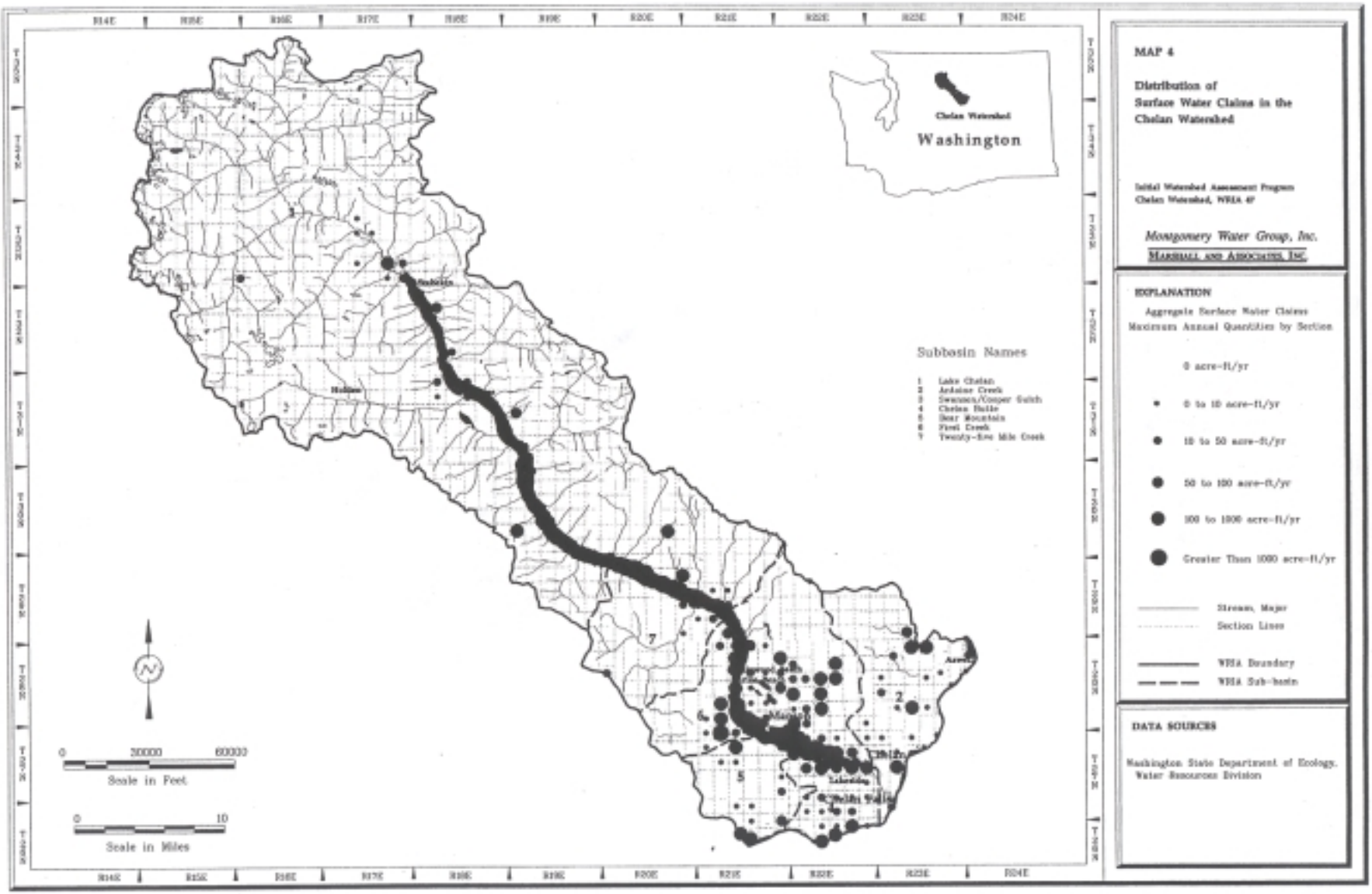
Aggregate Groundwater Permits
Maximum Annual Quantities by Section

- 0 acre-ft/yr
- 0 to 10 acre-ft/yr
- 10 to 50 acre-ft/yr
- 50 to 100 acre-ft/yr
- 100 to 1000 acre-ft/yr
- Greater Than 1000 acre-ft/yr

Stream, Major
Section Lines
WRIA Boundary
WRIA Sub-basin

DATA SOURCES

Washington State Department of Ecology, Water Resources Division



MAP 4

Distribution of Surface Water Claims in the Chelan Watershed

Initial Watershed Assessment Program
Chelan Watershed, WRIA 45

Montgomery Water Group, Inc.
MARSHALL AND ASSOCIATES, INC.

EXPLANATION

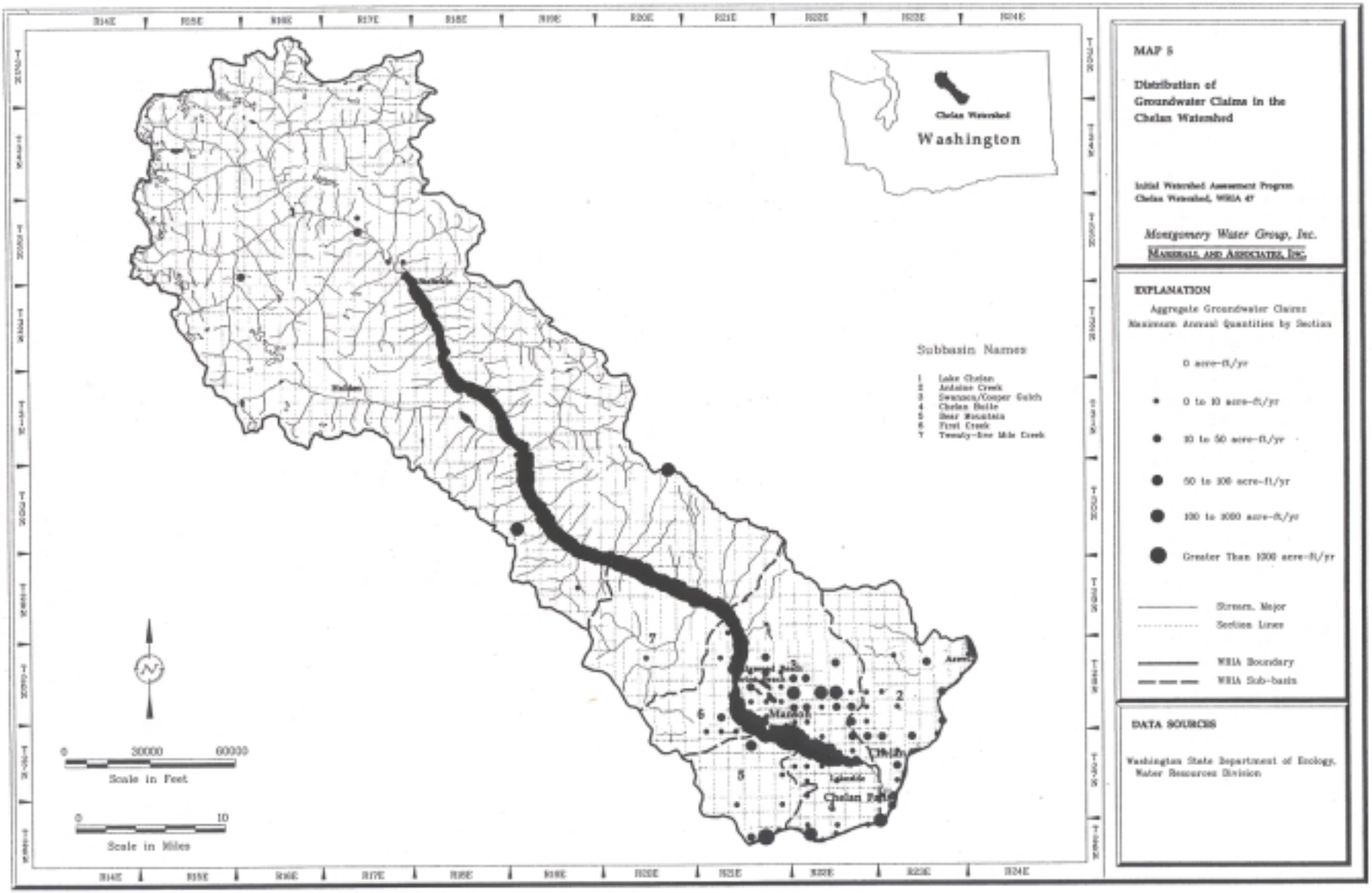
Aggregate Surface Water Claims
Maximum Annual Quantities by Section

- 0 acre-ft/yr
- 0 to 10 acre-ft/yr
- 10 to 50 acre-ft/yr
- 50 to 100 acre-ft/yr
- 100 to 1000 acre-ft/yr
- Greater Than 1000 acre-ft/yr

- Stream, Major
- Section Lines
- WRIA Boundary
- WRIA Sub-basin

DATA SOURCES

Washington State Department of Ecology,
Water Resources Division



MAP 5

Distribution of Groundwater Claims in the Chelan Watershed

Initial Watershed Assessment Program
Chelan Watershed, WRIA 47

Montgomery Water Group, Inc.
MARSHALL AND ASSOCIATES, INC.

EXPLANATION

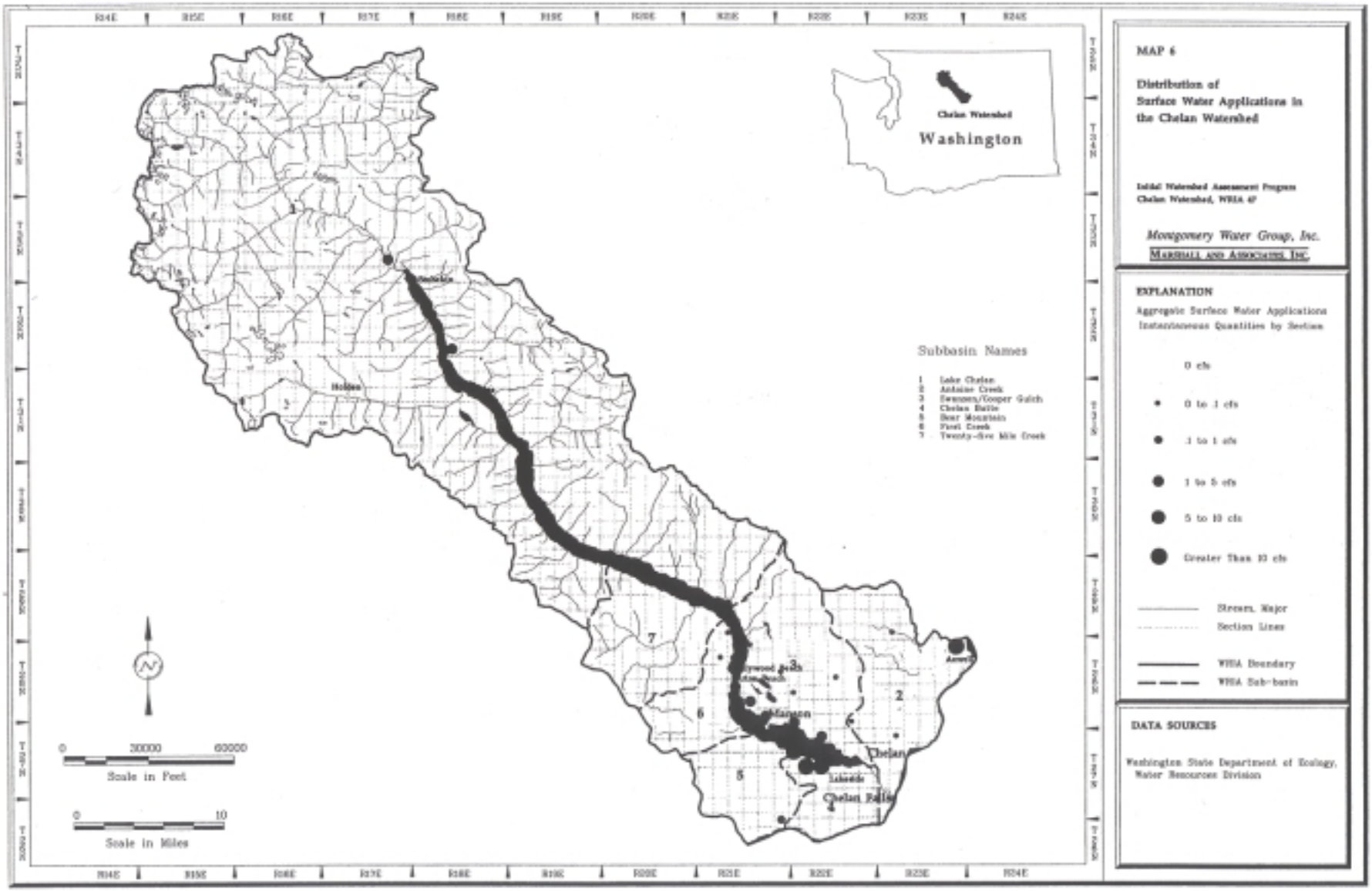
Aggregate Groundwater Claims
Maximum Annual Quantities by Section

- 0 acre-ft/yr
- 0 to 10 acre-ft/yr
- 10 to 50 acre-ft/yr
- 50 to 100 acre-ft/yr
- 100 to 1000 acre-ft/yr
- Greater Than 1000 acre-ft/yr

- Streams, Major
- Section Lines
- WRIA Boundary
- WRIA Sub-basin

DATA SOURCES

Washington State Department of Ecology, Water Resources Division



MAP 6

Distribution of Surface Water Applications in the Chelan Watershed

Initial Watershed Assessment Program
Chelan Watershed, WRIA 47

Montgomery Water Group, Inc.
MARSHALL AND ASSOCIATES, INC.

EXPLANATION

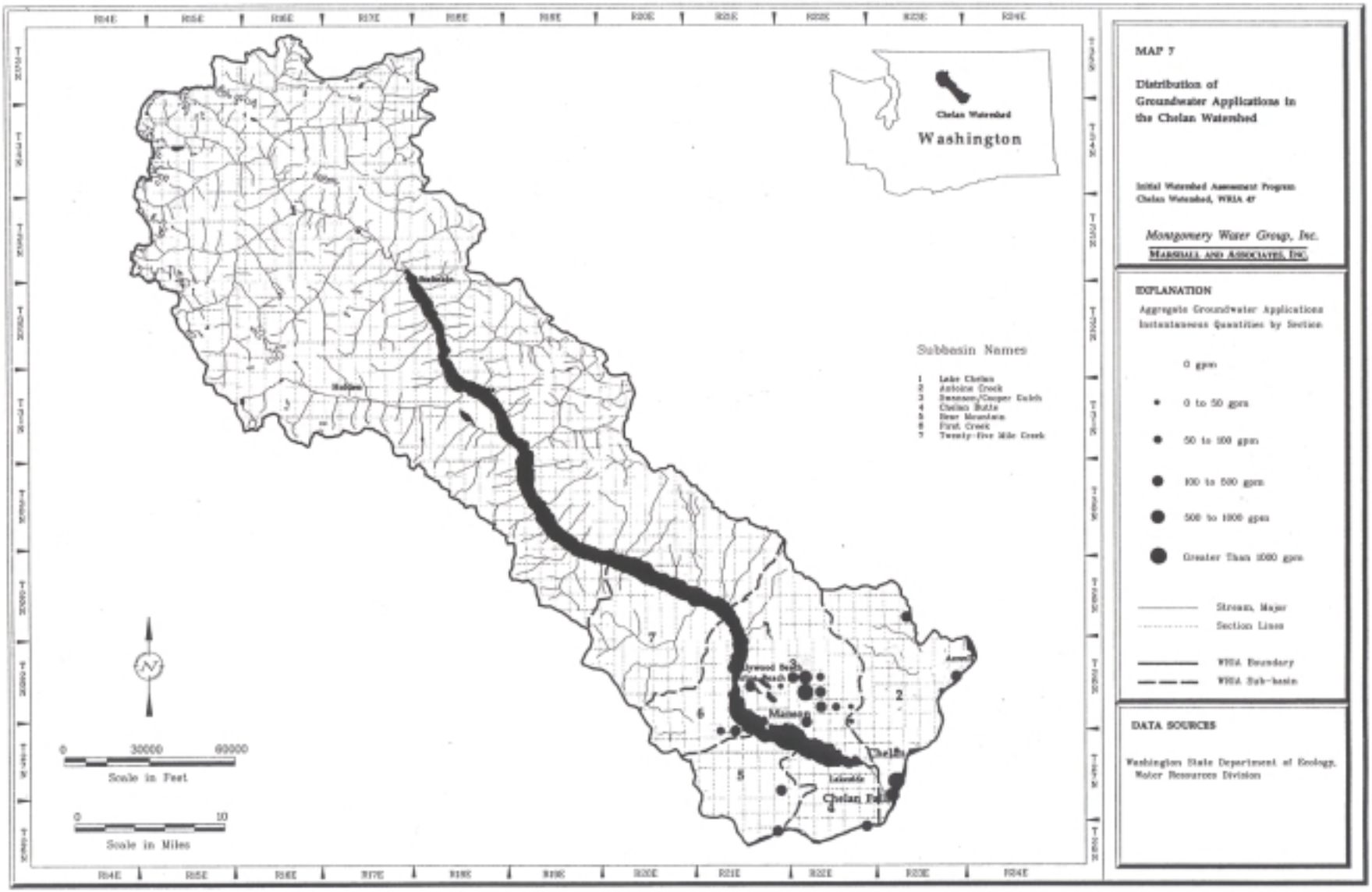
Aggregate Surface Water Applications
Instantaneous Quantities by Section

- 0 cfs
- 0 to .1 cfs
- .1 to 1 cfs
- 1 to 5 cfs
- 5 to 10 cfs
- Greater Than 10 cfs

Streams, Major
Section Lines
WRIA Boundary
WRIA Sub-basin

DATA SOURCES

Washington State Department of Ecology,
Water Resources Division



MAP 7

Distribution of Groundwater Applications in the Chelan Watershed

Initial Watershed Assessment Program
Chelan Watershed, WRIA 45

Montgomery Water Group, Inc.
MARSHALL AND ASSOCIATES, INC.

EXPLANATION

Aggregate Groundwater Applications
Instantaneous Quantities by Section

- 0 gpm
- 0 to 50 gpm
- 50 to 100 gpm
- 100 to 500 gpm
- 500 to 1000 gpm
- Greater Than 1000 gpm

Stream, Major
Section Lines
WRIA Boundary
WRIA Sub-basin

DATA SOURCES

Washington State Department of Ecology,
Water Resources Division

APPENDIX A

AGREEMENT BETWEEN DEPARTMENT OF ECOLOGY AND CHELAN COUNTY PUD NO. 1 REGARDING WATER RIGHT CERTIFICATE NO. 319

AGREEMENT CONCERNING WATER RIGHT
CERTIFICATE NO. 319

THE AGREEMENT made and entered into this 29th day of April , 1992, by and between the State of Washington, Department of Ecology (hereinafter "Ecology") and the Public Utility District No. 1 of Chelan County, Washington (hereinafter "District"), WITNESSETH:

WHEREAS, the District is owner and successor in interest of Water Right Certificate No. 319, which was issued pursuant to State Water Permit No. 584;

WHEREAS, the District is the current holder of a license from the Federal Energy Regulatory Commission (hereinafter "FERC") for Lake Chelan Project No. 637, entitling it to operate a hydroelectric project on said lake;

WHEREAS, Water Right Certificate No. 319 grants the District the right to appropriate 4,000 cfs of water from the Chelan River, in Chelan County, Washington, for the purpose of generating hydroelectric power with the priority date of July 22, 1925;

WHEREAS, Water Right Certificate No. 319, pursuant to the terms and conditions of Water Permit No. 584, is subject to the following language:

> This appropriation shall be subject to all existing rights and to reservation of not to exceed 33,000 acre feet each year for irrigation and domestic use on lands bordering and near the lake. This 33,000 acre feet or such part of it as may be required for beneficial use on said lands to be so used only under permits issued through this office as by statute provided; and unless and until all of said 33,000 acre feet is covered by valid appropriation, any unappropriated balance thereof shall be available for the use of the Chelan Electric Company, and its successors and assigns under this permit. The water thus reserved may be appropriated for diversion only above the proposed dam of the Chelan Electric company;

WHEREAS, in addition to the water appropriated in Water Right Certificate No. 319, it is estimated that 34,000 acre- feet per year ("afy") of water has been appropriated from Lake

Chelan, as of the date of this Agreement, pursuant to water rights certificates, water right permits and water right claims filed under the Water Registration Act, RCW 90.14;

WHEREAS, a dispute exists between the District and Ecology as to whether the 33,000 afy identified in Water Permit No. 584 includes water rights in existence prior to July 22, 1925, the priority date of the District's rights. It is estimated that 12,000 afy was appropriated prior to July 22, 1925. This question has caused uncertainty and delay in Ecology's issuance of new permits to appropriate water from Lake Chelan;

WHEREAS, the District and Ecology desire to settle the foregoing dispute and provide certainty for future permit decisions by clarifying the amount of water that the District's water rights are subject to pursuant to the language stated in Water Permit No. 584;

WHEREAS, the District further desires to make available from its Water Right Certificate No. 319, the right to the use of an additional 20,000 afy of water for appropriations by others for use within the Lake Chelan Water Basin (hereinafter "Water Basin"). The Water Basin shall be Water Resource Inventory Area No. 47 as defined in Chapter 173-500 of the Washington Administrative Code; and,

WHEREAS, Ecology as the administrator and regulator of water rights desires to administer any transfers of the right to the use of water under Water Right Certificate No. 319.

NOW, THEREFORE, in consideration of the resolution of the question of the nature and extent of Water Right Certificate No. 319, and the benefits to be derived by each party and specifically, the Lake Chelan users, it is AGREED and STIPULATED BY AND BETWEEN THE PARTIES AS FOLLOWS:

1. The parties stipulate that the 33,000 afy reservation identified in Water Permit No. 584 does not include water rights in existence prior to July 22, 1925. The parties stipulate that Water Right Certificate No. 319, pursuant to the terms and conditions of Water Permit No. 584, shall be interpreted by the parties to be subject to the 33,000 afy of water unappropriated as of July 22, 1925 and the water appropriated prior to July 22, 1925 (estimated at 12,000 afy) for a total estimated amount of 45,000 afy.

2. The District agrees to make available and hereby provides approval for transfers of the right to use up to 20,000 afy water from its water right authorized under Water Right Certificate No. 319 as defined and limited under paragraphs 1 and 3 herein.

3. The District's approval to transfer its right to the use of 20,000 afy is conditioned on the transferred water being used in the Lake Chelan Water Basin only.

4. Ecology shall administer the transfers of the 20,000 afy, and pursuant to the District's conditional approval of the transfers under paragraphs 2 and 3 above, Ecology may without further approval by the District transfer water from the available 20,000 afy to satisfy the criteria of water availability under RCW 90.03.290 for applications filed with Ecology for the right to use water in the Lake Chelan Water Basin. For the purposes of this Agreement, the Water Basin shall be Water Resource Inventory Area No. 47 as defined in Chapter 173-500 of the Washington Administrative Code.

5. The parties agree that the maximum amount of water that will be available for allocation from Lake Chelan under the terms of this Agreement and Water Right Certificate No. 319 shall be the 20,000 afy identified in paragraph 2 above and the 45,000 afy identified in paragraph 1 above, for a total of 65,000 afy. The 45,000 afy shall, with the exception of the right

granted to the District under Water Right Certificate No. 319, include all rights to the use of water which have been established both before and subsequent to July 22, 1925.

6. The Department of Ecology shall not transfer any of the 20,000 afy identified above until all of the unallocated portion of the 45,000 afy of water identified above has been allocated.

7. This Agreement is to allow for the efficient and proper transfer of a portion of the District's water right, and is not intended or to be considered a relinquishment of any portion of Water Right Certificate No. 319 or State Water Permit No. 584.

8. The District may at any time withdraw its approval for the transfer of any portion of the 20,000 afy not yet transferred by Ecology.

9. The District understands and agrees that any water right granted for water transferred from the 20,000 afy pursuant to the District's approval provided in this Agreement shall constitute a fully protected-water right and shall not be subject to revocation or additional conditions by the District, and that the District has no further interest in the right to the use of water that is transferred from the 20,000 afy; provided, however, that the District shall continue to have the full use of any portion of the 20,000 afy that has not been transferred as provided herein.

10. Ecology shall administer and review all transfers pursuant to RCW 90.03.380 and .390. The priority date of any water transferred from the 20,000 afy identified above shall be administered and regulated as junior to the District's priority date under Water Right Certificate No. 319 and State Water Permit No. 584.

11. Nothing in this Agreement shall otherwise effect the terms and conditions of Water Right Certificate No. 319 and the State Water Permit No. 584, or any appropriator's right to

apply for a change in the purpose of use, place of use, or the point of diversion of water under existing rights pursuant to RCW 90.03.380 (as amended).

12. This Agreement is contingent upon the FERC approving all provisions of this Agreement.

13. Ecology agrees that, except for nonconsumptive uses of water, it shall use no return flow computations in calculating whether there is any water available for appropriation from Lake Chelan from the 65,000 acre feet identified above in paragraph 5. For the purposes of this Agreement, nonconsumptive use is defined as a type of water use where there is no diversion from the source body, or where there is no diminishment in quantity or quality from the source.

14. In the event the District's water rights in Lake Chelan become the subject of any hearing before the Pollution Control Hearings Board or its successor, or any lawsuit, and in particular a water right adjudication brought pursuant to RCW 90.03.100 et. seq. (as amended), and if the District has abided by the terms of this Agreement, Ecology agrees to:

A. Not take a position contrary to the terms of this Agreement; and,

B. Not take a position contrary to the priority for the District's right to use water from Lake Chelan as being July 22, 1925, and that for the purposes of calculating whether water is available for appropriation from Lake Chelan, there is no return flow of water as described in Paragraph 13 herein.

15. The parties hereto agree to execute, acknowledge and deliver to the other party any further instruments that may be reasonably required to give full force and effect to the provisions of this Agreement.

16. Waiver by any party to this Agreement of a breach or violation of any provision of this Agreement shall not operate as or be construed to be a waiver of any subsequent breach of the same or other provision of this Agreement.

17. This Agreement has been executed and delivered and shall be construed in accordance of the laws of the State of Washington. All duties and obligations of the parties created hereunder are performable in Chelan County, Washington, and Chelan County, Washington shall be the venue for any litigation, special proceeding or other proceeding between the parties that may be brought or arise out of, in connection with or by reason of this Agreement.

18. All understandings and agreements between the parties heretofore made are merged in this Agreement, which alone fully and completely expresses their agreement. This Agreement is being entered into after full investigation and neither party is relying upon any statements or representations not embodied in this Agreement made by the other. No waiver or modification of this Agreement shall be valid unless in writing and duly executed by the parties.

19. This Agreement shall be binding upon and inure to the benefit of the parties hereto and their respective successors and assigns.

IN WITNESS WHEREOF the parties hereto have set their hands and seals the day and year first above written.

PUBLIC UTILITY DISTRICT NO. 1 OF
CHELAN COUNTY, WASHINGTON

By _____ General Manager/CEO

STATE OF WASHINGTON, ACTING BY AND
THROUGH THE DEPARTMENT OF ECOLOGY

By _____

APPENDIX B

PUBLIC WATER SYSTEMS IN CHELAN WATERSHED

Table B-1
Public Water Systems in Chelan Watershed

Location			Name	Water Source	Group	Capacity (gpm)
Twn	Rng	Sec				
Subbasin 1 – Lake Chelan						
29	20	3	North Fork Water Users	N Fk 25 Mile Crk	B	450
30	20	9	South Navarre Cg	South Navarre Spring	B	5
31	17	18	Holden Village	Copper Creek	A	2,700
31	18	10	Lucerne Bar	Lucerne Well	B	3
31	18	10	Refrigerator Harbor C Gr	Well	B	3
33	17	7	Stehekin Valley Ranch	Well #1	A	100
33	17	16	Griffith	Drilled Well #1	B	50
33	17	22	Company Creek	Drilled Well #1	B	50
33	17	22	Maintenance Area	Drilled Well #1	B	92
33	17	26	Robertson Water System	Well #1	B	25
33	17	26	Stehekin School	Well #1	B	14
33	17	36	Stekehin River Resort		B	45
33	17	36	Weaver Point	Drilled Well #1	B	85
33	18	31	Stehekin Landing	Well #1	A	100
33	18	31	Stehekin Landing	Well #2	A	100
					Total	3,822
Subbasin 2 – Antoine Creek						
27	23	2	Stocker	Well #1	B	n/a
27	23	2	Stozker	Well	B	720
27	23	4	Apple Acres Village	Well #1	A	15
27	23	4	Apple Acres Village	Well #2	A	25
27	23	4	Collins Water System	Well Lot #1	B	40
27	23	6	Granite Glenn	Well # 2	A	25
27	23	6	Granite Glenn	Well # 1	A	25
27	23	17	Isenhart Irrigation District	Lake Chelan	A	2,000
27	23	20	Chelan Station Water System	Wa. St. Dept of Game	A	1,000
27	23	33	Snow Creek Water System	Spring # 1	A	35
28	23	28	Mcclellan Water System	Well #1	B	10
28	24	6	Wells Hydroelectric Project	Well #4	A	500
28	24	6	Wells Hydroelectric Project	Well #1	A	3,000

Location			Name	Water Source	Group	Capacity (gpm)
Twn	Rng	Sec				
28	24	7	Azwell Orchards	Well #1	A	327
					Total	7,722
Subbasin 3 – Swanson/Cooper Gulch						
27	21	3	Chelan Ridge Water System	Lk. Chelan	B	63
27	21	3	Lake Chelan State Park	Lake Chelan	A	240
27	21	3	Mcculley Water System	Well #1	B	4
27	22	4	Sny - Bar	Well #1	B	4
27	22	7	Last Resort Condominium	Lake Chelan	B	40
27	22	7	Tract C Minneapolis Beach Homeow	Lake Chelan	A	60
27	22	13	Chelan River Irr Dist	Lake Chelan	A	6,000
27	22	13	Chelan - Water Dept, City of	Lake Chelan	A	3,000
28	21	12	H.R. Water System	Well	B	15
28	21	14	Overbay Orchard	Lake Chelan	B	9
28	21	21	Cove Owners Assoc.	Lake Chelan	A	30
28	21	21	Lk Chelan Yacht Club	Lake Chelan	A	50
28	21	27	Lake Chelan Reclamation District	Lakeshore	A	1,300
28	21	35	Lake Chelan Reclamation District	Lake Chelan	A	3,000
28	22	19	Cur Mac Orchard	Well #1	B	9
28	22	27	Henderson Highlands	Well	B	n/a
28	22	32	Chelan Red Orchard Inc	Well # 1	B	20
28	22	32	Lakeshore Orchards	Lake Chelan	B	30
28	22	33	Chelan Heights	Well	B	15
					Total	13,889
Subbasin 4 - Chelan Butte						
26	22	9	Butte Ranch	Well #1	A	30
27	22	15	Chelan-Water Dept, City of	Lake Chelan	A	800
27	22	15	Little Butte Water System	Lake Chelan	A	60
27	22	16	Alamo Orchard Water System	Lake Chelan	B	20
27	22	16	Laffertys Southshore Water Syste	Lake Chelan	A	70
27	22	16	Macdougall Water System	Lake Chelan	B	23
27	23	30	Chelan Falls Water District	Well # 1	A	200
27	23	30	Chelan Falls Water District	Well # 2	A	200
					Total	1,403

Location			Name	Water Source	Group	Capacity (gpm)
Twn	Rng	Sec				
Subbasin 5 – Bear Mountain						
26	21	10	Robison Tract	Well # 1	A	90
27	21	12	Lakeview Short Plat Water System	Lake Chelan	B	50
27	21	12	Sunnybank Water System	Lake Chelan	A	50
27	21	21	Chelan Park Ranches Water Assoc.	Well #1	A	25
27	21	25	Carrolls Coules		B	20
27	21	25	Carrolls Coules		B	18
27	21	28	Hillcrest	Well #1	B	10
27	21	34	Stanton Jack Water System	Well #1	B	3
					Total	266
Subbasin 6 – First Creek						
27	21	4	Alpenhorn Drive In	Well #1	A	12
27	21	4	Watson's Harverene Resort Inc.	Lake Chelan	A	n/a
28	21	8	Morning Sun Estates Water System	Spring	B	45
28	21	16	Kellys Resort	Lake Chelan	A	n/a
28	21	32	Granite Falls Community Beach As	Granite Falls Creek	B	100
29	21	33	Fields Point/Chelan R.D.	Fields Point Well	A	70
29	21	33	Village At Fields Point	Lake Chelan	B	50
					Total	277
Subbasin 7 – Twenty Five Mile Creek						
29	20	24	Holden Village Bed & Breakfast	Well #1	B	6
29	20	27	Grouse Mountain Spring	Grouse Spring	B	n/a
29	21	19	Twenty Five Mile Creek State Park	Well #1	A	90
29	21	19	Twenty-Five Mile Guard Station	Lake Chelan	B	n/a
					Total	96

n/a - not listed in WRIS database.

APPENDIX C

TABULATED STREAMFLOW RECORDS AND STATISTICS

CHELAN WRIA
STREAMFLOW EXCEEDENCES

Period	Stehekin River at Stehekin			Railroad Creek at Lucerne			Chelan River at Chelan		
	90% (cfs)	50% (cfs)	10% (cfs)	90% (cfs)	50% (cfs)	10% (cfs)	90% (cfs)	50% (cfs)	10% (cfs)
1 Jan	168	344	796	25	48	103	621	1,482	2,955
2	166	330	750	23	44	93	584	1,462	2,915
3	162	318	721	23	42	87	553	1,475	2,932
4	158	310	707	22	40	83	515	1,452	2,853
5 Feb	158	304	685	21	38	81	484	1,423	2,744
6	159	302	668	21	38	79	452	1,405	2,670
7	163	308	676	21	39	81	411	1,386	2,637
8	168	315	689	21	39	83	381	1,384	2,659
9 Mar	177	331	715	22	40	84	346	1,380	2,696
10	197	367	777	23	42	91	316	1,404	2,857
11	232	433	911	26	48	105	292	1,408	2,963
12	290	538	1,114	31	57	126	257	1,334	2,871
13 Apr	382	698	1,395	40	73	158	220	1,276	2,833
14	515	939	1,842	56	103	219	191	1,269	2,898
15	697	1,254	2,406	80	147	307	172	1,293	2,973
16	935	1,657	3,099	110	201	411	163	1,343	3,171
17 May	1,244	2,175	3,963	159	283	554	159	1,413	3,471
18	1,582	2,708	4,761	214	369	689	172	1,573	4,032
19	1,939	3,282	5,675	277	462	831	201	1,800	4,866
20	2,273	3,767	6,336	333	538	920	263	2,116	5,975
21 Jun	2,443	4,016	6,702	377	599	997	367	2,590	7,364
22	2,473	4,060	6,787	382	602	991	526	3,130	8,564
23	2,326	3,782	6,304	367	573	941	740	3,635	9,301
24	2,085	3,383	5,657	337	521	853	981	4,000	9,240
25 Jul	1,883	3,045	5,099	305	466	755	1,235	4,188	8,494
26	1,670	2,672	4,435	275	418	670	1,419	4,016	7,242
27	1,447	2,303	3,813	233	356	570	1,473	3,550	5,872
28	1,233	1,920	3,146	194	293	466	1,403	2,962	4,566
29 Aug	1,055	1,613	2,624	165	247	390	1,234	2,505	3,781
30	897	1,336	2,129	140	206	321	1,059	2,109	3,172
31	762	1,112	1,743	119	173	265	930	1,805	2,701
32	669	968	1,506	105	151	228	857	1,639	2,470
33 Sep	567	823	1,287	89	128	195	820	1,580	2,401
34	488	716	1,142	76	112	174	804	1,562	2,387
35	414	627	1,043	64	97	156	782	1,563	2,418
36	351	550	960	54	85	141	782	1,616	2,525
37 Oct	317	515	949	49	80	139	760	1,620	2,536
38	285	489	959	44	75	138	744	1,606	2,500
39	280	501	1,041	42	76	149	739	1,624	2,533
40	268	504	1,123	39	75	156	700	1,591	2,531
41 Nov	255	501	1,184	36	73	162	686	1,590	2,595
42	245	493	1,201	34	72	163	677	1,585	2,655
43	237	483	1,198	32	68	155	662	1,567	2,697
44	230	468	1,173	31	65	151	655	1,568	2,718
45 Dec	217	441	1,108	30	63	145	650	1,571	2,744
46	207	418	1,043	29	58	133	647	1,570	2,768
47	195	387	947	28	55	122	637	1,567	2,775
48	179	354	866	26	50	112	631	1,570	2,790

STEHEKIN RIVER AT STEHEKIN, WASH.
USGS STATION: 12451000

FLOW (CFS)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1911	.0	.0	650.0	319.7	320.0	717.8	1892.3	4189.7	5648.3	3030.3	1249.4	889.4	.0
1912	303.0	310.6	295.3	213.6	217.3	263.2	1175.2	3702.3	4577.7	1877.7	1126.6	532.6	1216.3
1913	302.7	292.0	254.4	228.5	304.8	356.5	1761.1	3823.9	4020.0	3226.1	1526.6	877.3	1414.5
1914	627.2	434.0	283.1	380.7	238.1	596.4	1912.3	3546.1	3631.0	2591.3	1190.1	635.8	1338.8
1915	589.3	945.9	456.5	225.8	190.2	499.2	2139.7	1892.3	1679.7	1273.6	1240.0	492.4	968.7
1927	.0	.0	.0	324.4	233.3	269.0	1029.5	2799.7	5229.3	2484.8	1204.5	927.2	.0
1928	1280.5	965.4	1026.3	842.9	448.0	687.6	1114.0	5036.8	3426.0	2326.5	1008.7	584.7	1562.3
1929	775.3	324.7	223.8	156.5	128.3	271.5	624.9	2824.5	3217.3	1646.1	936.7	456.7	965.5
1930	252.9	147.5	124.5	86.0	260.3	538.3	2134.3	2193.5	2646.3	2106.5	957.0	583.0	1002.5
1931	415.8	324.3	190.8	181.9	274.8	426.8	1204.4	4120.6	3222.0	1588.4	741.8	626.5	1109.8
1932	327.2	479.4	252.5	278.3	973.2	1084.9	1814.3	3588.7	4380.3	2192.3	1028.2	486.3	1407.1
1933	492.2	1411.2	915.9	516.7	297.4	276.6	1193.5	2416.1	4904.3	4163.5	1931.7	806.5	1610.5
1934	1581.1	1733.9	1266.1	784.1	658.8	1546.4	4643.7	4289.4	3505.7	2152.6	1211.9	663.8	2003.1
1935	405.5	1188.4	638.1	1057.3	1115.4	682.1	1040.3	3536.1	4428.0	2885.5	1270.5	900.7	1595.7
1936	423.9	217.4	176.6	155.7	116.3	263.7	2077.8	4500.6	3562.7	1384.4	841.3	523.8	1187.0
1937	337.0	157.1	167.6	114.1	115.0	193.7	621.7	2823.7	5227.7	2547.1	829.6	566.1	1141.7
1938	583.4	561.5	424.2	395.5	267.7	409.5	1721.2	4311.9	5097.0	2317.7	759.1	600.7	1454.1
1939	394.8	308.7	418.0	552.8	274.8	465.9	1806.0	3400.3	2735.7	2314.5	986.9	511.3	1180.8
1940	539.6	542.9	577.5	290.3	279.2	654.4	1843.7	3837.7	3100.0	1477.4	774.2	580.2	1208.1
1941	990.9	411.4	370.9	258.0	237.6	807.4	2341.3	2276.5	2028.3	1204.6	682.2	655.7	1022.1
1942	1084.7	640.8	757.5	320.5	249.1	284.0	1559.8	2840.0	2806.3	2003.5	890.5	409.0	1153.8
1943	245.7	198.5	271.1	267.1	235.0	367.3	2049.6	2992.6	4361.7	3790.0	1354.2	638.0	1397.6
1944	408.3	250.0	356.0	182.0	158.8	301.7	1098.6	2610.3	2674.3	1267.1	680.6	739.8	894.0
1945	492.7	370.4	400.2	445.1	400.3	327.8	716.7	3506.8	3243.7	1870.3	794.5	551.2	1093.3
1946	741.3	663.7	355.9	244.4	203.9	346.4	1365.3	5318.4	4010.3	2823.9	1198.2	580.8	1487.7

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1947	477.1	306.5	353.4	298.3	388.7	900.6	1996.2	4293.2	3118.7	1932.9	920.9	577.4	1297.0
1948	881.0	615.0	447.7	300.1	255.1	259.2	1017.3	4197.7	6110.3	2205.2	1245.0	650.7	1515.4
1949	691.4	358.8	287.3	188.8	211.5	315.6	1627.3	5065.8	3875.3	2392.6	1210.2	817.5	1420.2
1950	635.7	1658.5	1128.7	427.9	264.3	378.0	728.4	2736.8	7738.3	5479.0	2001.9	838.9	2001.4
1951	888.7	843.9	990.8	637.0	912.5	429.6	1899.2	4677.7	4772.7	3382.3	1269.1	756.0	1788.3
1952	788.4	552.9	325.3	219.4	197.6	258.0	1622.1	3928.7	3252.0	2174.5	1085.8	522.0	1243.9
1953	323.6	175.2	150.3	311.0	563.2	438.6	1097.7	3623.2	3654.7	3536.5	1491.9	742.9	1342.4
1954	771.4	746.7	522.9	422.3	333.5	372.1	946.2	4110.5	4636.7	4939.7	2342.9	1162.5	1775.6
1955	569.9	1246.4	760.6	367.4	289.3	260.1	549.3	2023.9	5461.7	3686.5	1566.3	801.0	1465.2
1956	1184.6	1876.6	503.7	270.2	181.3	204.0	1827.1	5528.4	5166.0	4114.8	1575.8	959.9	1949.4
1957	901.0	712.2	1017.8	398.2	250.3	325.9	1332.5	5652.9	3751.3	1678.7	931.3	698.9	1470.9
1958	486.2	478.5	353.4	241.3	345.6	468.2	1066.1	5810.3	3874.0	1716.5	970.6	650.5	1371.8
1959	866.6	834.2	1167.1	633.9	379.8	445.1	1884.3	3601.6	5301.7	3768.7	1395.1	1399.3	1806.4
1960	1868.9	1474.8	1187.6	431.2	282.4	517.1	1633.7	2887.1	4786.0	3196.5	1218.9	637.2	1676.8
1961	499.9	433.0	258.7	374.7	582.1	720.2	1573.7	4153.2	6296.0	2451.0	1276.8	643.4	1605.2
1962	596.5	361.4	254.7	568.9	882.9	395.8	1875.9	2341.0	3802.7	2387.7	1253.4	645.2	1280.5
1963	610.3	1020.3	722.6	515.4	757.8	715.4	906.3	3192.6	3510.3	1925.8	1207.1	770.1	1321.2
1964	579.0	505.4	480.8	412.6	302.8	360.7	997.2	2684.2	5942.3	3853.9	1495.3	702.3	1526.4
1965	747.8	365.5	321.0	276.1	461.8	661.7	1485.7	3109.4	4316.3	2679.0	1528.1	518.0	1372.5
1966	491.2	507.7	265.1	247.5	191.4	316.0	1574.7	3385.8	3205.7	2341.0	1155.3	652.5	1194.5
1967	630.1	493.0	776.1	476.1	481.4	393.7	575.4	3272.2	7363.0	3164.2	1403.1	832.8	1655.1
1968	1097.3	1274.7	898.0	1193.5	952.2	1078.1	895.3	3282.9	4704.0	3254.2	1261.0	935.4	1735.6
1969	473.2	470.3	392.5	456.0	240.6	367.1	1576.0	5247.4	5565.7	1718.1	899.5	888.9	1524.6
1970	717.8	497.7	228.4	172.9	191.1	238.7	613.9	2816.7	4511.3	1807.2	853.9	601.1	1104.2
1971	292.1	269.1	207.5	445.2	1208.6	455.8	824.5	5041.9	5010.0	4385.5	2072.9	652.8	1738.8
1972	466.4	434.5	313.5	265.1	327.7	1194.0	1147.6	4831.0	6841.0	4410.0	2309.7	836.7	1948.1
1973	563.2	361.4	427.6	328.4	169.7	315.8	859.0	2555.2	2417.3	1549.0	1060.9	477.8	923.8
1974	351.5	356.0	308.0	847.7	505.7	485.2	1168.9	3116.8	7668.0	4528.4	2715.8	1006.5	1921.5

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1975	381.5	350.6	322.0	364.5	244.6	262.1	645.0	2952.9	5146.3	4391.9	1347.2	744.7	1429.5
1976	675.6	1140.0	1896.1	661.2	573.9	375.2	840.6	3921.9	3895.3	4290.3	2518.4	1150.9	1828.3
1977	479.8	390.9	288.0	418.1	373.1	326.2	1213.7	1475.0	2487.7	1157.4	1240.7	597.4	870.7
1978	317.8	606.1	896.4	317.7	260.6	771.9	1566.7	3000.0	4788.3	3040.0	1257.4	1028.8	1487.6
1979	519.5	869.4	312.4	180.3	165.7	480.4	930.2	3107.7	2368.3	1466.0	855.0	609.4	988.7
1980	368.2	232.9	834.8	376.3	283.8	456.4	1923.7	3949.7	3054.7	1988.7	920.1	670.0	1254.9
1981	379.2	632.4	1697.8	1049.9	748.3	715.7	1145.8	2908.5	2620.3	2277.8	1303.2	648.3	1343.9
1982	607.2	581.8	360.4	321.9	652.6	586.5	761.1	3056.8	6227.7	3184.0	1474.7	797.8	1551.0
1983	536.7	375.5	344.8	562.9	412.5	820.2	1389.4	4270.3	3734.7	2451.8	1406.3	715.2	1418.4
1984	377.0	847.7	435.4	1576.5	689.3	717.8	891.3	1714.6	4320.0	3215.2	1491.4	583.2	1404.9
1985	515.8	345.8	227.1	185.2	170.9	273.5	1493.7	3431.3	3522.0	1967.1	1019.5	619.2	1147.6
1986	635.9	870.2	294.7	248.5	489.1	1204.4	1551.0	3229.0	3538.0	1535.8	1049.1	471.7	1259.8
1987	379.7	547.0	342.7	241.8	234.6	641.4	1952.4	4496.5	2896.7	1479.4	806.3	578.0	1216.4
1988	230.2	167.0	163.2	126.0	167.9	456.1	2123.2	3210.3	3287.7	2073.9	1099.2	86l.6	1163.8
1989	985.2	816.5	569.1	430.8	384.3	377.8	1402.2	2956.1	3809.0	1892.3	1148.3	510.8	1273.5
1990	353.0	1358.2	1063.3	465.8	460.5	640.3	2468.7	2404.2	3534.7	2692.6	1286.1	622.5	1445.8
1991	937.9	3192.0	932.7	549.3	855.7	658.2	1399.7	3302.9	4170.7	4141.6	2120.3	936.4	1933.1
1992	554.0	1013.8	432.6	365.9	693.3	1440.6	1966.3	3295.8	3115.0	1505.0	835.0	539.3	1313.1
1993	473.6	397.3	253.5	222.4	236.9	337.2	918.2	4678.7	2513.0	1241.0	1070.0	.0	.0
AVG	610.8	669.2	529.2	405.7	394.5	520.1	1427.3	3540.4	4153.4	2600.0	1255.3	702.6	1400.7

RAILROAD CREEK AT LUCERNE, WASH.
USGS STATION: 12451500

FLOW (CFS)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1911	.0	.0	97.2	63.9	47.8	74.6	197.8	346.2	608.5	400.3	240.1	145.7	.0
1912	52.5	62.6	41.9	37.6	31.9	34.7	144.8	445.3	594.6	338.6	211.3	86.3	173.5
1913	44.0	35.4	28.4	16.7	33.4	37.9	148.5	423.8	659.1	.0	.0	.0	.0
1927	.0	.0	.0	36.4	22.3	17.6	96.2	373.2	868.2	414.7	232.7	151.2	.0
1928	175.3	126.1	146.3	118.3	76.7	97.5	157.7	741.0	514.7	383.3	157.0	114.5	234.0
1929	86.3	42.9	34.1	27.6	21.0	29.4	53.5	381.9	500.3	246.6	166.0	86.4	139.7
1930	38.9	21.2	24.5	14.2	26.4	59.6	233.8	316.9	387.3	295.5	161.8	104.6	140.4
1931	56.6	39.8	27.3	28.5	34.8	41.0	100.7	485.5	485.2	238.0	129.6	95.6	146.9
1932	42.6	50.5	33.2	35.3	96.9	131.9	213.5	506.4	635.1	352.2	178.5	80.4	1%.4
1933	72.0	187.7	101.3	64.7	40.5	38.1	157.6	334.3	736.9	656.4	303.8	103.8	233.1
1934	110.2	192.7	163.0	103.6	97.0	198.5	716.9	657.3	520.0	315.7	180.4	90.9	278.8
1935	69.9	176.1	114.2	161.0	155.5	104.9	136.2	483.7	701.2	435.2	181.0	136.2	237.9
1936	65.8	33.5	27.6	28.4	18.1	29.8	201.7	589.4	570.2	226.9	134.6	86.0	167.7
1937	53.5	26.7	27.3	20.4	20.1	24.5	61.1	333.9	843.1	454.6	137.2	76.0	173.2
1938	88.4	84.7	51.8	48.0	36.9	46.4	216.0	613.2	810.2	345.3	124.0	71.2	211.3
1939	63.2	46.4	46.6	60.2	32.5	59.8	216.5	433.4	391.5	335.5	160.4	77.7	160.3
1940	66.7	65.9	67.0	40.0	35.7	62.3	207.9	490.4	496.4	250.9	120.0	92.6	166.3
1941	124.8	67.6	47.8	33.9	31.2	88.6	311.8	372.3	335.4	230.7	140.9	108.9	157.8
1942	131.6	99.3	114.2	56.8	38.9	36.5	173.6	397.1	385.6	396.4	185.1	68.9	173.7
1943	39.7	35.5	37.4	40.3	40.0	57.2	236.8	331.7	546.7	531.8	201.7	101.4	183.3
1944	62.9	38.3	49.5	32.0	27.3	39.9	100.0	330.5	406.9	205.2	116.6	121.7	127.6
1945	74.2	65.6	62.0	62.9	52.6	44.2	79.0	388.7	483.0	269.4	133.9	86.2	150.1
1946	88.7	93.9	52.4	34.3	29.6	43.9	135.9	707.5	627.9	435.5	213.2	102.8	213.8
1947	82.9	62.6	53.3	42.4	48.4	104.6	257.5	667.9	521.0	310.6	150.0	94.2	198.8
1948	147.5	106.2	73.0	46.3	42.7	37.8	118.0	682.4	1074.7	419.1	228.8	116.2	257.7

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1949	103.7	60.3	49.4	36.3	42.2	53.9	225.9	699.8	612.4	354.0	166.4	102.5	208.9
1950	99.1	178.4	143.2	63.6	45.5	43.5	91.7	465.1	1000.3	635.9	317.4	126.1	267.5
1951	141.1	136.2	134.7	94.5	123.3	64.6	332.3	817.2	807.4	564.4	217.9	118.1	296.0
1952	121.2	76.9	50.0	34.1	28.7	34.3	203.2	596.4	539.1	332.8	163.6	91.1	189.3
1953	63.5	32.2	26.3	43.4	55.3	53.7	149.2	535.6	627.3	648.3	260.5	127.1	218.5
1954	118.2	100.3	70.4	55.5	51.6	52.1	119.9	625.2	671.4	746.0	353.3	171.9	261.3
1955	91.5	157.8	91.4	59.2	51.8	50.0	80.1	286.2	999.9	590.0	247.2	130.8	236.3
1956	131.7	230.6	80.7	44.0	28.7	30.9	230.2	787.4	87.3	622.7	270.0	148.9	290.3
1957	108.2	82.8	102.3	55.1	47.4	50.5	154.4	823.7	560.7	283.2	144.3	117.1	210.8
AVG	88.0	88.0	68.8	51.2	47.4	58.1	184.1	513.8	629.4	402.0	191.8	106.8	202.4

CHELAN RIVER AT CHELAN, WASH.
USGS STATION: 12452500

FLOW (CFS)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1904	.0	1708.0	1275.8	935.3	904.0	1054.2	2728.7	5726.1	7622.7	6517.1	3057.6	1332.0	.0
1905	910.5	806.7	786.0	741.8	756.6	1902.7	2331.7	3871.9	7164.7	5077.7	2191.8	1301.0	2320.3
1906	1755.8	1163.8	816.3	854.0	913.4	1223.9	2077.0	4584.2	4123.0	4017.7	1740.0	1204.3	2039.5
1907	911.3	1981.7	1870.8	746.5	840.7	1059.2	1595.3	5339.7	6839.3	4988.7	2269.7	1191.0	2469.5
1908	975.5	578.8	394.7	501.9	456.1	1578.2	1889.7	3860.0	6789.3	6344.5	2393.2	1177.2	2244.9
1909	677.0	640.8	717.1	542.4	560.2	1206.8	1498.3	2764.5	6882.3	4978.7	1418.9	1154.3	1920.1
1910	755.0	915.3	1744.7	760.2	619.6	2390.0	3031.0	7434.5	6773.3	5063.9	1737.4	761.7	2665.6
1911	2850.3	1906.0	870.8	362.3	388.8	727.4	2262.0	3363.2	6304.7	4075.2	2060.3	996.5	2180.6
1912	618.3	402.0	464.5	436.6	486.4	454.5	1935.8	4803.2	6234.3	4322.9	1372.1	847.5	1864.8
1913	476.7	453.2	431.7	459.6	477.2	1122.4	1370.4	3511.6	7961.3	5359.4	2167.1	1306.4	2091.4
1914	714.9	678.3	530.5	677.5	543.6	1343.7	2674.3	5139.7	5730.3	4515.8	1284.9	706.2	2045.0
1915	783.4	1253.7	902.9	535.5	423.4	579.4	3413.0	3334.5	2630.7	1900.0	1517.4	601.3	1489.6
1916	387.9	559.9	607.4	500.4	512.9	1959.6	2607.0	4901.9	7581.7	7479.0	3525.5	1393.9	2668.1
1917	541.1	346.7	345.2	297.5	398.7	996.5	559.4	3340.8	6813.7	6262.3	2037.1	1175.7	1926.2
1918	756.3	495.2	817.4	3414.8	1117.3	874.0	1720.0	4272.6	6590.7	4697.1	1662.7	1071.0	2290.8
1919	1024.1	780.9	932.2	865.8	769.3	614.8	2070.0	4898.1	6409.3	6058.7	2381.0	1258.8	2338.6
1920	577.6	460.4	567.6	594.9	838.7	1051.8	1018.9	2884.8	2927.7	4788.4	2172.7	1134.0	1584.8
1921	1723.9	1086.0	821.7	849.7	938.0	1351.3	1982.0	5169.0	9230.0	5794.8	25T7.6	641.0	2680.4
1922	829.0	1570.3	1868.7	1108.1	719.9	557.9	1010.9	3344.2	7084.7	3800.0	1535.8	1245.3	2056.2
1923	716.6	495.9	376.3	368.5	343.6	581.0	2285.3	4845.2	6305.3	5082.6	1741.0	1130.7	2022.7
1924	638.4	432.6	352.1	330.4	578.3	1817.9	1490.3	5220.6	4240.7	2692.9	1474.2	1064.8	1694.4
1925	765.6	634.2	818.3	934.2	864.3	1498.4	2766.3	5840.0	5884.0	4334.5	1639.4	1029.2	2250.7
1926	650.8	384.2	320.3	304.7	320.6	701.8	2193.7	3330.3	2201.0	2031.9	1029.8	842.3	1192.6
1927	700.3	730.0	663.9	716.1	589.3	1107.2	1011.3	3051.9	6481.7	3347.1	428.9	972.1	1650.0
1928	2101.3	657.2	596.7	671.2	676.8	576.6	656.8	3545.2	2862.4	2850.6	1417.8	1677.0	1524.1

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1929	1251.8	1521.0	1792.2	2342.3	2305.4	654.5	356.0	168.3	235.0	1599.1	2088.7	2406.7	1393.4
1930	2374.5	2314.0	1838.5	1431.7	138.3	42.6	71.6	153.7	890.0	2213.1	2203.5	1760.7	1286.0
1931	1551.6	1645.7	2040.0	1397.2	427.1	209.1	171.1	T70.3	3275.9	2016.5	2265.8	2281.3	1504.3
1932	2152.9	1355.5	1196.8	335.9	472.7	665.4	880.3	3974.0	4949.7	2571.3	1495.5	1393.1	1786.9
1933	1786.5	764.3	2273.5	1165.0	1819.9	1853.5	588.4	1243.9	6516.0	5286.5	2296.1	1347.0	2245.0
1934	2456.6	3286.7	2804.2	2576.8	2957.9	1047.9	4415.5	6731.3	4462.0	2765.2	2196.1	2005.0	3142.1
1935	2006.8	786.8	844.5	1515.8	3948.9	2046.6	872.5	2489.6	5796.0	3592.9	2155.5	2237.0	2357.7
1936	2182.6	1997.3	2119.4	1581.0	1460.6	366.8	386.4	537.9	3866.6	1919.4	2156.1	2183.3	1729.8
1937	2149.7	2105.7	1809.7	1338.5	1178.3	675.7	930.0	543.5	1267.8	3386.8	2196.8	2166.3	1645.7
1938	2124.8	2049.6	1475.3	1154.6	906.5	867.9	746.2	3137.0	6293.0	3193.2	2140.3	2126.3	2184.6
1939	2164.8	2163.7	2130.3	899.0	694.1	931.1	764.9	862.7	1193.0	2669.9	2132.6	2105.0	1559.2
1940	2198.4	2221.0	2189.4	1788.4	980.4	1108.5	915.6	596.6	2319.0	2308.1	2200.0	2086.3	1742.6
1941	2142.6	2110.7	1298.7	1203.5	961.5	930.8	349.8	118.3	2176.2	1791.0	1841.0	1551.6	1373.0
1942	718.5	828.7	1158.4	1417.7	1301.5	1049.7	980.0	2490.6	3249.0	2677.4	1373.6	1540.0	1565.4
1943	1883.9	1425.9	902.0	1394.9	1301.7	1675.5	978.8	960.3	4691.0	5117.4	2188.4	1995.0	2042.9
1944	2059.0	2116.3	1891.4	1478.5	210.0	173.8	24.6	60.0	1068.1	1474.6	1466.6	1941.0	1163.7
1945	1983.9	2022.3	1956.8	1144.5	145.7	199.1	819.6	892.8	3051.1	2503.9	1740.6	2065.3	1543.8
1946	2123.9	1652.1	1294.3	1399.1	1829.3	1442.4	1548.9	1933.5	4238.0	3786.1	2222.3	2183.0	2137.7
1947	2023.9	1898.0	1464.8	1782.9	1535.3	1666.8	1181.8	1961.0	3018.0	2467.7	2219.7	2065.3	1940.4
1948	968.9	913.9	1236.3	2087.0	1749.0	1429.8	1140.2	2308.1	9565.7	2801.8	2251.0	2027.3	2373.3
1949	1842.5	1889.9	2364.9	2320.0	1797.5	1191.5	1199.7	1766.5	3634.7	3101.8	2202.3	2156.7	2122.3
1950	2159.7	1649.5	1370.9	2125.0	1511.7	1379.1	965.1	4039.9	6712.7	6451.3	2476.8	1355.3	2683.1
1951	952.2	1253.2	1725.1	1679.4	4308.4	2259.7	2657.3	6294.8	5576.3	4304.5	1651.1	1729.1	2865.9
1952	651.3	1988.0	1855.0	3650.6	1733.4	1446.5	1472.4	1400.4	1499.1	2257.1	1627.7	2063.1	1803.7
1953	1736.8	2067.3	1674.5	1651.0	1721.8	2016.5	1699.9	1496.5	797.1	4077.6	1967.2	1964.6	1905.9
1954	1623.2	2070.3	2205.8	2197.1	1932.9	2072.3	1089.3	2333.2	3284.0	6339.7	2979.7	2137.0	2522.0
1955	2188.4	2212.7	2231.9	2227.1	2191.8	2154.5	1562.7	97.2	2501.5	4589.7	2366.5	2098.0	2201.8
1956	1647.1	1247.2	1886.4	1761.0	3046.6	2324.5	1623.9	5659.7	7133.3	5386.1	2125.8	2032.7	2989.5

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1957	2223.9	2282.7	2306.8	2301.9	2238.9	2092.6	1179.3	1302.5	5052.7	2291.9	1159.6	2236.3	2222.4
1958	2285.8	2317.0	2303.2	2221.6	1503.7	1910.0	1272.6	771.5	4063.0	2178.4	977.4	2130.7	1994.6
1959	2059.0	1755.0	1521.6	1873.5	3478.9	2369.0	1105.6	2212.5	5181.6	5373.2	1674.5	1882.3	2540.6
1960	2490.8	2331.0	2365.5	2753.5	2316.2	2331.9	2037.7	1611.4	5125.3	3975.5	1345.7	2187.0	2572.6
1961	2170.3	2086.0	2244.8	2145.8	1920.7	2166.5	1404.0	623.1	5321.9	3150.0	1332.9	1364.6	2160.9
1962	1552.5	2031.7	2093.5	2049.7	2001.4	1882.6	244.3	83.1	1878.1	2585.8	1454.7	1088.2	1578.8
1963	1632.2	2079.7	2087.1	2086.8	1101.7	1847.0	880.1	685.9	3676.6	2330.1	1459.5	777.3	1720.3
1964	2084.5	2099.3	2111.6	2119.4	2098.3	2080.6	1558.3	345.1	3153.6	4932.3	1697.5	742.7	2085.3
1965	1693.2	1964.3	2107.1	2107.4	1618.6	1016.8	949.5	1060.5	4981.3	3386.6	1836.6	851.2	1964.4
1966	1909.4	2046.0	2048.4	2041.9	2018.6	2001.6	1242.5	570.5	167.7	2791.3	1316.3	1845.5	1666.6
1967	2050.0	2090.0	2087.1	2067.1	2046.4	2026.5	1754.6	261.1	4650.2	4092.3	1451.4	1800.0	2198.1
1968	2081.3	2109.7	2123.9	2114.8	2115.9	2089.4	1052.8	1670.7	6968.3	4096.5	1662.1	2073.3	2513.2
1969	2136.5	2113.0	2156.8	2134.8	2134.6	2100.0	104.0	2146.1	6253.7	2191.3	1478.5	2013.3	2246.9
1970	2143.5	2179.7	2155.8	2092.9	2144.6	1761.0	56.0	167.1	852.2	1689.3	1400.9	2006.0	1554.1
1971	1839.4	1859.7	1891.3	1971.6	1224.1	2205.2	1346.3	3343.9	4472.3	4964.8	2828.1	2221.7	2514.0
1972	2231.6	2132.3	2233.5	2242.3	2220.7	1628.4	2173.3	3764.0	8005.0	4983.5	3007.7	2019.7	3053.5
1973	2175.8	2173.3	2184.8	2180.6	2143.2	842.3	15.5	15.7	292.4	1760.0	1603.2	1668.0	1421.3
1974	1615.8	2078.0	2112.6	2003.0	2140.0	2155.2	1812.7	1598.5	7383.3	5714.2	2837.1	1941.3	2782.6
1975	2151.9	1924.0	1953.5	2167.4	2135.4	2090.0	954.3	804.9	3481.3	4648.6	1816.4	1731.0	2154.9
1976	1889.0	2042.7	2133.5	2199.7	1987.1	2176.8	1837.9	4313.2	3366.0	5079.7	3246.6	2134.3	2700.5
1977	2061.0	1967.3	1911.6	1930.3	1162.4	695.3	427.5	20.7	189.4	966.7	1445.4	1515.3	1191.1
1978	1507.4	1475.0	2070.3	2122.6	2122.5	2146.8	1190.2	922.0	4635.1	3963.9	1877.1	1560.3	2132.8
1979	1962.6	2128.7	2082.3	1950.0	1755.4	1905.8	751.4	37.2	193.2	1089.7	1443.2	1760.3	1421.6
1980	1664.8	1845.3	1976.1	2114.8	2144.5	2127.7	1088.8	623.3	3052.3	2476.1	1491.0	1514.7	1843.3
1981	1503.5	1500.0	1870.0	2078.7	2043.6	1557.7	988.4	1352.1	3513.0	3007.1	1547.6	1362.3	1860.3
1982	1605.7	1969.7	2000.6	2022.6	2062.9	2060.3	1387.6	1952.6	5394.7	3817.4	1992.3	1550.9	2318.1
1983	1929.7	2053.0	2082.6	2074.2	2031.4	1619.7	2058.7	2128.4	4188.3	3374.2	1870.2	1717.5	2260.7
1984	1851.9	2046.0	2033.5	2010.6	2050.7	2033.9	2006.7	1383.9	2382.0	3803.2	2020.7	1184.5	2067.3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVG
1985	1977.4	1964.5	2052.9	1973.9	1377.1	995.2	989.2	1013.2	1034.0	1798.7	844.6	1134.0	1429.6
1986	2061.6	2196.7	2203.2	2200.0	1486.1	978.4	1010.0	1128.7	3885.3	1893.9	1059.8	1115.3	1768.3
1987	1768.1	2177.7	2210.0	2203.5	2203.6	1920.6	867.0	2150.0	1806.3	1799.7	729.7	1117.9	1746.2
1988	2106.8	1872.3	1982.9	2200.0	2055.4	456.2	384.0	1147.0	1955.1	2443.5	1258.8	1192.8	1587.9
1989	2013.2	2207.3	2200.0	2200.0	2200.0	1792.7	2116.3	2199.7	2334.0	2020.1	1097.3	1319.7	1975.0
1990	1881.0	1993.3	2200.3	2148.7	2210.0	2207.7	1843.3	2212.3	2449.0	3236.1	1622.7	1446.9	2121.0
1991	1910.0	2592.7	2219.0	2210.0	2210.0	2203.9	2207.0	3012.3	5056.0	4846.5	2478.7	1545.0	2707.6
1993	2161.6	2190.0	2172.3	2099.4	1785.4	925.2	50.0	108.5	2728.0	.0	.0	.0	.0
AVG	1640.1	1624.2	1622.6	1595.2	1484.2	1422.6	1358.6	2383.6	4292.7	3656.6	1857.1	1567.8	2042.1