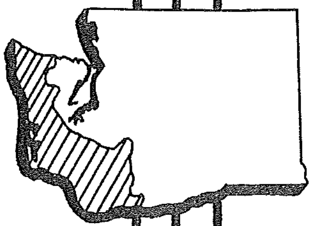
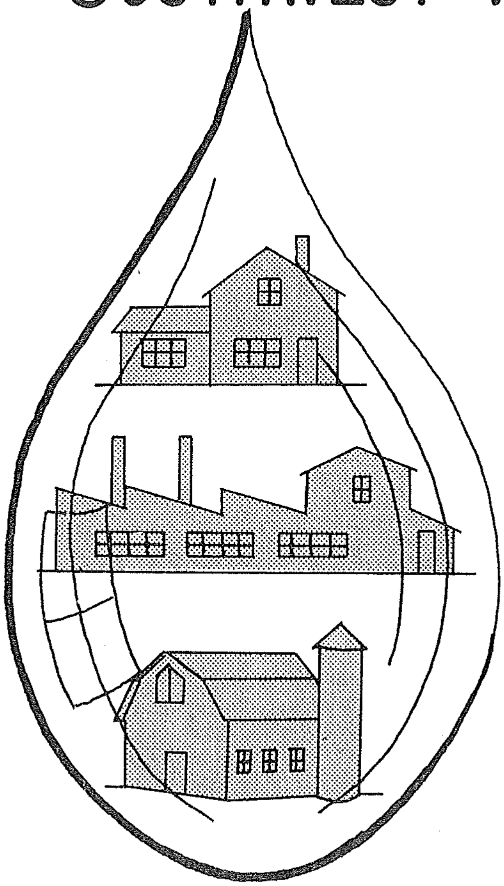
REVIEW DRAFT



MUNICIPAL, INDUSTRIAL AND RURAL WATER SUPPLY IN SOUTHWEST WASHINGTON



SOUTHWEST WASHINGTON RIVER BASINS STUDY

STATE OF WASHINGTON
DANIEL J. EVANS
GOVERNOR

DEPARTMENT OF ECOLOGY
JOHN A. BIGGS
DIRECTOR

MAY, 1973

REVIEW DRAFT

MUNICIPAL, INDUSTRIAL AND RURAL WATER SUPPLY IN SOUTHWEST WASHINGTON

Prepared for:

STATE OF WASHINGTON
Department of Ecology
John A. Biggs, Director

Prepared by:

Washington State Department of Social and Health Services,
Division of Health

May 1973

Olympia, Washington 98504

State of Washington Department of Ecology

STATE WATER PROGRAM

FOREWORD

Water Resource Management Programs are being developed by the Department of Ecology for Southwest Washington River Basins under the Water Resources Act of 1971. In developing these programs, water for municipal, industrial and rural ("individual domestic") use must be evaluated with respect to other uses, which may be in competition for the same resource.

The purpose of "Municipal, Industrial and Rural Water Supply in Southwest Washington" ("M & I Report") is to: (1) appraise the present use of public and individual (rural) water use in the Southwest Washington Study Area; (2) determine the future water needs on a regional basis; and (3) present "single-purpose" means to meet foreseeable short- and long-term needs. It was prepared by the Department of Social and Health Services as a technical support study for the Southwest Washington (Type IV) River Basins Study, a cooperative effort of the State of Washington and the United States Department of Agriculture. The study is guided by a Plan of Work and Agreement dated July 31, 1968. The Department of Ecology is the study coordinator for the State.

Although this study was initiated prior to the enactment of the Water Resources Act of 1971, the "M & I Report" is responsive to the concern of the State Legislature that "adequate and safe supplies of water shall be preserved and protected in potable condition to satisfy human domestic needs," (90.54.020 RCW).

The "M & I Report" is also expected to provide basic information to guide future decisions relative to:

1. Planning for the development of water supply systems that will provide water to the public generally in regional areas... [90.54.020(7) RCW].
2. The reservation and setting aside of waters for beneficial utilization in the future [90.54.050(1) RCW].

In addition to the main report, which will be a U. S. Department of Agriculture publication, the Department of Ecology plans to publish reports similar to the "M & I Report" on the following subjects for the Southwest Washington River Basins:

- Water Resources
- Fisheries Resources
- Game Fish and Wildlife Resources
- Outdoor Recreation
- Agricultural Alternatives

These and other information sources will provide basin citizen committees and agency personnel with technical information to develop Water Resource Management Programs for Southwest Washington River Basins.

CONTENTS

ILLUSTRATIONS

TABLES

TABLES (Cont.)

TABLES (Cont.)

TABLES (Cont.)

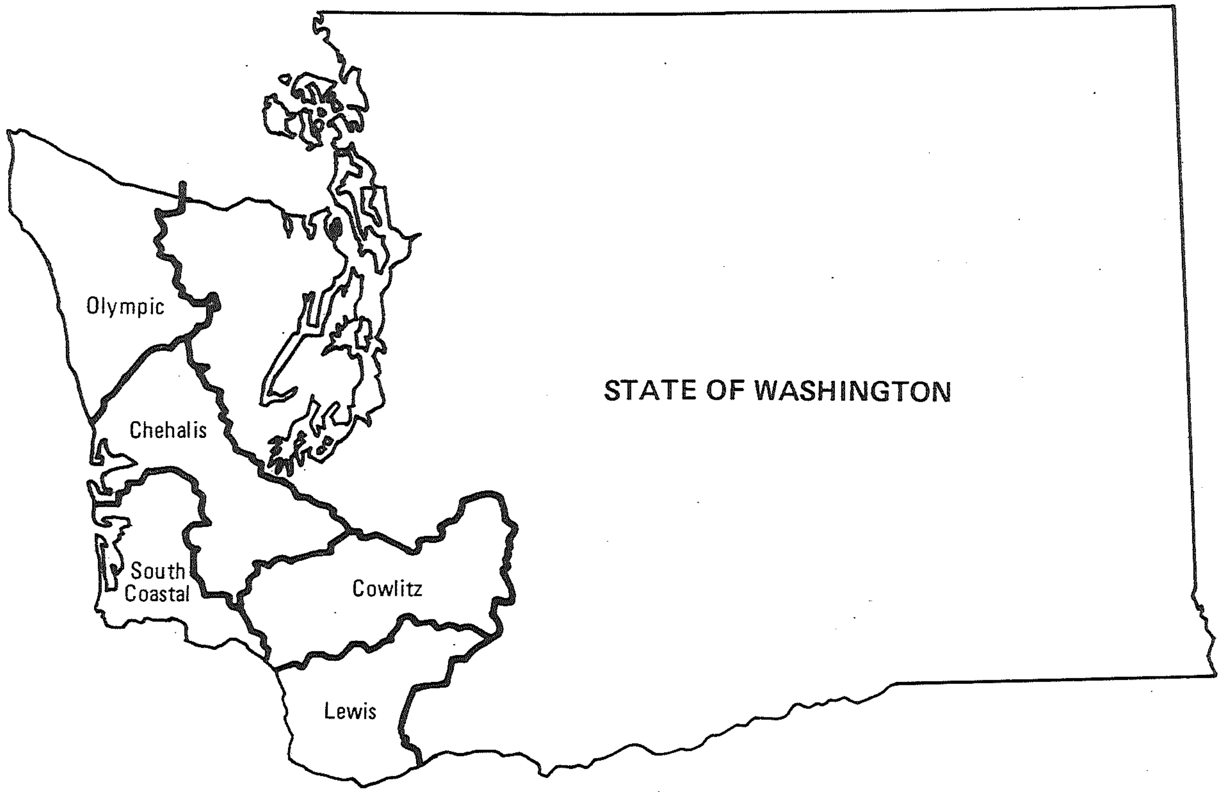


Figure 1. Southwestern Washington River Basins

PURPOSE AND SCOPE

This appendix reports the results of a detailed investigation of municipal and industrial water supplies and uses for 1970. Because of the constant change that occurs in such systems, no attempt has been made to incorporate recent expansions of or additions to the larger water systems. Instead, this report represents a comparison of the supply and use data that existed in 1970. Thus, the report serves as a baseline on which to evaluate future needs for municipal and industrial water supplies.

Comparison of the supply and use data reveals that substantially more water is available than is presently being used for municipal and industrial purposes. With adequate planning, sufficient water resources exist in the Area to meet the municipal and industrial demand during the foreseeable future.

Information in this appendix illustrates present and future demands for municipal and industrial water, and describes in general terms how the demand is currently being met. The data presented are based upon a single-purpose use of the water resources for analysis with other water uses in developing the Comprehensive Plan. No attempt has been made to analyze in detail the adequacy of existing supply systems.

AREA DESCRIPTION

The Southwestern Washington Area includes all land west of the Cascade Divide except the Puget Sound drainage Basin. The Area includes four entire counties, and parts of seven others, involving altogether an area of about 11,000 square miles, or about 16 percent of the area of the

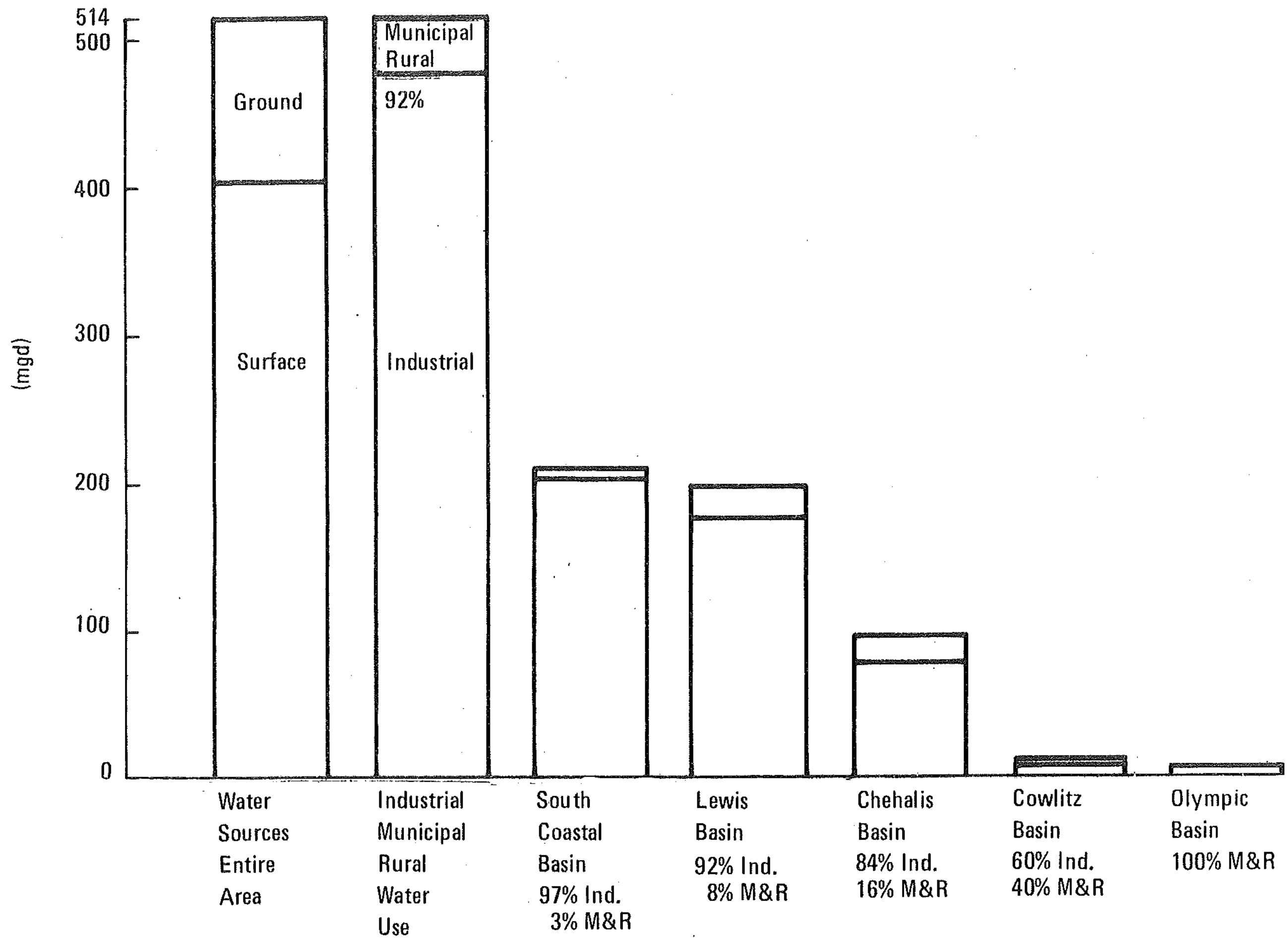


Figure 2. Water Source and Use Characteristics—1970

Table 1. Average Daily Water Use (mgd) – 1970

Basin	Average Daily Use	Surface Water Use	Ground Water Use	Municipal and Rural Use	Industrial Use
Lewis	197.7	104.2	93.5	14.7	184.0
Cowlitz	10.2	5.9	4.3	3.8	6.4
South Coastal	210.5	200.2	10.3	6.4	204.1
Chehalis	94.7	91.0	3.7	15.3	79.4
Olympic	1.2	0.1	1.1	1.2	–
Total	514.3	401.4	112.9	41.4	473.9

are no interbasin diversions within the Area.

MUNICIPAL

Municipal water use is defined as water served by a public or private purveyor through a distribution system. Included are residential, commercial and public uses, and minor industrial uses directly related to goods and services for the local population. The latter, therefore, are included in the municipal gallons per capita per day (gpcd) use figures.

Municipal water use presently averages over 41 mgd as shown in Table 1. Municipal use constitutes about one-tenth of the total water used by municipal and industrial consumers in the Area. Per capita water use varies from city to city because of a number of factors that influence the rate of use. Aberdeen, for example does not meter its service connections, and has an exceptionally high rate of water use, while Vancouver shows a relatively low figure. Total average daily municipal water use in the Southwest Washington Area, for a served population of 242,915 is about 175 gpcd. Table 2 shows present municipal per capita use for the major cities in the Area.

INDUSTRIAL

Industrial water use averages about 474 mgd, which represents over 90

Table 2. Municipal Water Use – 1970

Basin	System	Estimated Population Served	Average Daily Water Use (gpcd)
Lewis	Vancouver	74,000	86
	Clark Co. PUD No. 1	14,700	169
	Camas	7,600	241
Cowlitz	Kelso	11,500	107
	Cowlitz Co. PUD No. 1	6,500	69
South Coastal	Longview	30,000	120
	Raymond	3,670	131
	Long Beach	3,500	77
	South Bend	2,000	360
Chehalis	Aberdeen	22,000	272
	Hoquiam	10,500	129
	Centralia	10,500	286
	Chehalis	5,800	165
Olympic	Forks	3,100	129
	Pacific Beach	1,400	150

percent of the total used by municipal and industrial consumers. Of this amount, about 380 mgd, or 80 percent, is supplied from surface water sources. A small fraction of the industrial water use is included in the municipal per capita use figure, however, when the percentage of municipal water used by industry was known, the municipal and industrial usages were separated.

Industries listed separately reflect the needs of large water-using industries that are not directly related to the local population.

Table 3 summarizes the location, by basin, and the amount of water used by the major industries. Many of the industrial users shown obtain their water through municipal systems, and probably will continue to receive water from these systems. But their present demand and future needs are analyzed separately because their size and location are not directly related to total population and their water supplies could conceivably be independent of municipal supplies.

The pulp and paper industry is by far the most important in terms of the quantity of water used. This industry accounts for nearly 90 percent of the total water used by all industries—an average demand of 415 mgd. Almost all water used in pulp and paper manufacturing comes from surface water sources.

The chemical, metal and food processing industries constitute the remainder of the industrial water use. The total consumption of

Table 3. Summary of Southwest Washington Water Use—1970

Basin and Use	Estimated Population Served	Surface Water Usage (mgd)		Estimated Population Served	Ground Water Usage (mgd)		Estimated Population Served	Total Usage (mgd)	
		Avg Daily	Max. Month		Avg Daily	Max. Month		Avg Daily	Max. Month
Olympic									
Municipal	1,400	0.08	0.16	6,225	0.84	1.17	7,625	1.08	1.63
Rural-Individual	725	0.04	0.08	4,350	0.24	0.46	5,075	0.12	0.24
Industrial	--	--	--	--	--	--	--	--	--
							12,700	1.20	1.87
Chehalis									
Municipal	49,340	11.44	15.87	9,020	1.66	2.34	58,360	13.10	18.20
Rural-Individual	3,270	0.18	0.36	36,870	2.03	4.05	40,140	2.20	4.41
Industrial	--	79.40	84.40	--	--	--	--	79.40	84.40
							98,500	94.70	107.01
South Coastal									
Municipal	42,990	5.79	8.14	6.00	0.08	0.12	43,590	5.87	8.26
Rural-Individual	1,726	0.10	0.18	10,384	0.45	1.05	12,110	0.55	1.23
Industrial	--	194.35	214.10	--	9.70	9.90	--	204.05	224.00
							55,700	210.47	233.49
Cowlitz									
Municipal	22,540	2.59	3.63	1,300	0.23	0.32	23,840	2.82	3.95
Rural-Individual	1,700	0.09	0.18	16,360	0.91	1.80	18,060	1.00	1.98
Industrial	--	3.20	3.50	--	3.20	3.50	--	6.40	7.00
							41,900	10.22	12.93
Lewis									
Municipal	4,100	1.32	1.48	105,400	11.71	17.11	109,500	13.03	18.59
Rural-Individual	2,750	0.15	0.30	25,650	1.41	2.82	28,400	1.56	3.12
Industrial	--	103.60	112.60	--	80.40	85.10	--	184.00	197.70
							137,900	198.59	219.41
Totals									
Municipal	120,370	21.22	27.28	122,545	14.52	21.06	242,915	35.88	50.63
Rural-Individual	10,171	0.56	1.10	93,614	5.04	10.18	103,785	5.43	10.98
Industrial	--	380.55	414.60	--	93.30	98.50	--	473.85	513.10
Totals	130,541	402.33	442.98	216,159	112.86	129.74	346,700	515.16	574.71

these three industries averages 58 mgd.

RURAL-INDIVIDUAL

About 104,000 persons in rural areas rely on small individual systems such as wells or local surface sources for water supplies. No actual water use data are available for these systems; therefore, an average per capita figure of 55 gpcd is assumed in determining this component. Estimates of rural-individual water use show an average daily consumption of 5.4 mgd, or about 1.1 percent of the Area's total municipal and industrial water use. It is estimated that about 90 percent of the rural-individual population draw from ground water sources, and the remaining 10 percent receive water from surface sources. Table 3 includes a summary of rural-individual water use.

State. The study Area is divided into five subareas as follows: (1) Olympic Basins; (2) Chehalis Basins; (3) South Coastal Basins; (4) Cowlitz Basins; and (5) Lewis Basins. The study Area is bordered on the north by the Straight of Juan de Fuca, the east by the Puget Sound Area and the Cascade Divide, the south by the Columbia River, and the west by the Pacific Ocean.

The 1970 Census of Population for the Area indicates a population of 346,700, which is mainly concentrated in the river valleys and prairie uplands of the valleys.

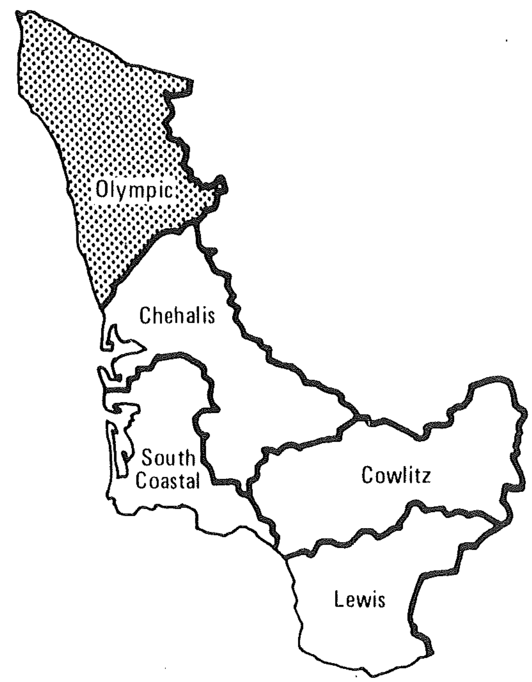
Major population centers are Vancouver, Kelso-Longview, Hoquiam-Aberdeen, and Chehalis-Centralia. The trends indicate a continuing and rapid rise in population near urban developments. Agriculture, forestry and associated industry dominate the economy of the Area, but other industrial development, particularly aluminum, is well established and is likely to expand.

PRESENT STATUS

Water supplies for municipal, industrial, and rural individual purposes are considered in this report and summarized by basin in Table 3. In 1970, this usage accounted for 514 million gallons per day (mgd). Figure 2, which shows use characteristics, reveals that most of the municipal and industrial water supplied in the Area is used in three basins.

Table 1 compares water used in each basin for municipal and industrial purposes with water supplied from each basin for these purposes. There

Olympic Basins



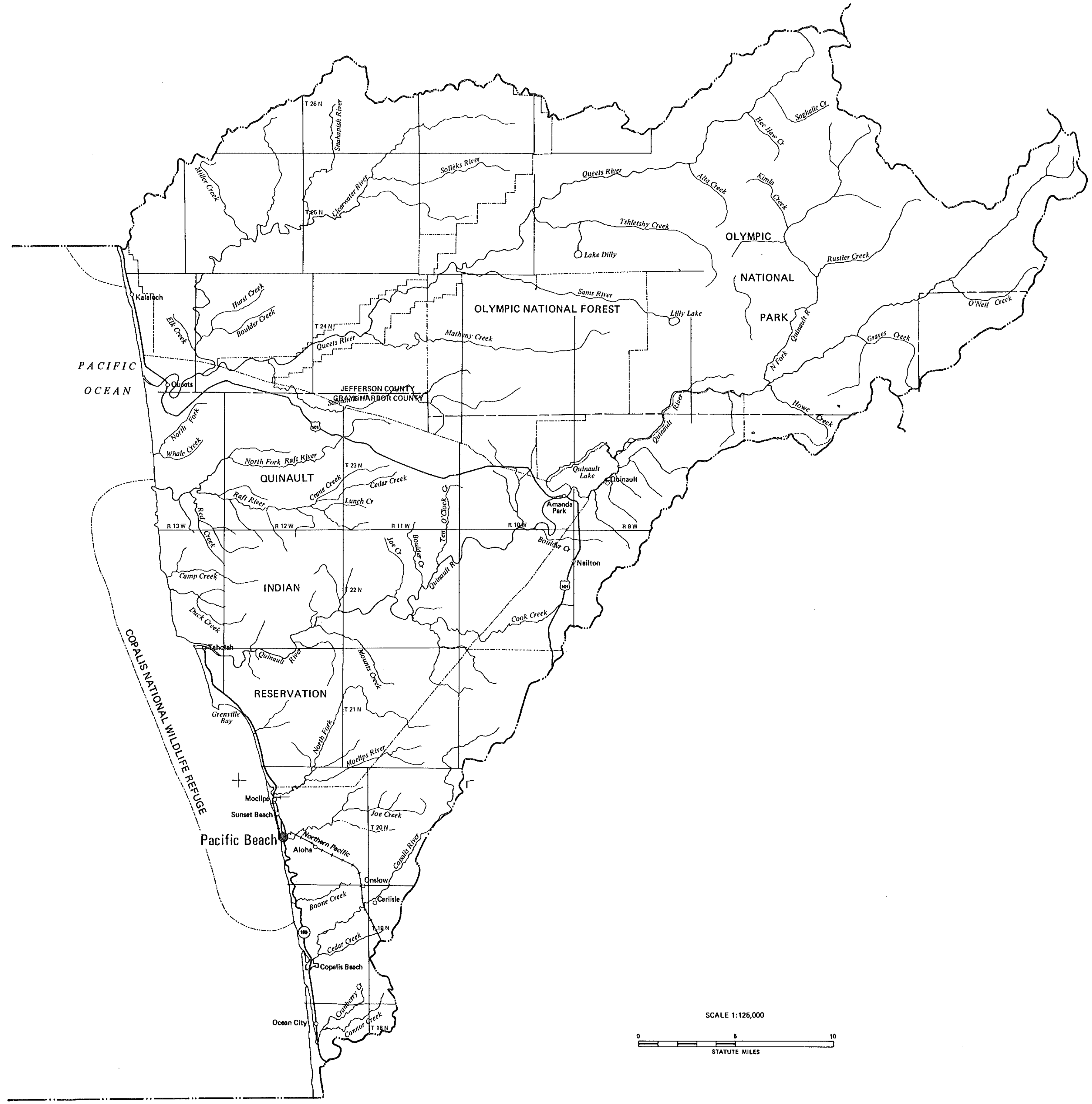


Figure 5. Olympic Basin—Queets-Quinault Area, WRIA 21

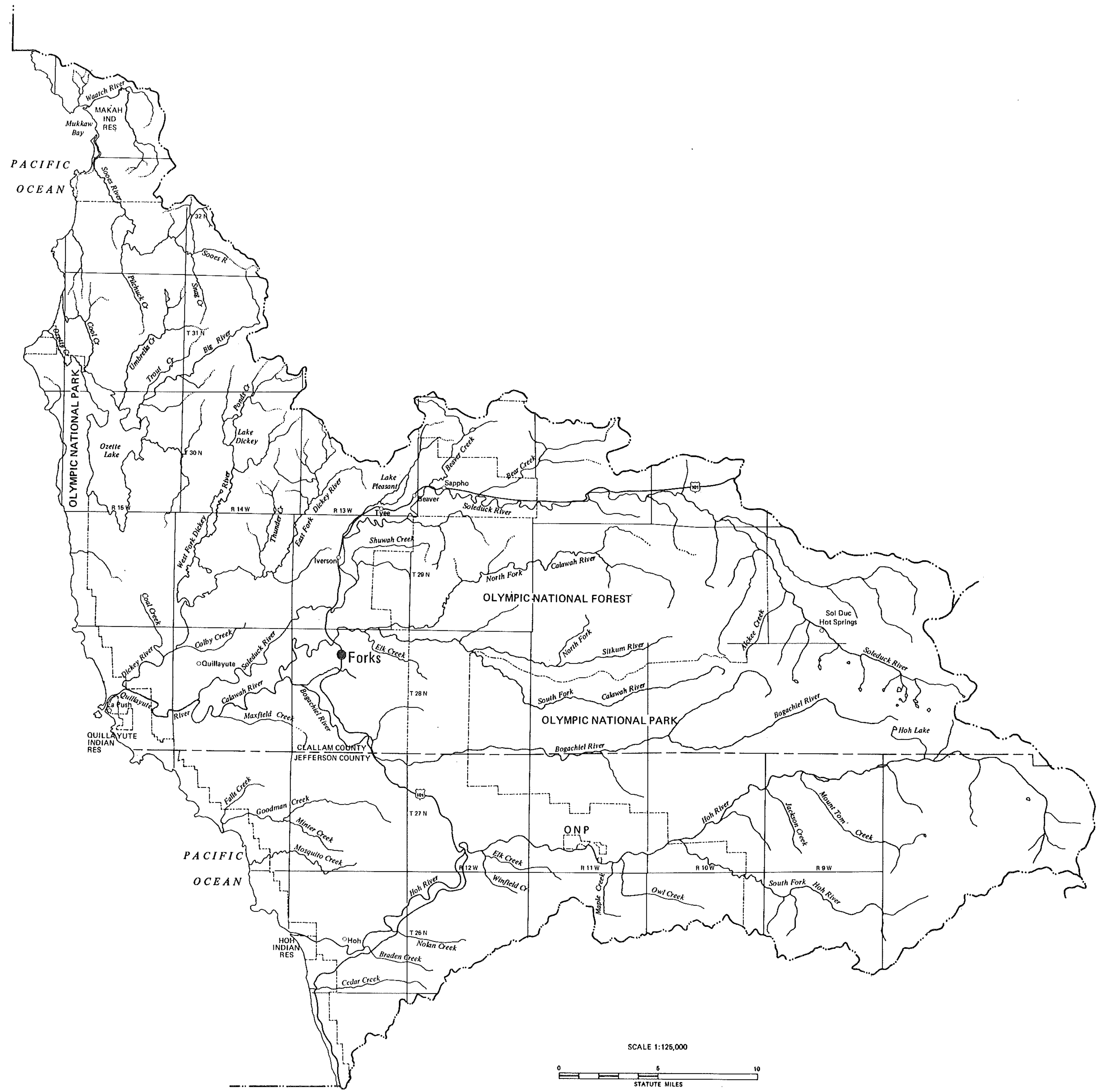


Figure 4. Olympic Basin—Soleduck-Hoh Area, WRIA 20

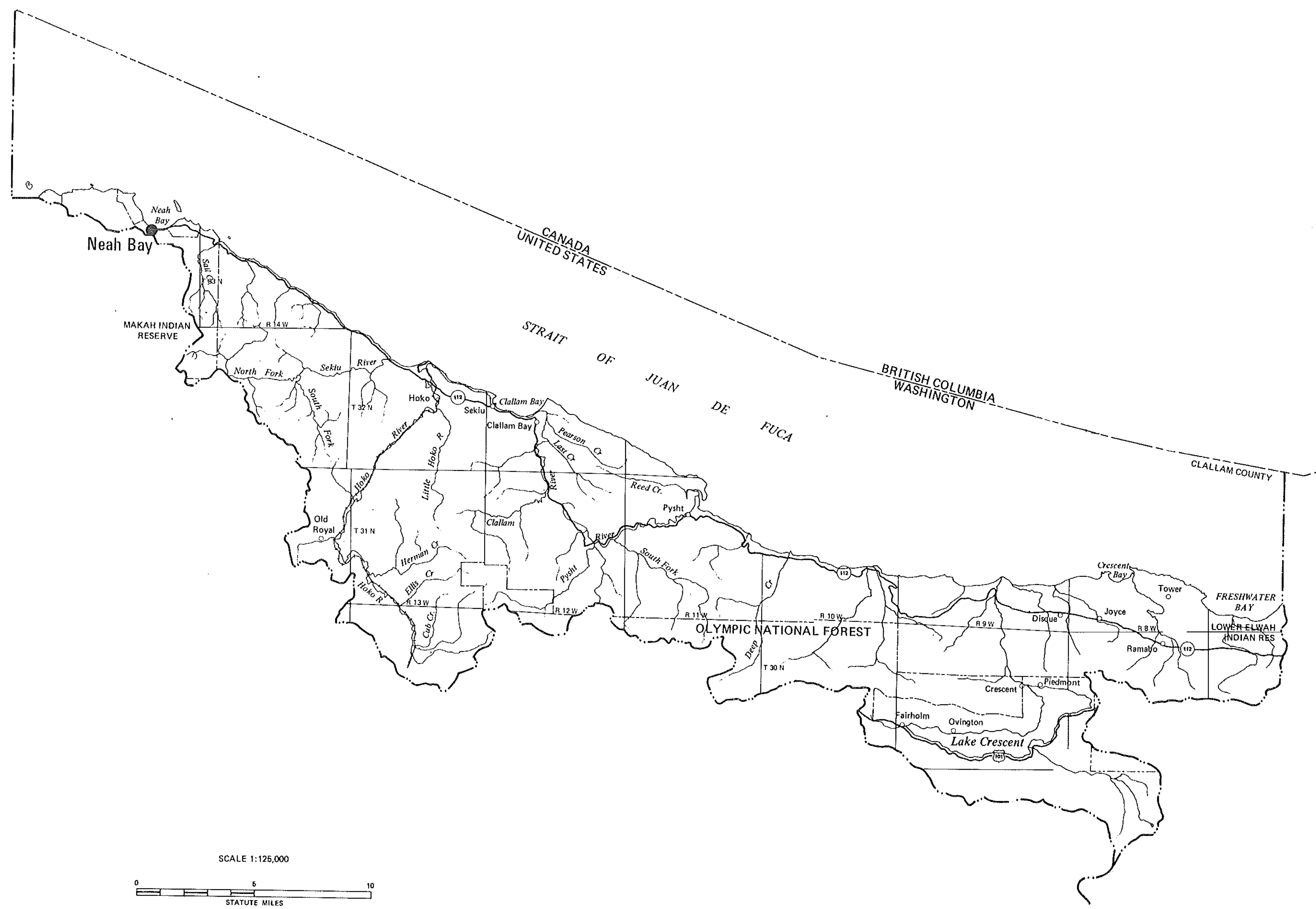


Figure 3. Olympic Basin—Lyre-Hoko Area, WRIA 19

OLYMPIC BASIN

INTRODUCTION

The Olympic Basin is located in the northwest portion of the State. It is bordered on the west by the Pacific Ocean, the north by the Strait of Juan de Fuca, the east by the Elwha-Dungeness Basin, and on the south by the Chehalis North Basin. The Basin is made up of the North Peninsula and Olympic Coast watersheds, occupying about 2,800 square miles in Clallam, Jefferson, and Grays Harbor Counties.

The Basin is sparsely populated, with economic activity centered primarily around the logging industry. Population growth is projected to locate primarily near the existing communities, with the water needs to be met by the municipal systems. Projections indicate that the total water use will nearly double, due primarily to domestic consumption, with a minor contribution due to industrial use.

PRESENT STATUS

Present water use is within the supply capabilities of the existing source developments. The Basin is largely rural with a substantial percentage of total water use supplied from individual wells or larger municipal ground water developments. In 1970, surface water sources were virtually untapped, with only scattered minor development located in the Basin. Recently, however, more extensive surface water developments have been used.

WATER USE

In 1970, total water use in the Olympic Basin averaged 1.2 mgd. Of this amount, the municipal water use totaled over 0.8 mgd. Rural demand, which constitutes the remainder, is about 30 percent of the total water use. See Table 4 for a breakdown of the total Basin water use for 1970.

Municipal

The present average municipal water use of 0.85 mgd is supplied to a total of 6,000 consumers in the Basin for an average municipal per capita consumption of 141 gpd. Forks, the largest user with 0.40 mgd, serves 2,450 persons and has a per capita water usage of 163 gpd. The Pacific Beach system uses 0.21 mgd in serving 1,400 persons in the communities of Pacific Beach and Moclips for a per capita use of 150 gpd. The remaining smaller municipalities use an average of 0.19 mgd, serve 2,200 people, and show a per capita water use of 87 gpd.

Rural-Individual

Water use by about 6,600 rural individual and small rural community consumers is estimated at 0.37 mgd. This is based on an estimated average per capita use of 55 gpd.

Industrial

Present industrial water use is small and is supplied on an individual

Table 4. Municipal and Rural Water Use for 1970 – Olympic Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Forks	163	2,450	0.40				0.40	0.56	0.58
Pacific Beach	150	1,400	0.21				0.21	0.28	0.35
Neah Bay	100	1,000	0.10				0.10	0.14	0.22
Clallam Bay	114	700	0.08				0.08	0.11	0.29
Tahola Indian Reservation	80	500	0.04				0.04	0.06	0.06
Other Rural Communities	55	1,575	0.09	0.08	0.16	0.24	0.01	0.02	0.0
Rural-Individual	55	5,075	0.28	0.04	0.08	0.12	0.24	0.46	0.72
Total	93	12,700	1.20	0.12	0.24	0.36	1.08	1.63	2.25

Notes: All figures are rounded.
Municipal – Max monthly = 1.4 x (Avg daily), Max monthly = 2.0 x (Avg daily), Max daily = 3.0 x (Avg daily)

basis by various small firms. No specific data on industrial use is presently available.

WATER SUPPLIES

Ground water is used to provide 90 percent of the average daily municipal and rural-individual water requirement in the Basin. Surface water developments provide the remaining 10 percent.

MUNICIPAL

The two major systems, Forks and Pacific Beach, rely on ground water for their source of supply. With the exception of Neah Bay, which developed a surface supply in 1971, the remaining municipal systems, and most of the small rural community systems, also use ground water as their source of supply.

Forks

The Forks Water Department supplies 2,450 persons with 0.40 mgd for an average per capita use of 163 gpd. The water supply consists of four wells with a combined maximum capacity of 1.24 mgd. The water supply is treated by chlorination and fluoridation, and stored in two reservoirs with a total capacity of 900,000 gallons.

Pacific Beach

The Pacific Beach Water Company is a privately owned corporation serving the communitieis of Pacific Beach and Moclips. The system serves a total population of 1,400 people with an average of 0.21 mgd for a per capita use of 150 gpcd.

The water system is supplied by two wells located in Pacific Beach. The water supply is treated by an iron removal process and chlorination. The system is fully metered and a total storage capacity of 150,000 gallons is available.

Other Public Water Supplies

Three smaller municipal water systems provide an average of 0.22 mgd to 2,200 persons for an average of 100 gpcd. All of the systems except Neah Bay use ground water as their source of supply.

WATER RIGHTS

The recorded ground water rights in the Basin total over 8 cfs, with the City of Forks having rights to 1.76 cfs. Pacific Beach has ground water rights totaling 0.67 cfs. The remainder of the ground water rights in the Basin are allocated primarily for small municipal and rural purposes. :ic

The recorded surface water rights in the Basin show a total of over 83 cfs. A substantial percentage of the rights are allocated for fish propagation and recreation. A small portion of the rights are recorded for commercial and municipal use, however present use of surface water for these purposes is limited.

Surface and ground water rights applications, permits, and certificates for municipal, industrial, domestic water supply and irrigation purposes in the Olympic Basin are summarized as of September 30, 1966. See Table 5.

WATER RESOURCES

Adequate water resources exist in the Olympic Basin for all foreseeable domestic and industrial requirements throughout the study period. Surface water alone totals many times the demand, even under the worst expected drought conditions.

SURFACE WATER

Surface water resources are more than adequate to provide a plentiful supply of municipal and industrial water. In addition, because the streams in the Basin originate in the isolated mountains in the eastern portion of the Basin, gross contamination is unlikely to occur.

Quantity

The average runoff of the Olympic Basin is approximately 21,100 cfs. Drainage from the northern portions of the Basin consists of small streams which range in length from about 2 to 10 miles and are tributary to the Strait of Juan de Fuca. The Hoko River drains an area of 69 square miles and has an average flow of 398 cfs (1962-1968).

Table 5. Water Rights (cfs)—Olympic Basin

Type	Municipal	Individual and Community Domestic	Industrial and Commercial	Totals
Surface	44.84	16.12	22.18	83.14
Ground	3.20	2.70	2.42	8.32
Total	48.04	18.82	24.60	91.46

Notes:

Municipal: Municipal Supplies, Fish Propagation, Stock (game birds), Fire Protection, Recreation.

Individual and Community Domestic: Single Domestic, Stock (undefined), Irrigation (undefined, lawn, garden), Domestic/ Private Contractor.

Industrial and Commercial: Irrigation (cranberry farming), Heat Exchange, Railway, Power Generation, Stock (dairying) Industrial, Commercial (undefined).

The remainder of the Basin drains to the Pacific Ocean with the larger rivers being located in this area. The Hoh River drains about 300 square miles and has an average flow of 2070 cfs at Forks (1926-1968). The Queets River drains 446 square miles and an average flow of 4115 cfs (1930-1949). The primary source of the Hoh and Quinault Rivers is the glacial activity near Mt. Olympus. Variations in annual discharge during the same period included high and low flows of 495 cfs and 324 cfs on the Hoko River, 3269 cfs and 1396 cfs on the Hoh River, and 6196 cfs and 2872 cfs on the Queets River.

The Basin minimum runoff quantity is estimated at 11,200 cfs with a 50 year recurrence interval and 10,250 cfs with a 100 year recurrence interval. Generally, the highest runoff occurs during the months of November and December, declining gradually to a secondary high as a result of glacial and snow melt during April, May, and June. August and September are the months of lowest flow.

A Low Flow Frequency analysis made by the U.S. Geological Survey is given for various stations in the Olympic Basin. The 7-day and 30-day low flows for three selected stations in the Basin for recurrence intervals of 1.05, 5, 10, and 20 years are shown in Table 6.

Quality

Water quality data was obtained from the U.S. Geological Survey for selected rivers and stations in the Olympic Basin. The data includes stations on the Quinault, Queets, Hoh, and Soleduck Rivers. See Table

Table 6. Low Flow Frequency—Olympic Basin

River	Location	Recurrence Interval —Years	7 Day Low Flow —cfs	30 Day Low Flow —cfs
Queets	Near Clearwater	1.05	64.0	76.0
		5	23.5	28.5
		10	20.5	25.0
		20	19.0	23.5
Hoh	Near Falls	1.05	860	1,050
		5	500	630
		10	450	560
		20	420	510
Hoh	At U.S. Highway 101 near Falls	1.05	950	1,200
		5	555	700
		10	500	620
		20	460	550

Table 7. Chemical Analysis By Rivers — Olympic Basin (From 1959 to 1967)

Item	Flow (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Chloride (Cl)	Sulfate (SO_4)	Fluoride (F)	Bicarbonate (HCO_3)	Nitrate (NO_3)	Diss. Solids	Specific Conductance (μmho)	Orthophosphate (PO_4)	Silica (SiO_2)	Iron (Fe)	pH	Coliform Org. (MPN)	Hardness as CO_3
QUINAULT RIVER AT QUINAULT LAKE																		
Maximum	3,798	10.0	0.8	1.9	0.4	2.0	6.8	0.2	29	0.5	42	65	0.06	5.2	0.27	7.4	230	27
Mean	2,813	8.8	0.5	1.5	0.2	1.2	5.7	0.1	25	0.2	37	60	0.01	4.7	0.14	7.1	20	24
Minimum	1,780	8.0	0.1	1.3	0	0.5	4.8	0	22	0	32	54	0	3.8	0.04	6.8	0	22
QUEETS RIVER AT QUEETS																		
Maximum	–	10.0	1.3	3.0	0.8	3.0	10.0	0.1	32	0.6	49	81	0.04	6.1	0.67	7.5	430	30
Mean	–	7.9	0.8	2.4	0.3	2.1	6.5	0.1	24	0.3	40	61	0.01	5.1	0.19	7.1	86	23
Minimum	–	3.5	0.2	1.9	0	1.2	3.6	0	10	0	26	30	0	3.9	0.06	6.8	0	10
HOH RIVER AT HWY 101 NEAR FORKS																		
Maximum	–	12.0	1.6	2.2	0.6	2.2	11.0	0.2	34	0.6	53	88	0.04	6.9	0.63	7.6	930	35
Mean	–	11.0	0.8	1.8	0.3	1.3	8.0	0.1	30	0.2	46	71	0.01	4.8	0.21	7.3	87	30
Minimum	–	8.0	0.2	1.2	0	0.5	4.4	0	24	0	28	38	0	3.2	0.07	6.6	0	22
SOLEDUCK RIVER NEAR FORKS																		
Maximum	–	15.0	1.7	2.7	0.7	1.8	9.8	0.2	47	0.3	58	102	0.04	5.9	0.14	7.9	360	43
Mean	–	10.7	1.2	2.0	0.3	1.2	6.0	0.1	35	0.1	46	74	0.01	5.2	0.05	7.5	28	31
Minimum	–	5.0	0.7	1.4	0	0.8	2.8	0	18	0	27	38	0	4.2	0	7.0	0	16

7 for a detailed listing of the data.

Chemical-Physical

The chemical quality of the rivers in the Olympic Basin is good. The water is soft, low in dissolved solids, and has a high dissolved oxygen concentration. During the period of record, 1959 through 1967, calcium and magnesium ion concentrations, water hardness indicators, never exceeded 15 mg/l. Also, the sodium-potassium ion ratio remains fairly constant throughout the year. Average dissolved oxygen concentrations are high, ranging from 11.4 mg/l on the Hoh River to 10.6 mg/l on the Quinault River at Quinault Lake.

The physical quality of the water is generally good, however, during periods of high runoff, high turbidity and color are common problems in the streams draining the Olympic Mountains.

Bacteriological

The bacteriological quality of the Rivers in the Basin is generally very good, and gross contamination is unlikely to occur due to the isolation of the watersheds. During the period of 1959 through 1967, samples taken indicated a maximum coliform count of 230 MPN on the Quinault River, 360 MPN on the Soleduck River, 430 MPN on Queets River and 930 MPN on the Hoh River.

GROUND WATER

Ground water in the Basin is available in most areas and supplied 90 percent of the total Basin water use in 1970. Moderate to large yields of water are obtained near the larger communities, with studies indicating the aquifers are capable of sustaining an increased development.

Quantity

In general, the lowlands and river bottom areas contain an accumulation of sand and gravel which constitutes a good aquifer. Recharge is derived from precipitation and infiltration along streams and rivers. Withdrawals along the Pacific Coast have not been large enough to cause salt water intrusion, however, with future large developments, this could become a problem.

Quality

The chemical quality from the several aquifer units differs considerably. Water from the younger deposits generally has a dissolved solids concentration of less than 250 mg/l and is soft to moderately hard. Water hardness ranges from 3 to 262 mg/l as $CaCO_3$, and silica content is usually between 60 and 10 mg/l. The pH values in the Basin range from about 6.0 to over 9.0. High iron content is the major ground water quality problem along the ocean beaches in the Pacific Beach area. Detailed ground water quality data is presented in Table 8.

Table 8. Ground Water Quality — Olympic Basin

Owner	Location	Depth (ft)	Date	Temp. (°F)	Concentration (mg/l) Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved Solids	Hardness (as CO_3)	Specific Conductance (μmho)	pH
City of Forks	28/13W-4Q1	135	5/2/61	49	15.0	0.07	22.0	3.3	4.3	0.2	76	0	11.0	3.0	0.2	0.4	0.03	97	68	155	8.1
U.S. Government	29/9W-32	Spring	11/30/54	132	58.0	–	1.2	0	80.0	2.6	92	26	34.0	17.0	1.6	1.0	–	262	3	355	9.2
Makah Indian Tribe	33/15W-14	52	2/27/53	47	6.7	–	59.0	6.7	14.0	1.0	208	0	20.0	7.0	–	3.2	–	227	175	377	–
Bay Fish Co.	33/15W-10R1	38	5/16/52	–	–	–	–	–	–	–	268	0	15.0	26.0	0.4	2.2	–	–	244	516	–
Pacific Beach Water Co.	20/12W-20 B1	193	11/27/59	–	60.0	3.7	12.0	6.5	14.0	1.1	–	0	1.3	11.0	0.1	0.2	0.11	161	57	183	6.2
U.S. Government	23/9W-19	46	4/24/58	–	13.0	0.28	5.4	1.1	2.6	1.0	23	0	2.6	22.0	0.0	0.4	–	40	18	53	6.6

Table 9. Chemical Analysis By Water Distribution Systems—Olympic Basin

Sillica ($Si O_2$)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Sodium (Na)	Potassium (K)	Calcium (Ca)	pH	Conductance (μmho)	Turb. (JTU)	Color (std units)	Odor	Magnesium (Mg)	Free O_2	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Sulfite (SO_3)	Chlorine (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite (NO_2)	Orthophosphate (PO_4)	Total Solids	Total Hardness	$CaCO_3$ Hardness	Noncarbonate Hardness	Calcium Hardness	Magnesium Hardness
NEAH BAY WATER SYSTEM—STREAM after Filtration																APRIL 7, 1972												
2.75	–	0.18	0.003	6.2	0.45	0.0	6.5	52	1.6	35	–	5.3	–	–	–	7.8	–	5.5	0.06	0.10	0.03	0.07	–	22	–	2	0	–
FORKS WATER DISTRICT—WELLS																NOVEMBER 27, 1968												
14.5	–	0.17	–	5.81	0.78	16.0	7.3	120	2.5	1	–	6.6	–	85.4	–	7.8	–	1.5	0.009	2.57	–	0.25	–	56	–	–	–	–
CLALLAM BAY-SEKIU WATER SYSTEM—WELLS																DECEMBER 27, 1968												
12	–	0.26	–	2.71	0.41	9.6	6.5	44	1.5	1	–	4.9	–	48.8	–	3.4	–	4.0	0.05	0.88	–	–	–	32	–	–	–	–
TAHOLAH INDIAN AGENCY SYSTEM—WELLS																JANUARY 6, 1969												
22.3	–	0.44	–	3.25	1.4	11.8	7.5	114	8	15	–	4.6	–	103	–	2.7	–	17.0	0.05	–	–	0.30	–	48	–	–	–	–
PACIFIC BEACH WATER SYSTEM—WELLS																JULY 14, 1968												
10	–	0.05	–	4.35	0.78	8.0	6.5	34	13	12	–	3.89	–	48.8	–	5	–	14	0.10	0.67	–	0.27	–	36	–	–	–	–

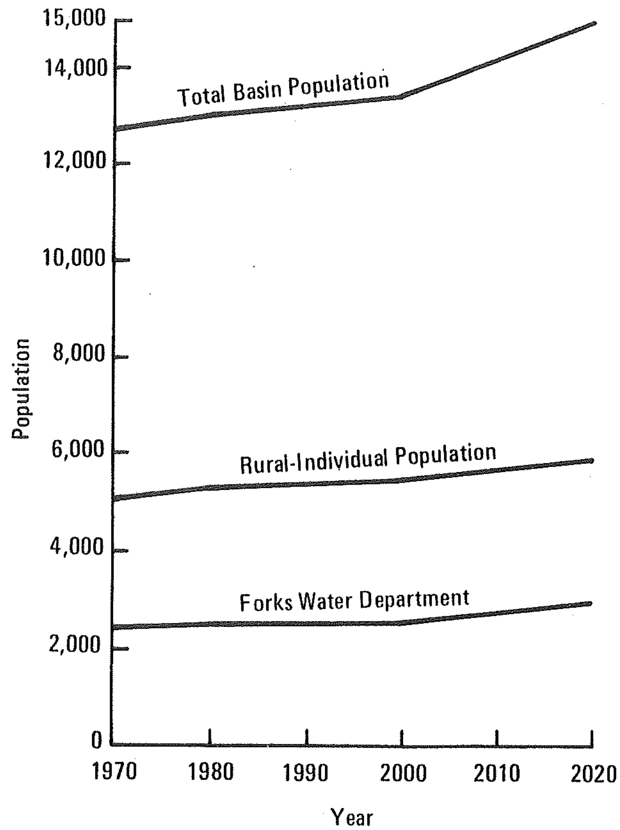


Figure 6. Olympic Basin Projected Population Growth

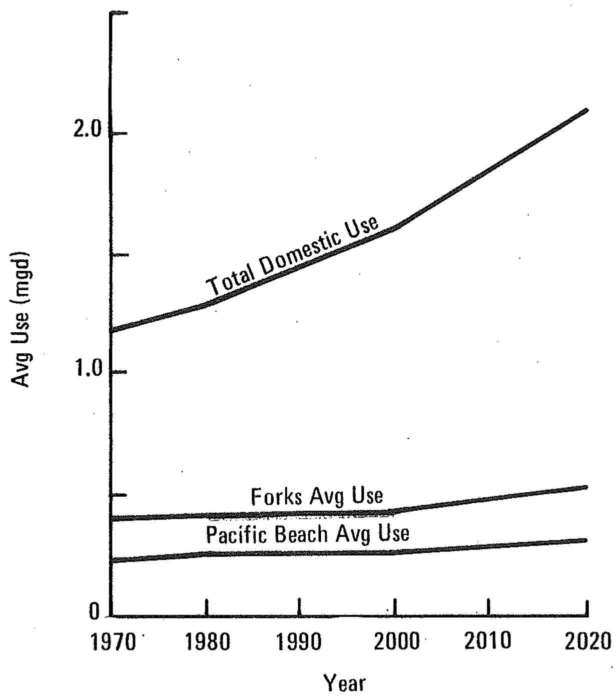


Figure 7. Olympic Basin Projected Water Use

Table 10. Municipal and Rural Water Use for 1980 – Olympic Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Forks	163	2,500	0.41				0.41	0.53	0.73
Pacific Beach	150	1,460	0.22				0.22	0.28	0.39
Clallam Bay	142	720	0.10				0.10	0.13	0.18
Tahola Indian Reservation	142	510	0.07				0.07	0.09	0.13
Neah Bay	142	1,020	0.14	0.14	0.19	0.26			
Other Rural Communities	60	1,610	0.10	0.08	0.16	0.24	0.02	0.04	0.06
Rural-Individual	60	5,180	0.31				0.31	0.62	0.93
Total	110	13,000	1.35	0.22	0.35	0.50	1.13	1.69	2.42

Notes: all figures are rounded.
Avg daily = 1.42 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)

Table 11. Municipal and Rural Water Use for 2000 — Olympic Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Forks	162	2,600	0.42				0.42	0.55	0.75
Pacific Beach	162	1,520	0.25				0.25	0.33	0.45
Clallam Bay	162	750	0.12				0.12	0.16	0.22
Tahola Indian Reservation	162	530	0.08				0.08	0.11	0.16
Neah Bay	162	1,060	0.17	0.17	0.23	0.31			
Other Rural Communities	80	1,680	0.13	0.10	0.21	0.31	0.03	0.05	0.08
Rural-Individual	80	5,360	0.43				0.43	0.86	1.29
Total	118	13,500	1.60	0.27	0.44	0.62	1.33	2.06	2.95

Notes: All figures are rounded.
Avg daily = 1.62 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)

PRESENT AND FUTURE NEEDS

Future water requirements in the Basin will be determined primarily by the rate of growth of population and agriculture usage. Surveys indicate that a steady growth of these factors can be expected through the study period. Details of this growth, projected to the year 2020 are given in Figures 6 and 7 and Tables 10 and 11.

Basic water supplies pose no problem for the Basin through the year 2020. The Hoh River alone has an average flow of 1340 mgd, which is many times the total projected domestic and industrial Basin water use by 2020. In addition, ground water availability in the populated areas of the Basin is adequate to meet all projected domestic needs. Most low population density rural regions that are beyond the service area of the larger communities also have adequate ground and surface water supplies for the year 2020.

PROJECTED POPULATION GROWTH

The population of the Basin is projected to increase from the 1970 population of 12,700 to 15,000 by the year 2020. The majority of the increased population is expected to occur around the existing communities in the Basin.

PROJECTED INDUSTRIAL GROWTH

No significant industrial water use is projected through the study period.

PROJECTED WATER REQUIREMENTS

Based on the population projections, it is anticipated that by the year 2020 average water use will nearly double to reach a total of 2.1 mgd. The projected total municipal water use is shown in graphical form, as well as the projected water use of the two largest systems. See Figure 7 for details of the water use projections.

Municipal

Municipal water requirements, presently 0.9 mgd are projected to reach 0.93 mgd by 1980, 1.04 mgd by 2000 and 1.32 mgd by 2020. By the year 2020, municipal needs will account for approximately 63 percent of the total Basin water use.

Municipal per capita water use is projected to be 142 gallons per day (gpd) by 1980, 162 gpd by 2000, and 178 gpd by 2020. This scale will be used for projecting the water needs for all systems showing a 1970 domestic per capita consumption of 150 gallons per capita per day (gpcd) or less. For the systems showing a domestic per capita use of between 150 and 180 gpcd, the 1970 gpcd figure will be used for the projections with no increase, until it matches the above scale. For those systems showing an excessive domestic gpcd figure of over 180 gpcd, it is assumed that their consumption will be reduced to be consistent with the scale by 1980, through increased metering and maintenance of the systems.

Rural-Individual and Small Rural Community Systems

Rural-Individual and Small Rural Community water requirements presently average 0.29 mgd based on 55 gpcd. By 1980 all water use is projected to be supplied by ground water, and water use is projected to reach about 0.41 mgd, based on 60 gpcd. The per capita consumption is projected to increase uniformly at 1 gpcd per year throughout the study period, with the 2020 average water use reaching 0.77 mgd. The increase in per capita consumption is based on projected increases in irrigation and the standard of living. See Tables 10 through 14.

MEANS TO SATISFY NEEDS

GENERAL

The average daily water use is projected to reach 2.1 mgd by the year 2020. This is an increase of about 0.9 mgd over the 1970 use. Peak water requirements are projected to be over 4.2 mgd.

The major water users will be centered near the more urbanized areas and will receive water from presently developed and expanded sources. The smaller rural communities are expected to continue using ground water sources as their major source of water due to the higher cost involved for surface water development.

The total Basin water needs projected for 2020 can be met by water available in the Basin without conflict over withdrawals for water supplies. Urban growth is not anticipated to bring about sufficient population density to make a regional water supply system feasible.

Table 12. Municipal and Rural Water Use for 2020 —Olympia Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic Average Daily	Surface Water Use (mgd) Domestic Max Monthly	Surface Water Use (mgd) Domestic Max Daily	Ground Water Use (mgd) Domestic Average Daily	Ground Water Use (mgd) Domestic Max Monthly	Ground Water Use (mgd) Domestic Max Daily
Forks	178	2,900	0.52				0.52	0.68	0.94
Pacific Beach	178	1,700	0.30				0.30	0.39	0.54
Clallam Bay	178	850	0.15				0.15	0.19	0.26
Tahola Indian Reservation	178	600	0.11				0.11	0.14	0.19
Neah Bay	178	1,200	0.24	0.24	0.31	0.43			
Other Rural Communities	100	1,850	0.18	0.14	0.29	0.43	0.04	0.07	0.11
Rural-Individual	100	5,900	0.59				0.59	1.18	1.77
Total	140	15,000	2.09	0.38	0.60	0.86	1.71	2.65	3.81

Notes: All figures are rounded.
Avg daily = 1.3 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)

Table 13. Olympic Basin Water Supply—Present and Future Needs (mgd)

System	Peak Municipal and Industrial Demand 1970	1980	2000	2020
Forks	2,450	2,500	2,600	2,900
Optimum	1.61	1.65	1.71	1.91
Existing	1.24	1.24	1.65	1.71
Needs	—	0.41	0.06	0.20
Pacific Beach	1,400	1,460	1,520	1,700
Optimum	0.92	0.96	1.00	1.12
Existing	0.58	0.58	0.96	1.00
Needs	—	0.38	0.04	0.12
Other Smaller Systems	2,775	3,860	4,020	4,200
Optimum	1.83	2.53	2.65	2.76
Existing	1.26	1.26	2.53	2.65
Needs	—	1.27	0.12	0.11
Total Needs	—	2.06	0.22	0.43

Notes: Optimum = 1.6 gpm/service plus maximum monthly industrial use (658 gped); Existing = Plant capacity. All figures are rounded.

Table 14. Summary of Projected Water Use (mgd) – Olympic Basin

System	Date	Population	Surface Water Use		Ground Water Use		Total Use	
			Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly
Municipal	1970	7,625	0	0	0.84	1.01	0.92	1.17
	1980	7,820	0.22	0.35	0.82	.91	1.04	1.26
	2000	8,140	0.27	0.44	0.90	1.01	1.17	1.45
	2020	9,100	0.38	0.60	1.12	1.18	1.50	1.78
Individual-Rural	1970	5,075	0.04	0.08	0.24	0.46	0.28	0.46
	1980	5,180	–	–	0.31	0.62	0.31	0.62
	2000	5,360	–	–	0.43	0.86	0.43	0.86
	2020	5,900	–	–	0.59	1.18	0.59	1.18
Total	1970	12,700	0.12	0.24	1.08	1.47	1.20	1.63
	1980	13,000	0.22	0.35	1.13	1.53	1.35	1.88
	2000	13,500	0.27	0.44	1.33	1.85	1.60	2.39
	2020	15,000	0.38	0.60	1.71	2.36	2.09	2.96

Note: All figures are rounded.

BASIN PLANS

The cities of Forks and Pacific Beach are expected to supply over 50 percent of the total projected municipal water requirements for the entire Basin by the year 2020. Smaller supplies will provide the remaining 50 percent to about 4,500 persons.

The projections for future needs are based on a more economical and efficient use of water as a valuable resource. To provide for the economical use of the present and future water supplies, it is recommended that all systems provide for 100 percent metering and increased maintenance by the year 1980. Present trends indicate that a program of more economical and efficient use of water tends to stabilize or reduce the per capita consumption.

Forks

By the year 1975, Forks will need to add new sources of supply totaling 0.41 mgd to meet the source requirements of the projected 1980 population based on the Division of Health's recommendations of providing 1.6 gpm/service source capacity. In addition, a parallel increase in both storage and distribution capacity must be provided in order to assist in meeting peak residential demands and fire fighting requirements. Based on providing at least one day's storage at peak usage of 1.6 gpm/service.

Additional improvements of 0.06 mgd and 0.20 mgd in service development are needed by the years 1990 and 2010 respectively.

Parallel developments increasing both distribution and storage capacities must also be provided to meet the optimum system capacity requirements projected for the year 2020.

Alternate plans listed in the following table consider further local ground water development, or a surface water development utilitizing the Calawah River, to meet the projected water requirements through the study period.

Studies indicate that the potential ground water available for development within the service area is adequate to meet the water requirements throughout the study period. The ground water development would provide good quality water, while development costs are substantially lower than a comparable surface water development.

An adequate amount of surface water is available from the nearby Calawah River. The water is of relatively high quality; however the initial cost of the development will be high due to the need for complete treatment.

Pacific Beach

Except for capacity, the water supply situation of Pacific Beach is similar to that of Forks. By the year 1975, increases in supply capacity of 0.38 mgd with parallel improvements in distribution and storage capacities are needed to provide the projected 1980 optimum system capacity requirements.

Additional improvements of 0.16 mgd in source development are needed between the years 1990 and 2010, to meet the projected optimum system capacities for 2000 and 2020 respectively. Parallel improvements increasing both distribution and storage capacities must also be provided to meet the optimum system capacity requirements projected for the year 2020.

Plans considered to meet the increased source capacity requirements consider either further local ground water development or a surface water development, using the Moclips River.

Further ground water development would provide the least expensive alternative, even though provisions needed for iron removal raise the initial cost. However, before development, investigations of the possibility of future salt water intrusion should be undertaken.

The surface water development utilizing the Moclips River would require complete treatment of the water raising the initial cost beyond that of the ground water development. In addition, no quality or quantity data is available for the River, therefore the reliability is unknown. A study of its firm potential as an alternate source should be initiated.

Other Public Water Supplies

The Washington State Division of Health's Public Water Supply Facilities Inventory was used to obtain the combined system capacities of the smaller public water supplies in the Basin. The data indicated that by

1975 the source distribution and storage capacity of the small systems must be increased by a total of 1.27 mgd by 1990 and 0.22 mgd by 2010 are needed to meet the optimum system capacity requirements for the years 2000 and 2020, respectively.

Presently 95 percent of the water used is from ground water sources. This percentage is used to determine future cost estimates. Ground water developments generally cost less than surface water developments due to the need for filtration of surface water. Ground water is projected to continue being the major source of supply through the study period.

Table 15. Olympic Basin Water Supply Capital Improvements

System	Plan Level	Population	Average Annual Use (mgd)	Optimum System Capacity (mgd)	Previous System Capacity (mgd)			Needed Capital Improvements ($ x 10^6/mgd)			Year of Improvements
					Source	Distrib	Storage	Source	Distrib	Storage	
Forks	exist	2,450	0.40	1.6							
	1980	2,500	0.41	1.65	1.24	1.24	1.24	0.41	+	0.41	1975
	2000	2,600	0.42	1.71	1.65	1.65	1.65	0.06	+	0.06	1990
	2020	2,900	0.52	1.91	1.71	1.71	1.71	0.20	+	0.20	2010
Pacific Beach	exist	1,400	0.21	0.92							
	1980	1,460	0.22	0.96	0.58	0.58	0.58	0.38	+	0.38	1975
	2000	1,520	0.25	1.00	0.96	0.96	0.96	0.04	+	0.04	1990
	2020	1,700	0.30	1.12	1.00	1.00	1.00	0.12	+	0.12	2010
Other Public Water Supplies	exist	2,775	0.39	1.83							
	1980	3,860	0.41	2.53	1.26	1.26	1.26	1.27	+	1.27	1975
	2000	4,020	0.50	2.65	2.53	2.53	2.53	0.12	+	0.12	1990
	2020	4,200	0.68	2.76	2.65	2.65	2.65	0.11	+	0.11	2010

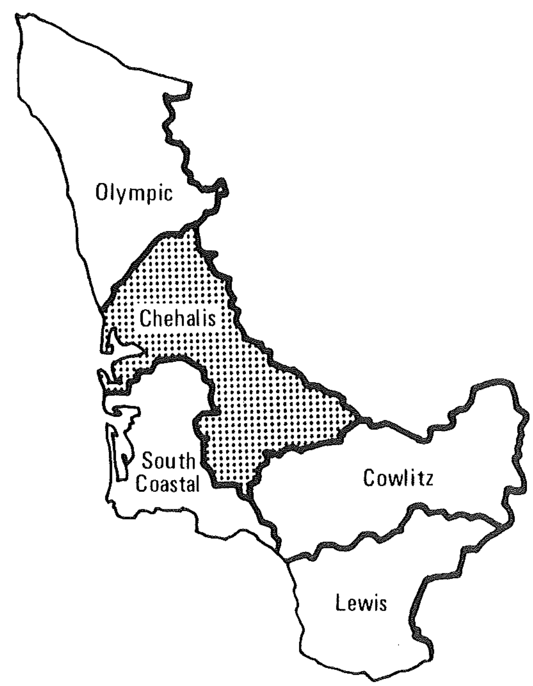
Notes:
1. Optimum System Capacity: Represents 1.6 gpm/service plus max monthly industrial use.
2. Previous System Capacity: System capacity of the previous plan level.
3. Needed Capital Improvements: Capital improvements needed to meet optimum system capacity.
+ Based on population increase.

Table 16. Estimate of Capital Costs for Needed Improvements—Olympic Basin

Plan Level	Source GW	Source SW	Development	Year of Devel. (mgd)	Opt. Water Use (mgd)	NEEDED IMPROVEMENT (mgd) Source	Storage	Distrib	CAPITAL COST (millions of dollars) Source	Treat.	Storage	Distrib.	MAINT. & OPER. (millions of dollars) Source	Treat.	Total
FORKS															
Present	x		Local G.W. Development	existing	1.61										
1980	x		" "	1975	1.65	0.41	0.41	+	0.03	0.001	0.04	–	0.001	–	0.072
2000	x		" "	1990	1.71	0.06	0.06	+	0.004	–	0.006	0.03	–	–	0.04
2020	x		" "	2010	1.91	0.20	0.20	+	0.013	–	0.02	0.10	–	–	0.133
									0.047	0.001	0.066	0.13	0.001		0.245
Alternative															
Present	x		Local G.W. Development	existing	1.61										
1980		x	Intake &treat. Calawh R.	1975	1.65	0.41	0.41	+	*	0.090	0.040		–	0.004	0.134
2000		x	" "	1990	1.71	0.06	0.06	+	*	0.013	0.006	0.03	–	–	0.049
2020		x	" "	2010	1.91	0.20	0.20	+	*	0.045	0.020	0.10	–	0.002	0.167
										0.148	0.066	0.13		0.006	0.350
PACIFIC BEACH															
Present	x		Local G.W. Development	existing	0.92										
1980	x		" "	1975	0.96	0.38	0.38	+	0.025	0.001	0.038	–	0.001	–	0.065
2000			" "	1990	1.00	0.04	0.04	+	0.003	–	0.004	–	–	–	0.007
2020	x		" "	2010	1.12	0.12	0.12	+	0.008	–	0.012	0.059	–	–	0.079
									0.036	0.001	0.054	0.059	0.001		0.151
Alternative															
Present	x		Local G.W. Development	existing	0.92										
1980		x	Intake & treat. Moclips R.	1975	0.96	0.38	0.38	+	*	0.090	0.038	–	–	0.004	0.132
2000		x	" "	1990	1.00	0.04	0.04	+	*	0.008	0.004	–	–	–	0.012
2020		x	" "	2010	1.12	0.12	0.12	+	*	0.026	0.012	0.059	–	0.001	0.098
										0.124	0.054	0.059		0.005	0.242
Other Public Water Supplies	85%	15%			1.83										
1980			G.W. & S.W. Development	existing	2.53	1.27	1.27	+	*	1.250	0.127	0.363	0.010	0.010	1.76
2000			" "		2.65	0.12	0.12	+	*	0.024	0.012	0.053	–	0.001	0.09
2020			" "		2.76	0.11	0.11	+	*	0.024	0.011	0.594	–	0.001	0.63
										1.298	0.150	1.010	0.010	0.012	2.48

*Included in treatment cost.
+Based on population growth.

Chehalis Basin



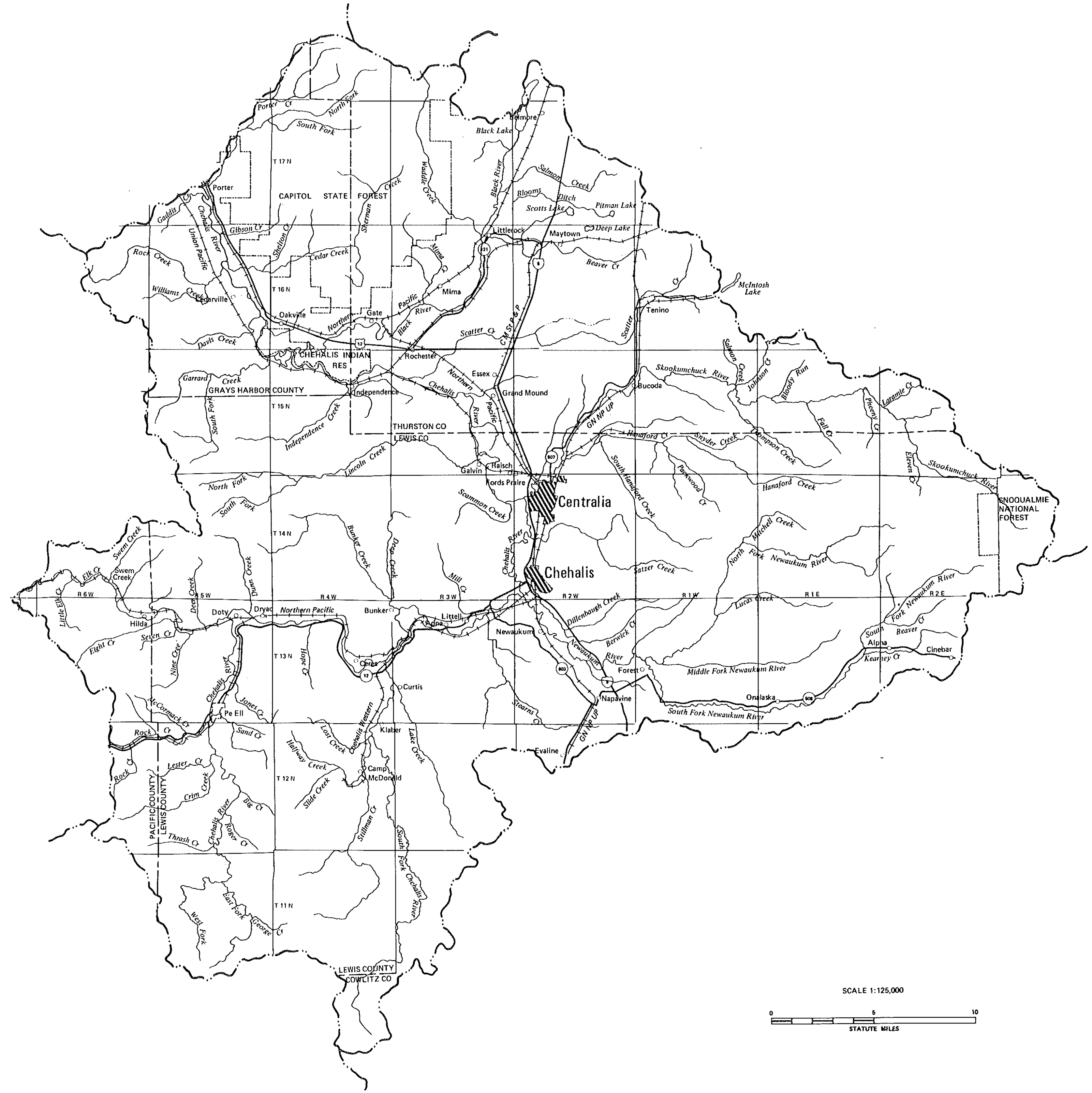


Figure 9. Chehalis Basin – Upper Area, WRIA 23

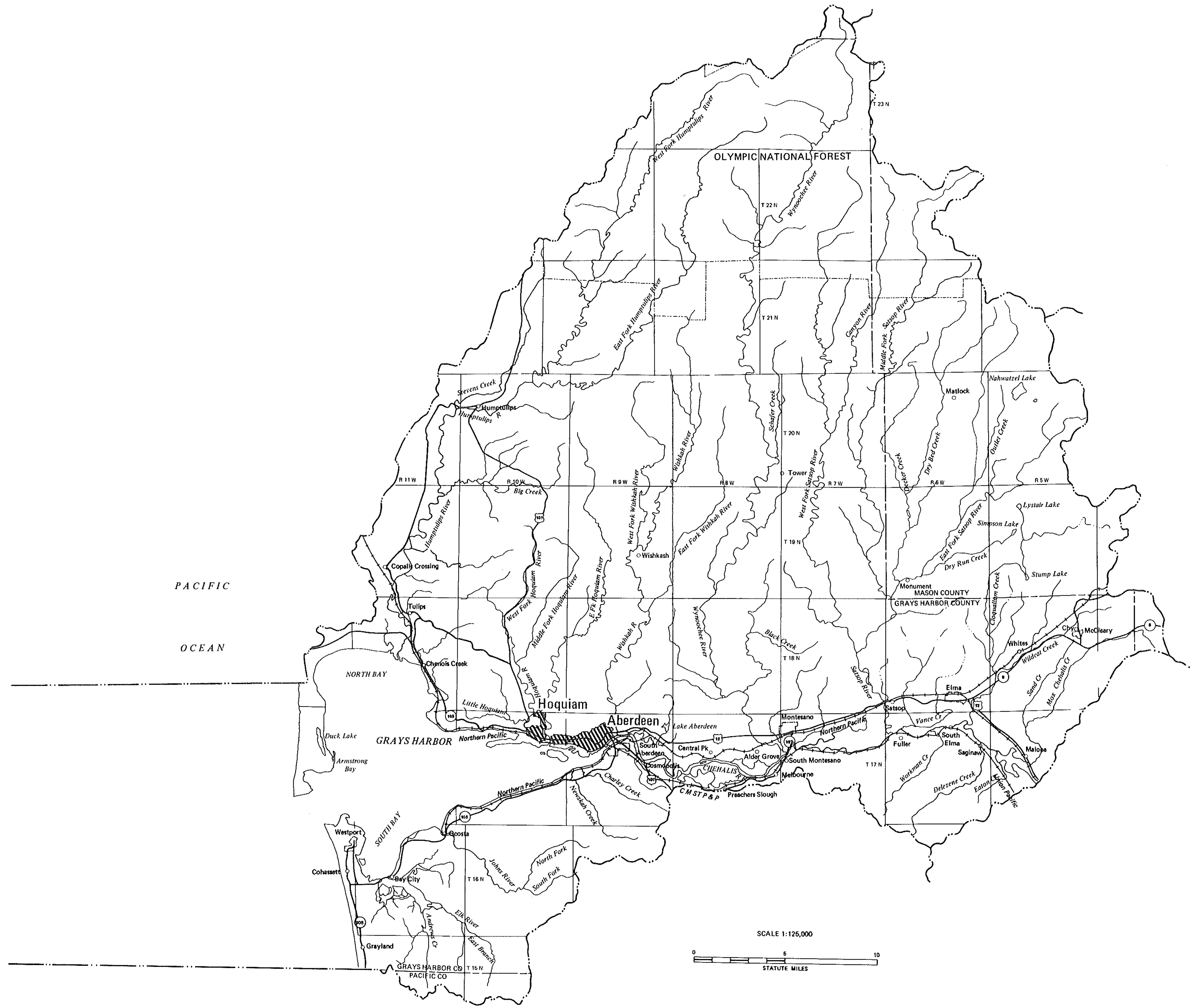


Figure 8. Chehalis Basin – Lower Area, WRIA 22

CHEHALIS BASIN

INTRODUCTION

The Chehalis Basin is located in the Southwestern portion of the State. The Basin is bordered on the north by the Olympic Basin, the east by the Hood Canal, Shelton, and Deschutes watersheds, on the south by the Cowlitz and South Coastal Basins and on the west by the Pacific Ocean. The Basin occupies about 2600 square miles of Grays Harbor, Thurston, Lewis, Mason and Pacific counties, being composed of the Chehalis North and Chehalis South watershed areas. The Basin population and industries are located principally along the Chehalis River.

The population of the Basin is projected to nearly double by the year 2020, with the majority of the growth projected to occur around the existing urban centers of Aberdeen-Hoquiam and Centralia-Chehalis. Industrial growth is also projected to locate near the existing urbanized centers. Projections indicate that water use will double by the year 2020, thus exceeding present water supply system capacities.

PRESENT STATUS

Present water use is within the supply capabilities of the existing source developments. The Basin is largely rural with the water needs met by individual wells and small municipal distribution systems.

Surface water sources have been developed as the major source of supply for the larger community systems in the Basin.

WATER USE

Total water use in the Chehalis Basin presently averages 94 mgd. Of this amount, the domestic demand averages over 13 mgd. Industrial water use, which makes up the remainder, is over six times the amount used for domestic purposes. See Tables 17 and 18 for a breakdown of Basin water use in 1970.

Municipal

The present average municipal water use of 12 mgd is supplied to a total of 58,500 consumers in the Basin, for an average municipal per capita consumption of 205 gpd. The Aberdeen system is the largest user, with 4.5 mgd, serves 22,000 persons in the cities of Aberdeen and Cosmopolis, and has a per capita consumption of 204 gpd. The Hoquiam system uses 1.4 mgd in serving 10,500 persons for a per capita use of 129 gpd. Centralia provides 10,500 people with an average flow of 3.0 mgd for a per capita use of 286 gdp. Chehalis uses 0.96 mgd in serving 5,800 people for a per capita consumption of 165 gpd. The remaining smaller municipalities use an average of 1.77 mgd, serve 9,600 people, and show a per capita water use of 185 gpd.

Rural-Individual

Over 40,000 rural-individual consumers use 2.2 mgd, based on an estimated average per capita consumption of 55 gpcd.

L : 9.19
U : 5.71 − 1.15 = 4.56
14.90
1.86
16.76

Table 17. Municipal and Rural Water Use for 1970 — Chehalis Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic Average Daily	Surface Water Use (mgd) Domestic Max Monthly	Surface Water Use (mgd) Domestic Max Daily	Ground Water Use (mgd) Domestic Average Daily	Ground Water Use (mgd) Domestic Max Monthly	Ground Water Use (mgd) Domestic Max Daily
Aberdeen* L	272	22,000	6.0	6.0	7.8	11.0			
Hoquiam L	129	10,500	1.55	1.35	1.89	2.33			
Centralia U	286	10,500	3.00	3.00	4.20	5.50			
Chehalis U	165	5,800	2.20	0.96	1.34	1.73			
Pe Ell U	243	540	0.13	0.13	0.18	0.39			
Montesano L	78	3,600	0.28				0.28	0.39	0.75
Elma L	298	2,500	0.75				0.75	1.05	1.70
Westport L	287	1,500	0.43				0.43	0.62	1.06
Tenino U	105	950	0.10				0.10	0.14	0.17
Oakville U	213	470	0.10				0.10	0.14	0.30
Other Rural Communities 1/2	55	6,300	0.35				0.35	0.70	1.05
Rural-Individual	55	33,840	1.86	0.18	0.36	0.54	1.68	3.35	5.03
Total	157	98,500	16.66	11.62	15.87	21.49	3.60	7.20	9.80

Notes: All figures are rounded.
*Includes Cosmopolis.
Rural — Max monthly = 2.0 (Avg daily), Max daily = 3.0 (Avg daily) — 90% of rural population uses ground water.
Municipal — Figures obtained from chlorination reports or water facilities inventory.

Table 18. Chehalis Basin Industrial Water Use for 1970 (mgd)

Name	Type	Source	Avg Daily	Max. Monthly	Max. Daily
Rayonier Hoquiam	Pulp	Aberdeen Ind. Supply	40.0	41.0	42.0
Weyerheauser Cosmopolis	Pulp	Aberdeen Ind. Supply	29.0	32.0	35.8
Others	Assume Wood Rel.	—	10.4	11.4	13.0
Total			79.4	84.4	90.8

Notes: Chemical and metal industries; average daily = maximum monthly wood-related industries; maximum monthly = 1.10 (average daily). All figures are rounded.

Industrial

Industrial water use in the Basin presently averages about 80 mgd. The major industrial users are the Rayonier Pulp mill in Hoquiam with an average water use of 40 mgd, and the Weyerhaeuser Pulp mill in Cosmopolis with an average water use of 29 mgd. Other smaller industries in the Basin use water at a total average rate of over 10 mgd.

WATER SUPPLIES

Surface water is used to meet nearly all of the Basin's municipal and industrial water requirements totaling over 92 mgd. The four largest municipal systems all use surface water as their primary source, and supply over 85 percent of all the municipal water used in the Basin.

MUNICIPAL

The four major systems, Aberdeen, Hoquiam, Centralia and Chehalis, rely primarily on surface water for their source of supply. Most of the remaining systems, which are smaller municipal systems, use ground water.

Aberdeen

The Aberdeen municipal water system serves the City of Aberdeen and the adjacent community of Cosmopolis to the east. The total population of about 22,000 is served with an average of about 6.0 mgd for a per capita consumption of 272 gpcd.

The system obtains their domestic water supply by gravity flow from a diversion dam on the Wishkah River. The supply system includes a concrete gravity dam having a storage capacity of 39 million gallons, and a 20 mile transmission line with a capacity of 10 mgd. However, during late summer, the dependable yield of the stream drops to about 5.5 mgd. During the dry periods, or in case of emergency, water can be transferred from the industrial supply to the domestic distribution system by portable diesel pumps with a combined capacity of 3.3 mgd.

Total storage capacity within the system totals approximately 27.8 million gallons. The water is prechlorinated at the headworks and secondary chlorination is used at the outlets of all open reservoirs. In addition, chlorination equipment is provided at the pump station connecting the industrial supply to the domestic system.

Hoquiam

The Hoquiam municipal water system supplies an average of 1.55 mgd to its customers. Of this amount, about 1.35 mgd is supplied to the 10,500 people in the service area for a per capita use of 129 gpd. The remainder is supplied to industry on a year round basis.

The City presently has three basic sources of supply, including Davis Creek with a minimum estimated flow of 2.88 mgd, the West Fork of the Hoquiam River with a minimum flow of 2.88 and the Little Hoquiam River with the minimum flow estimated at 1.5 mgd.

The Davis Creek Supply is the major supply of the City, being used almost continuously. The Davis Creek watershed is for the most part city owned. The West Fork of the Hoquiam River is used in the summer for peaking purposes. A major highway passes through the watershed near the intake, thus possible pollution is a problem. The Little Hoquiam River is generally satisfactory in quality, however, watershed control by the City is nonexistent.

Treatment of the water supplies consists of screening, settling, and chlorination of the water supplies. Complete treatment with filtration is presently being studied for the domestic supply. Storage capacity totals 10.2 million gallons, with two major storage facilities comprising the total storage. One reservoir is open, with post chlorination provided for quality control.

Centralia

The Centralia municipal water system serves approximately 10,500 people with an average of 3.0 mgd for a per capita use of 286 gpcd. The city presently has two sources of supply, the North Fork of the Newaukum River and a series of five wells located north of the city. In addition, the city has recorded water rights on the Skookumchuck River; however, that source is not used.

The city obtains its year-round supply from the North Fork of the Newaukum River. The chlorination facility at the headworks is jointly owned and operated with the city of Chehalis, however, separate intake and screening facilities exist. The transmission line to Centralia is about 14 miles long with a capacity of 4.8 mgd.

Water needed to meet peak use periods, or as an alternative source during periods of poor water quality in the Newaukum River, is obtained from the well field. The well field has a total yield capacity of 5.9 mgd. The total storage capacity of the system is 8.5 mgd, being composed of two open reservoirs.

Chehalis

The Chehalis water system supplies an average of 2.2 mgd to its customers. Of this amount, about 0.96 mgd is supplied to the 5,800 people in the service area for a per capita use of 165 gpcd. The remainder is supplied to industrial firms in the area.

The City presently obtains its water from two sources of supply, the North Fork of the Newaukum River and the Chehalis River. The North Fork of the Newaukum River is the primary source and is located east of the City. The watershed encompasses an area of about 18 square miles and is owned by the Weyerhaeuser Company, while the City owns the property surrounding the intake. The water is chlorinated near the headworks at a facility jointly operated with Centralia. The water is transmitted about 17 miles to the City's treatment plant.

The Chehalis River supply is a wet well arrangement, with two pumps discharging into a transmission line to the treatment plant.

The treatment facility is a conventional rapid sand filter plant. Raw water from either the Newaukum River or the Chehalis River is fed into the plant, with the finished water discharged to a 5 million gallon open reservoir. The capacity of the treatment plant is 4.85 mgd, while the total system storage capacity is 6 million gallons.

Other Public Water Supplies

Six smaller municipal water supplies provide an average of 1.79 mgd to about 9,600 people for an average per capita consumption of 187 gpd. Of the total, five of the systems use ground water, providing 9,100 people with 1.66 mgd.

RURAL-INDIVIDUAL

Over 32,000 persons obtain water from about 10,700 individual systems, of which about 90 percent are supplied by ground water.

INDUSTRIAL

Virtually all of the industrial water used in the Basin is obtained from surface water supply developments. The major industrial water users in the Basin, the Rayonier mill in Hoquiam and the Weyerhaeuser Company in Cosmopolis, obtain water from the Aberdeen Industrial Water System. The Industrial System obtains its supply from a diversion on the Wynoochee River, and has an optimum capacity of 110 mgd. Other industrial water users in the Basin obtain water from local municipal systems.

WATER RIGHTS

The City of Aberdeen has water rights for 48 acre feet on the Wishkah River. Hoquiam has recorded water rights on Davis Creek for 9.7 mgd, and on the West Fork of the Hoquiam River for 1.42 mgd. The City has no recorded right on the Little Hoquiam River, yet they hold a vested right in that dams, intakes, and pipelines, owned by the City have been in service for about 30 years. It is recommended that the City request the right to water from this source.

The Cities of Chehalis and Centralia hold water rights on the North Fork of the Newaukum River. Chehalis has the right to the first 2.8 mgd and the right to water in excess of 7.6 mgd, with Centralia holding the right to the remaining 4.8 mgd. The quantity of water available at the intake, however, is often below 7.6 mgd during dry periods, therefore, the City of Chehalis' reliable supply from this source is technically 2.8 mgd. Chehalis also has water rights totaling 9.7 mgd on the Chehalis River. Sufficient water is available to provide this amount.

Surface water rights in the Chehalis Basin total 1620 cfs, which is more than adequate to meet the projected domestic and industrial needs of the Basin.

Ground water rights total 425 cfs. Ground water availability studies have been conducted, and their findings indicate that ground water availability is sufficient to meet the needs of small ground water developments in the Basin, but it is generally not adequate to support large development.

Surface and ground water rights, applications, permits, and certificates for municipal, industrial and domestic water supply and irrigation purposes in the Chehalis Basin are summarized as of September 30, 1966, in Table 19.

WATER RESOURCES

Adequate water resources exist in the Chehalis Basin for all foreseeable requirements of domestic and industrial needs throughout the study period. Surface water alone will provide many times the demand, even under the worst expected drought conditions.

SURFACE WATER

Surface water is presently used to supply the majority of the water needs in the Basin, with a substantial resource still remaining for development. Since many of the smaller tributary streams to the Chehalis River originate in isolated mountainous areas, gross pollution is not likely to occur.

Quantity

The major drainage system to be found in the Basin is that of the Chehalis River. It has a drainage area of 1012 square miles, or all but 616 square miles of the total Basin area. The flow of the Chehalis River ranges from an average of 541 cfs at Doty to 5057 cfs at South Elma. The large tributary streams are the Wynoochee River (771 cfs), the Satsop River (1,922 cfs), and the Newaukum River (476 cfs).

Table 19. Water Rights (cfs)—Chehalis Basin

Type	Municipal	Individual and Community Domestic	Industrial and Commercial	Totals
Surface	590.11	197.52	833.01	1,620.64
Ground	33.60	220.00	172.00	425.60
Total	623.71	417.52	1,005.01	2,046.24

Notes:

Municipal: Municipal Supplies, Fish Propagation, Stock (game birds), Fire Protection, Recreation.

Individual and Community Domestic: Single Domestic, Stock (undefined), Irrigation (undefined, lawn, garden), Domestic/ Private Contractor.

Industrial and Commercial: Irrigation (cranberry farming), Heat Exchange, Railway, Power Generation Stock (dairying), Industrial, Commercial (undefined).

Most of the Basin is tributary to Grays Harbor. Only a small area of about 10 square miles drains directly to the Pacific Ocean. The Humptulips River (1299 cfs), the Hoquiam River (16.9 cfs) and several small streams bypass the Chehalis River, and are tributary directly to Grays Harbor.

The highest flows generally occur during the winter months of November and December, with secondary peaks in February and April as a result of snowmelt. The lowest flows occur during the summer months of July, August and September. The range of flow is from a high of nearly 200 percent of the mean annual flow during the month of December to a low of about 20 percent of the mean annual flow during the month of August.

A river low-flow frequency analysis, made by the U.S. Geological Survey, is given for various stations in the Chehalis Basin. The 7-day and 30-day low flows for recurrence intervals of 1.05, 5, 10, and 20 years for selected stations in the Basin are shown in Table 20.

Quality

Water quality data, obtained from the U.S. Geological Survey, is shown in Table 21. The data includes stations on the Chehalis River at Doty, at Porter, on the Wynoochee River near Montesano, and on the Humptulips River near Humptulips.

Table 20. Low Flow Frequency—Chehalis Basin

River	Location	Recurrence Interval —Years	7 Day Low Flow —cfs	30 Day Low Flow —cfs
Chehalis	Near Grand Mound	1.05	250	295
		5	120	135
		10	104	120
		20	94	114
	At Porter	1.05	410	465
		5	212	240
		10	188	209
		20	170	185
	At South Elma	1.05	550	700
		5	245	275
		10	220	245
		20	200	225
Wynoo-chee	At Oxbow near Aberdeen	1.05	175	205
		5	100	114
		10	94	104
		20	90	98
	Above Save Creek near Aberdeen	1.05	177	210
		5	104	116
		10	97	107
		20	94	103
	Near Montesano	1.05	210	245
		5	120	132
		10	110	120
		20	104	115
	North of Black Creek near Montesano	1.05	145	195
		5	42.6	54.0
		10	26.0	36.0
		20	16.0	24.0

Table 21. Chemical Analysis By Rivers – Chehalis Basin (From 1959 to 1967)

Item	Flow (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Chloride (Cl)	Sulfate (SO_4)	Fluoride (F)	Bicarbonate (HCO_3)	Nitrate (NO_3)	Diss. Solids	Specific Conductance (µmho)	Orthophosphate (PO_4)	Silica (SiO_2)	Iron (Fe)	pH	Coliform Org. (MPN)	Hardness as CO_3
CHEHALIS RIVER NEAR DOTY																		
Maximum	911	7.0	2.4	6.8	0.7	6.0	4.4	0.3	36	1.4	62	85	0.06	18.0	0.66	7.6	4,600	26
Mean	576	5.6	1.4	4.6	0.4	4.3	3.0	0.1	26	0.6	50	64	0.02	14.8	0.31	7.6	563	20
Minimum	321	3.5	0.6	3.5	0.1	2.5	2.2	0	17	0.1	39	45	0	13.0	0.04	6.7	0	14
CHEHALIS RIVER AT PORTER																		
Maximum	5,942	9.0	3.4	8.4	1.4	7.8	4.6	0.3	49	2.0	80	114	0.14	20.0	1.0	7.6	930	30
Mean	4,196	6.1	2.0	4.8	0.6	4.4	3.2	0.1	20	0.9	56	71	0.06	15.5	0.38	7.1	113	23
Minimum	3,065	3.0	0.7	2.7	0.2	2.0	1.6	0	15	0.1	35	41	0	12.0	0.08	6.7	0	14
WYNOOCHEE NEAR MONTESANO																		
Maximum	1,270	8.7	2.3	3.0	0.8	3.2	4.0	0.3	38	1.3	58	76	0.03	13.0	4.0	7.7	930	30
Mean	997	6.9	1.5	2.2	0.3	1.8	2.6	0.1	29	0.4	41	58	0.01	9.5	0.38	7.2	113	23
Minimum	707	4.5	0.7	1.6	0	0.5	1.0	0	16	0	28	36	0	7.3	0.01	6.8	0	14
HUMPTULIPS RIVER NEAR HUMPTULIPS																		
Maximum	1,760	8.0	2.3	3.7	0.5	3.2	4.0	0.3	35	0.8	52	70	0.04	13.0	0.43	7.8	430	27
Mean	1,332	6.0	1.4	2.7	0.2	2.3	2.5	0.1	27	0.3	41	56	0.01	10.1	0.12	7.2	78	21
Minimum	868	4.0	0.5	2.0	0	1.5	0.8	0	15	0	29	35	0	6.7	0.01	6.7	0	13

The surface water quality in the Basin is generally good, however, the lower reaches of the Chehalis River are of poor quality due to the increased development in that area. Most of the smaller tributary streams that originate in the Olympic Mountains are of good quality and due to the relative isolation of many of the watersheds, gross pollution is not likely.

Chemical-Physical. The chemical quality of the surface water in the Chehalis Basin is generally good. The water is soft, with the water hardness indicators, calcium and magnesium ion concentrations, generally less than 30 mg/l. Average dissolved solids concentrations are low in most areas, with maximum values of 70 mg/l in the Chehalis River at Porter, 45 mg/l in the Humptulips River near Humptulips, 39 mg/l in the Wynoochee River near Montesano, and 55 mg/l in the Skookumchuck River near Centralia.

The average dissolved oxygen concentrations are generally high, with average values of 10.9 mg/l in the Wishkah River near Wishkah, and 10.4 mg/l in the Chehalis River at Porter. However, in the lower reaches of the Chehalis River, dissolved oxygen concentration levels drop to between 0 and 3 mg/l during the summer months. A portion of the Chehalis River downstream from Chehalis also experiences a low D.O. during the summer months.

During high runoff periods, turbidity is a problem in many streams. Average color values are low, with maximum values around 20 units.

Bacteriological. The majority of the streams in the Basin except for the lower reaches of the Chehalis River have good bacteriological quality. The average MPN in the Wishkah River near Wishkah is 488. On the West Fork of the Hoquiam River near Hoquiam and on the Wynoochee River near Montesano, the average MPN is 699 and 84 respectively. Other smaller streams in the Basin are of similar quality, with average MPN values generally under 500.

However, on the Chehalis River, downstream from the city of Chehalis, the MPN averages 1200 at Porter, with the average increasing to over 4000 near the mouth of the River. The contamination is attributed to municipal and industrial waste discharges.

GROUND WATER

Several geological studies have been made with the findings indicating that the availability and quality of the ground water is highly variable. However, ground water availability is considered adequate for most small domestic uses, with several locations having quantities large enough to support large municipal developments.

Quantity

Studies of wells in the upper Chehalis Valley, upstream from the city of Elma, indicate that well yields are generally below 25 gpm, with many of the wells going dry during the late summer.

However, good ground water potential is found in two areas in the upper

Chehalis Valley, In the Centralia area between the Skookumchuck River and the city of Chehalis, several wells yield up to 1.25 mgd. Centralia's wells are located in this area, with a total firm capacity of 5.9 mgd. Also in the Newaukum Valley about 6 to 8 miles southeast of Chehalis, artesian water is available, with well yields of up to 0.72 mgd.

In the lower Chehalis Basin between Elma and Aberdeen, ground water is available from an upper and a lower aquifer in the Chehalis River Valley. The upper aquifer, which generally extends to a depth of 100 feet, supplies adequate water although it is reported to be of low quality. The lower aquifer supplies large quantities of water of excellent quality, with well yields ranging from 0.3 to 4.3 mgd.

Ground water in lesser amounts is also obtained from smaller valleys tributary to the Chehalis River Valley. Yields of up to 0.3 mgd have been obtained.

In the coastline areas, two aquifers are evidently present, both of which produce sufficient quantities of water for community domestic supplies; however, poor quality is a problem.

Quality

The ground water quality in the Basin varies greatly. In the upper Chehalis Valley, iron content of the water is generally high, and in several areas salinity and odor are common problems. Chemical analyses for wells in the Newaukum Valley show salinity and hardness in amounts sufficient to make the water unattractive for domestic use.

In the lower Chehalis River Valley, water from the shallower aquifer is high in iron and requires treatment for human consumption. However, water from the lower aquifer is of excellent quality.

In the coastal areas, shallow ground water generally contains organic matter that colors the water and produces a taste, and the deeper ground water has a high mineral content.

Bacteriological quality is not presently a problem, however, in the rural and unincorporated areas the shallow wells that serve as a source for domestic supply are subject to contamination from septic tank drainfields.

PRESENT AND FUTURE NEEDS

Future water requirements in the Basin will be determined primarily by the rate of growth of population, industry and agriculture. Surveys indicate that a substantial steady growth of these factors can be expected through the study period. Details of this growth, projected to the year 2020 are given in Table 24 and Figures 10 through 12.

Water supply poses no serious shortage problems for the Basin through the year 2020. The Chehalis River at South Elma alone averages 3270 mgd, which is about 30 times the average total projected Basin

Table 22. Ground Water Quality — Chehalis Basin

Owner	Location	Depth (ft)	Date	Temp. (°F)	Concentration (mg/l) Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved Solids	Hardness (as CO_3)	Specific Conductance (μmho)	pH
Emil Carlson	15/4W-10G1	26	6/1/60	54	27.0	0.04	12.0	3.0	5.9	0.80	50	0	4.2	3.8	0	2.7	0.08	90	42	111	6.1
City of Westport Well No. 2	16/11W-18N2	72	11/27/59	53	23.0	0.01	9.0	16	29	6.8	121	0	5.4	38.0	0.1	0.1	0.59	189	87	327	7.0
City of Elma	17/6W-4D1	40	11/27/59	51	20.0	0.00	6.0	1.6	3.8	0.4	28	0	2.1	4.0	0	1.9	0.02	58	22	73	7.4
City of Napavine	13/2W-3483	101	10/4/60	55	51.0	0.02	15.0	6.4	9.6	1.5	92	0	0.4	5.5	0.1	1.6	0.34	142	64	163	7.1
City of Centralia	14/2W-5G2	88	5/31/60	53	33.0	3.1	18.0	6.1	19	1.4	84	0	7.0	19.0	0.1	6.9	0.26	160	70	222	7.1
Oscar Keto	14/2W-22H1	1,020	10/14/58	57	4.4	6.5	5,140	821	10,500	58	0	0	9.4	28,900	0	80	—	45,500	16,200	63,600	4.3
State of Wash.	15/3W-14D2	80	11/12/59	50	27.0	0.06	9.5	1.9	4.7	1.0	40	0	4.2	3.8	0	2.5	0.11	75	31	94	6.9
City of Bucoda	15/1W-7E1	60	11/12/59	50	29.0	0.04	11.0	3.3	6.2	1.1	50	0	5.0	4.8	0	3.8	0.2	87	41	124	6.7
Melvin Paulson	15/3W-5B1	85	6/21/60	55	31.0	2.2	7.5	4.4	11.0	3.1	49	0	12.0	8.2	0.1	0.4	0.02	105	37	136	7.1

Table 23. Chemical Analysis By Water Distribution Systems—Chehalis Basin

Sillica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Sodium (Na)	Potassium (K)	Calcium (Ca)	pH	Conductance (μmho)	Turb. (JTU)	Color (std units)	Odor	Magnesium (Mg)	Free O_2	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Sulfite (SO_3)	Chlorine (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite (NO_2)	Orthophosphate (PO_4)	Total Solids	Total Hardness	$CaCO_3$ Hardness	Noncarbonate Hardness	Calcium Hardness	Magnesium Hardness
HOQUIAM WATER DEPARTMENT—SURFACE																MAY 27, 1970												
16.25	–	0.12	0.03	3.8	0.51	3.6	7.5	528	1.7	15	–	2.7	–	18.3	–	3.7	–	7.0	0.028	0.84	–	0.07	48	40	20	25	9	11
ABERDEEN WATER DEPARTMENT—SURFACE																SEPTEMBER 16, 1968												
12.5	–	0.04	0	14.5	0.23	7.2	7.2	60	1.2	12	–	1.8	–	46.4	–	0	–	4.7	0.03	0.35	–	0.05	64	25.2	–	–	18.0	7.2
CENTRALIA WATER DEPARTMENT—SURFACE																JULY 3, 1970												
1.25	–	0.08	–	5.0	0.86	6.0	7.1	80	1.3	4.0	–	4.6	–	26.8	–	0	–	5.75	0.78	<0.01	–	0.02	–	34	–	–	–	–
CHEHALIS WATER DEPARTMENT—SURFACE																MARCH 10, 1971												
6.25	–	0.04	0.012	3.8	0.15	8.8	7.0	70	0.2	14	–	3.4	–	19.5	–	11.0	–	4.5	0.76	0.46	–		49	36	36	20	22	14
PE ELL WATER DEPARTMENT—SURFACE																JULY 9, 1970												
7.5	–	0	–	4.0	0.47	3.6	7.2	66	0.43	10	–	2.7	–	24.4	–	5.8	–	3.0	0.04	2.03	–	0	–	20	–	–	–	–
WESTPORT WATER DEPARTMENT—WELLS																MARCH 25, 1969												
12.5	–	0.18	0.021	12.1		10.4	7.3	300	2	9	–	13.1	–	97.6	–	5.9	–	33.5	0.06	1.11	–	0.39	160	80	80	–	26	54
MONTESANO WATER DEPARTMENT—WELLS																FEBRUARY 14, 1969												
21.0	–	0.22	0.28	58.14	2.22	9.6	6.9	86	2.5	11	–	3.98	–	175	–	0	–	17.0	1.3	0	–	0.68	200	40	–	–	24	16
TENINO WATER DEPARTMENT—WELLS																JUNE 29, 1971												
5.0	–	7.5	0.006	11.8	1.75	8.0	6.85	116	0.93	0	–	6.3	–	61.0	–	16.2	–	3.75	0.055	0.34	–	0.25	91	46	46	–	20	26

Table 24. Projections of Total Industrial Water Use—
Chehalis Basin (mgd)

Year	Average Daily*	Maximum Monthly
1970	79.4	84.4
1980	117	138
2000	151	178
2020	164	193

Notes:

Projections based on 80% of total industrial water needs being used by wood-related industries.

See footnotes on "1970 Industrial Water Use".

*1970 values based on inventory data. All projections obtained from Appendix XI "M. & I. Water Supply" Columbia-North Pacific Region Comprehensive Framework Study — August 1970.

All figures are rounded.

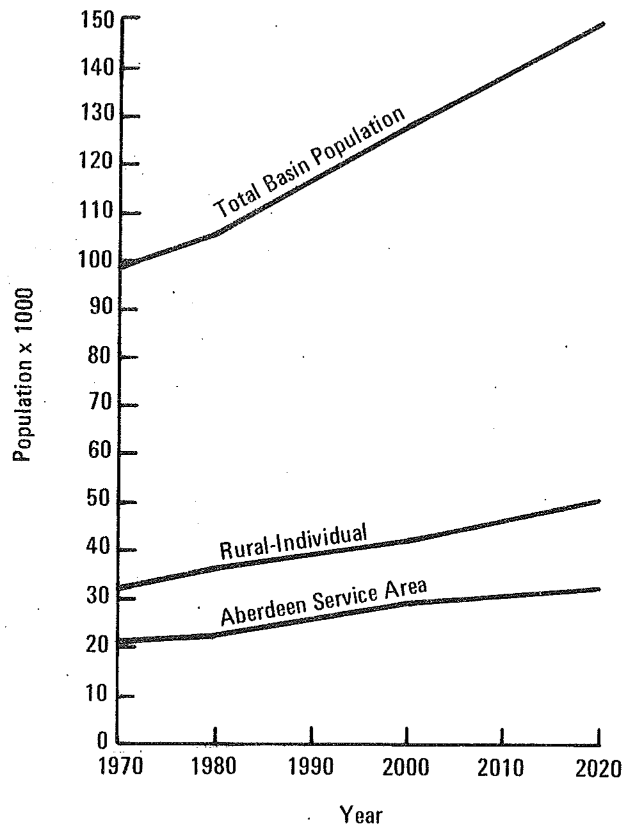


Figure 10. Chehalis Basin Projected Population Growth

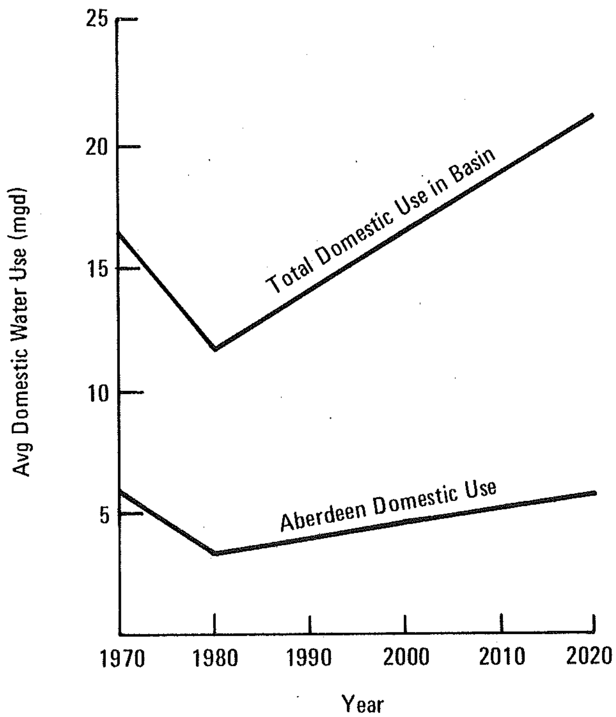


Figure 11. Domestic Water Use — Chehalis Basin

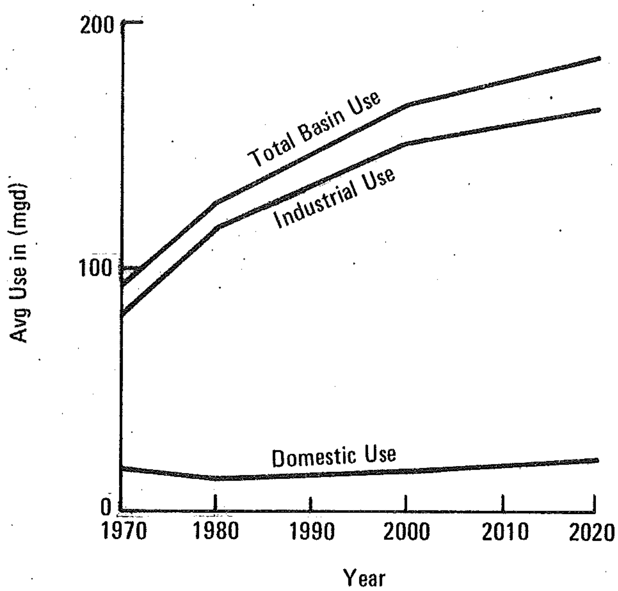


Figure 12. Total Water Use – Chehalis Basin

domestic and industrial water use for the year 2020. In addition, ground water availability near the populated areas of the Basin is available to meet some of the projected domestic needs. Most low population density rural regions that are beyond the service area of the major water supply systems also have adequate ground and surface water supplies for the year 2020.

PROJECTED POPULATION GROWTH

The projected population in the Chehalis basin for the years 1970 through 2020 is shown graphically in Figure 10. This projection indicates a steady growth of one percent per year for the period of 1970 through 2020. The 1970 population of 98,500 is projected to increase to 148,000 by 2020, for about a 150 percent growth during the study period. The majority of the anticipated increase in population is expected to occur in and around the existing urban areas along the Chehalis River.

PROJECTED INDUSTRIAL GROWTH

Industrial water use projections were obtained from the Municipal and Industrial Water Supply Appendix of the Columbia-North Pacific Framework Study. The projections indicate that the present industrial water use of 80 mgd will be doubled to reach an average use of 164 mgd by the year 2020, with peak industrial water use projected to be 193 mgd. See Table 24 for details of the industrial water use through the study period.

PROJECTED WATER REQUIREMENTS

Based on projections of population and industrial growth, total water requirements in the Basin are predicted to reach 185 mgd by the year 2020, representing an increase of 200 percent over 1970 usage. Figure 11 illustrates the total Basin domestic use as well as the water use of the four largest systems. Figure 12 shows the average total Basin water use, industrial use, and domestic use.

Municipal

Municipal water requirements, presently 15 mgd, are projected to reach 20 mgd by the year 2020. Municipal needs will account for over 10 percent of the total basin water use. Municipal per capita water use is projected to be 142 gallons per day (gpd) by 1980, 162 gpd by 2000, and 178 gpd by 2020. The scale will be used for projecting the water needs for all systems showing a 1970 domestic per capita consumption of 150 gallons per capita per day (gpcd) or less. For the systems showing a domestic per capita use of between 150 and 180 gpcd, the 1970 gpcd figure will be used for the projections with no increase, until it matches the above scale. For those systems showing an excessive domestic gpcd figure of over 180 gpcd, it is assumed that their consumption will be reduced to be consistent with the scale by 1980, through increased metering and maintenance of the systems.

Rural-Individual and Small Rural Community Systems

Rural-Individual and Small Rural Community water requirements presently average 2.1 mgd, or 55 gpcd. By 1980 all water use is projected to be supplied by ground water, with water use projected to reach about 2.5 mgd, based on 60 gpcd. The per capita consumption is projected to increase uniformly at 1 gpcd per year throughout the study period, with 2020 average water use reaching over 6.2 mgd. The increase in per capita consumption is based on a projected increase in irrigation and standard of living.

Industrial

Industrial consumers are projected to continue to account for about 90 percent of the total Basin water use through 1980. Further water use is projected to increase at a uniform rate until reaching an average use of 164 mgd by 2020. The major industrial growth is expected to develop around the existing industrial centers along the Chehalis River. See Table 24 for details of the projected industrial water use.

MEANS TO SATISFY NEEDS

GENERAL

The total average domestic water use is projected to reach 22 mgd by the year 2020, representing an increase of about 50 percent over the average 1970 use. Peak water requirements are projected to be over 23 mgd compared to the 1970 peak use of 14.7 mgd. Table 28 gives a listing of the system improvements needed in the Basin, to provide adequate water to meet the peak demand requirements.

The peak demand requirements are within the potential of the Basin without conflict over withdrawals for water supplies. No need for water

Table 25. Municipal and Rural Water Use for 1980 — Chehalis Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Aberdeen	142	23,500	3.34	3.34	4.34	6.00			
Hoquiam	142	11,200	1.59	1.59	2.05	2.86			
Centralia	142	11,200	1.59	1.59	2.05	2.86			
Chehalis	165	6,200	1.02	1.02	1.33	1.84			
PeEll	142	600	0.09	0.09	0.12	0.16			
Montesano	142	3,900	0.55				0.55	0.72	0.99
Elma	142	2,700	0.38				0.38	0.50	0.68
Westport	142	1,600	0.23				0.23	0.30	0.41
Tenino	142	1,000	0.14				0.14	0.18	0.25
Oakville	142	500	0.07				0.07	0.09	0.13
Other Rural Communities	60	6,800	0.40				0.40	0.80	1.20
Rural-Individual	60	36,200	2.18				2.18	4.36	6.54
Total		105,400	11.58	7.63	9.89	13.72	3.95	6.95	10.20

Notes: All figures are rounded.
Avg daily = 1.42 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)

Table 26. Municipal and Rural Water Use for 2000 – Chehalis Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Aberdeen	162	28,400	4.60	4.60	6.00	8.30			
Hoquiam	162	13,550	2.20	2.20	2.86	3.96			
Centralia	162	13,550	2.20	2.20	2.86	3.96			
Chehalis	162	7,500	1.21	1.21	1.57	2.18			
PeEll	162	700	0.11	0.11	0.14	0.20			
Montesano	162	4,700	0.76				0.76	0.99	1.37
Elma	162	3,300	0.54				0.54	0.70	0.97
Westport	162	1,900	0.31				0.31	0.40	0.56
Tenino	162	1,200	0.20				0.20	0.26	0.36
Oakville	162	600	0.10				0.10	0.13	0.18
Other Rural Communities	80	8,200	0.66				0.66	1.32	1.98
Rural-Individual	80	43,800	3.50				3.50	7.00	10.50
Total		127,400	16.39	10.32	13.43	18.60	6.08	10.80	15.92

Notes: All figures are rounded.
Avg daily = 1.62 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)

Table 27. Municipal and Rural Water Use for 2020 – Chehalis Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic Average Daily	Surface Water Use (mgd) Domestic Max Monthly	Surface Water Use (mgd) Domestic Max Daily	Ground Water Use (mgd) Domestic Average Daily	Ground Water Use (mgd) Domestic Max Monthly	Ground Water Use (mgd) Domestic Max Daily
Aberdeen	178	33,000	5.90	5.90	7.65	10.60			
Hoquiam	178	15,700	2.80	2.80	3.62	5.05			
Centralia	178	15,700	2.80	2.80	3.62	5.05			
Chehalis	178	8,700	1.55	1.55	2.02	2.80			
PeEll	178	800	0.14	0.14	0.18	0.25			
Montesano	178	5,500	0.98				0.98	1.27	1.76
Elma	178	3,800	0.68				0.68	0.88	1.22
Westport	178	2,200	0.39				0.39	0.51	0.70
Tenino	178	1,400	0.25				0.25	0.32	0.45
Oakville	178	700	0.12				0.12	0.16	0.22
Other Rural Communities	100	9,500	0.95				0.95	1.90	2.85
Rural-Individual	100	51,000	5.10				5.10	10.20	15.30
Total		148,000	21.66	13.19	17.09	23.75	8.47	15.24	22.50

Notes: All figures are rounded.
Avg daily = 1.78 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)

Table 28. Chehalis Basin Water Supply—Present and Future Needs (mgd)

System	Peak Municipal and Industrial Demand			
	1970	1980	2000	2020
Aberdeen	22,000	23,500	28,400	33,000
Optimum	14.5	15.4	18.7	21.7
Existing	5.5	5.5	15.4	18.7
Needs	–	9.9	3.3	3.0
Hoquiam	10,500	11,200	13,550	15,700
Optimum	7.2	7.4	8.9	10.3
Existing	6.0	6.0	7.4	8.9
Needs	–	1.4	1.5	1.4
Centralia	10,500	11,200	13,550	15,700
Optimum	6.9	7.4	8.9	10.3
Existing	9.5	9.5	9.5	9.5
Needs	–	–	–	0.8
Chehalis	5,800	6,200	7,500	8,700
Optimum	3.8	4.1	4.9	5.7
Existing	4.9	4.9	4.9	4.9
Needs	–	–	–	0.8
Other Smaller Systems	15,900	17,100	20,600	23,800
Optimum	10.5	11.3	13.6	15.7
Existing	15.7	15.7	15.7	15.7
Needs	–	–	–	–
Total Needs	–	11.3	4.8	6.0

Notes: Optimum = 1.6 gpm/service plus maximum monthly industrial use (658 gped); Existing = Plant capacity. All figures are rounded.

Table 29. Summary of Projected Water Use (mgd) – Chehalis Basin

System	Date	Population	Surface Water Use		Ground Water Use		Total Use	
			Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly
Municipal	1970	58,360	9.94	14.01	1.66	3.23	13.04	17.33
	1980	69,200	7.36	9.89	1.77	2.59	9.13	12.48
	2000	83,600	10.32	13.43	2.57	3.80	12.89	17.23
	2020	97,000	13.19	17.09	3.37	5.04	16.56	22.13
Individual-Rural	1970	33,840	0.18	0.36	1.68	3.35	1.86	3.71
	1980	36,200	–	–	2.18	4.36	2.18	4.36
	2000	43,800	–	–	3.50	7.00	3.50	7.00
	2020	51,000	–	–	5.10	10.20	5.10	10.20
Total	1970	98,500	10.12	14.37	3.34	6.58	14.90	21.04
	1980	105,400	7.36	9.89	3.95	6.95	11.31	16.84
	2000	127,400	10.32	13.43	6.07	10.80	16.39	24.23
	2020	148,000	13.19	17.09	8.47	15.24	21.66	32.33

Note: All figures are rounded.

from outside the Basin is apparent. However, regional water systems and interties should be planned to efficiently and adequately accommodate the population densities developing in the Aberdeen-Hoquiam and Centralia-Chehalis areas.

In the future, the major water users are projected to locate around the existing urbanized areas. The increased water use will be met primarily by expanded surface water supplies because high quality ground water in many areas is not adequate to meet large scale development. The surface water developments will require complete treatment. The smaller rural communities are projected to continue using groundwater sources as their primary source of supply. Self-supplied industry using primarily surface water will continue to require over 80 percent of the Basin water requirements. This will be provided for by the expansion of existing facilities.

BASIN PLANS

The cities of Aberdeen, Hoquiam, Centralia and Chehalis are expected to supply about 80 percent of the total projected municipal water requirements for the entire Basin by the year 2020. Smaller systems will supply the remaining 20 percent to about 16,000 persons.

The projection for future needs are based on a more economical and efficient use of water as a valuable resource. To provide for the economical use of the present and future water supplies, it is recommended that all systems provide for 100 percent metering, and increased maintenance by the year 1980. Present trends indicate that a program of more economical and efficient use of water tends to stabilize or reduce the per capita consumption.

Aberdeen

By the year 1975, Aberdeen will need to add new sources of supply totaling 9.9 mgd to meet the optimum source requirements of the projected 1980 population. This is based on the Division of Health's recommendations of providing 1.6 gpm/service source capacity. In addition, a parallel increase in both storage and distribution capacity must be provided in order to assist in meeting peak residential demands and fire fighting requirements, based on providing at least one day's storage at peak use.

Additional improvements of 3.3 mgd and 3.0 mgd in supply capacity are needed by the years 1990 and 2010 respectively. In addition, parallel developments increasing both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

The firm capacity of the existing source is about 5.5 mgd in the late summer months. Therefore, an additional supply must be developed to meet the optimum system requirements. The existing development on the Wishkah River should be used to meet average daily water requirements, with complete treatment provided near the

City. Alternate plans for future sources of supply must be developed in sufficient quantity to meet the peak water needs.

Since the Wishkah basin is not topographically suited to economical storage which would provide adequate source capacity throughout the summer months, it is likely that Aberdeen must become more dependent on the industrial supply for domestic consumption in the future. Arrangements should be made to purchase water on a permanent basis in the future to meet the peak water needs. Projections indicate that once the industrial system supply capacity is increased to 200 mgd in 1972, about 40 mgd will be available for domestic use. Utilization of the existing industrial system would provide an abundant source of water at a relatively low cost.

The water from both the Wishkah River and that obtained from the Industrial Supply line should be treated at a large centralized treatment plant, therefore obtaining increased economy of scale. By taking advantage of the increased economy of scale of the large treatment plant, and the fact that dams, intakes, and transmission lines are presently built, the development costs would be relatively low.

A groundwater development is a possible alternative to meet peak water requirements. Water quality of wells just outside the south city limits have shown to be excellent, however before development, a study to determine ground water availability must be made to determine the potential of a well field in this area. The well field would provide an excellent source for meeting peak water needs, with the cost of the development similar to that of the surface water supply.

Hoquiam

The city of Hoquiam had adequate source development to meet the average daily water use projected through the study period. However, to provide optimum system capacity for 1980, improvements in supply development totaling 1.4 mgd, with parallel improvements in storage and distribution capacities are needed by the year 1975.

Additional improvements of 1.5 mgd and 1.4 mgd in source development are needed by the years 1990 and 2010 respectively. In addition, parallel improvements to both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

To provide for optimum source capacity, additional water rights should be obtained on the West Fork of the Hoquiam River, allowing the city to fully utilize its facilities on the stream. In addition, water rights should be obtained on the Little Hoquiam River. The three existing developments should remain the primary source of supply, with complete treatment facilities to be located in the City to provide centralized treatment. For increased source capacity in the future, the City has provided for a 20 inch connection on the Davis Creek transmission line to utilize the untapped Middle Fork of the Hoquiam River. The future use of the Middle Fork of the Hoquiam River appears desirable due to the proximity of the existing transmission line, and the lack of conflict for water rights on the River.

Centralia

The city of Centralia presently has adequate source developments to meet the optimum water needs through the year 2020. However, throughout the study period, developments improving the distribution system and increasing storage capacity are needed to meet the optimum system requirements projected through the study period.

Centralia should continue using the North Fork of the Newaukum River as its primary source of supply, however, filtration must be provided. During peak periods of demand, supplemental water would be obtained from the city wells.

Ground water availability in the Centralia area is good, and should be used as the source of future supply developments due to the lower cost as compared with a similar surface water development.

Chehalis

By the year 1990, Chehalis will need to develop additional supply capacity totaling 0.1 mgd to meet the supply requirements of the projected population in the year 2000. In addition, a parallel increase in both storage and distribution capacity must also be accomplished. The increase is recommended to assist in meeting peak residential and industrial demands and fire fighting requirements, based on providing at least one day's storage at peak usage.

Additional improvements of 0.8 mgd in supply development are needed by the year 2010, with parallel developments increasing both distribution and storage capacities.

The alternatives for meeting the projected demands consider either using the Chehalis River source alone, or continuing to utilize a combination of the North Fork of the Newaukum and the Chehalis Rivers. A ground water supply was not considered due to the great variation in quality and quantity. Extensive exploratory work would be required to locate satisfactory producing wells, therefore an accurate cost estimate is not available.

The plan for using the Chehalis River has a psychological disadvantage primarily with regard to the high temperature of the Chehalis River water, which reaches 70°F, or 15°F higher than the North Fork supply. The high temperature of the water is not readily acceptable to industry or domestic consumers. However, the finished water would be bacteriologically and chemically of good quality, with the cost of the development being relatively low.

The plan for further utilization of the existing sources of supply would provide water of better physical quality during the summer months. However, the cost of development would be substantially greater.

Other Public Water Supplies

The Washington State Division of Health's Public Water Supply Facilities Inventory was used to obtain the combined system capacities of the other public water supplies in the Basin. The inventory data indicates a combined existing capacity of 15.7 mgd. The capacity is adequate to meet the projected optimum needs through the year 2020. However, constant upgrading of these systems is needed to meet storage and distribution requirements.

Presently, over 90 percent of the water supplied to the smaller municipalities is from ground water. This percentage was used in determining cost estimates for the future. Surface water developments require complete treatment, raising the initial capital costs over that of ground water developments. Those communities using ground water are projected to continue using that source throughout the projection period.

Table 30. Chehalis Basin Water Supply Capital Improvements

System	Plan Level	Population	Average Annual Use (mgd)	Optimum System Capacity (mgd)	Previous System Capacity (mgd)			Needed Capital Improvements ($ x 10^6/mgd)			Year of Improvements
					Source	Distrib	Storage	Source	Distrib	Storage	
Aberdeen	exist	22,000	6.0	14.5	–	–	–				
	1980	23,500	3.34	15.4	5.5	5.5	5.5	9.9	+	9.9	1975
	2000	28,400	4.60	18.7	15.4	15.4	15.4	3.3	+	3.3	1990
	2020	33,000	5.90	21.7	18.7	18.7	18.7	3.0	+	3.0	2010
Hoquiam	exist	10,500	1.55	7.2	–	–	–	–	–	–	
	1980	11,200	1.59	7.4	6.0	6.0	6.0	1.4	+	1.4	1975
	2000	13,550	2.20	8.9	7.4	7.4	7.4	1.5	+	1.5	1990
	2020	15,700	2.80	10.3	8.9	8.9	8.9	1.4	+	1.4	2010
Centralia	exist	10,500	3.00	7.2	–	–	–				
	1980	11,200	1.59	7.4	9.5	9.5	9.5	–	+	–	–
	2000	13,550	2.20	8.9	9.5	9.5	9.5	–	+	–	–
	2020	15,700	2.80	10.3	9.5	9.5	9.5	–	+	–	–
Chehalis	exist	5,800	2.20	3.8	–	–	–	–	–	–	–
	1980	6,200	1.02	4.1	4.8	4.8	4.8	–	–	–	–
	2000	7,500	1.21	4.9	4.8	4.8	4.8	0.1	+	0.1	1990
	2020	8,700	1.55	5.7	4.9	4.9	4.9	0.8	+	0.8	2010
Other Public Water Supplies	exist	15,900	2.1	10.5	–	–	–	–	–	–	
	1980	17,100	1.86	11.3	15.7	15.7	15.7	–	+	–	
	2000	20,600	2.68	13.6	15.7	15.7	15.7	–	+	–	
	2020	23,800	3.51	15.7	15.7	15.7	15.7	–	+	–	

Notes:

1. Optimum System Capacity: Represents 1.6 gpm/service plus max monthly industrial use.
2. Previous System Capacity: System capacity of the previous plan level.
3. Needed Capital Improvements: Capital improvements needed to meet optimum system capacity.

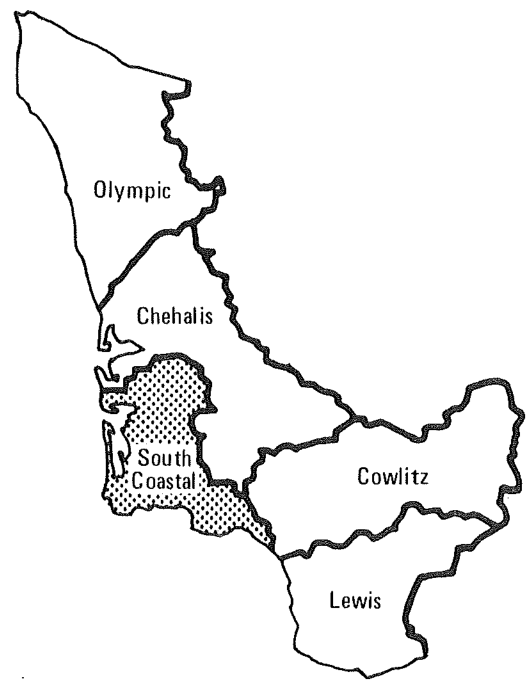
\+ To be based on population growth.

Table 31. Estimate of Capital Costs for Needed Improvements—Chehalis Basin

Plan Level	Source		Development	Year of Devel. (mgd)	Opt. Water Use (mgd)	NEEDED IMPROVEMENT (mgd)			CAPITAL COST (millions of dollars)				MAINT. & OPER. (millions of dollars)		Total
	GW	SW				Source	Storage	Distrib.	Source	Treat.	Storage	Distrib.	Source	Treat.	
ABERDEEN															
Present		x	Wishkah River	existing	14.5										
1980		x	Wishkah R. and Ind. Syst.	1975	15.4	9.9	9.9	+	–	1.73	0.99	0.16	0.092	0.14	
2000		x	" "	1990	18.7	3.3	3.3	+	–	–	0.33	0.54	0.122	0.17	
2020		x	" "	2010	21.7	3.0	3.0	+	–	–	0.30	0.51	0.158	0.21	
										1.73	1.62	1.21	0.372	0.52	5.45
Present		x	Wishkah River	existing	14.5										
1980	x	x	Wishkah R. & G.W. Dev.	1975	15.4	9.9	9.9	+	0.67	1.04	0.99	0.16	0.040	0.058	
2000	x	x	" "	1990	18.7	3.3	3.3	+	0.22	0.01	0.33	0.54	0.052	0.060	
2020	x	x	" "	2010	21.7	3.0	3.0	+	0.20	0.01	0.30	0.51	0.065	0.062	
									1.09	1.06	1.62	1.21	0.157	0.180	5.32
HOQUIAM															
Present			Davis Cr. W.F. Hoquiam, Little Hoquiam	existing	7.2										
1980			Above plus Middle F.	1975	7.4	1.4	1.4	+	**	1.34	0.14	0.08	0.009	0.071	
2000			Hoquiam	1990	8.9	1.5	1.5	+	–	–	0.15	0.26	0.011	0.086	
2020			" "	2010	10.3	1.4	1.4	+	–	–	0.14	0.24	0.013	0.104	
										1.34	0.43	0.58	0.033	0.261	2.64
CENTRALIA															
Present	x	x	N.F. Newaukum R.,	existing	7.2										
1980	x	x	Local G.W.	1975	7.4	–	–	+	–	0.87	–	0.08	0.015	0.044	
2000	x	x	" "	1990	8.9	–	–	+	–	–	–	0.26	0.020	0.045	
2020	x	x	Further G.W. Development	2010	10.3	–	–	+	0.11	0.004	–	0.24	0.26	0.046	
									0.11	0.874	–	0.58	0.061	0.135	1.76
CHEHALIS															
Present		x	N.Fork New. R. & Chehalis R.	existing	3.8	–	–	–	–	–	–	–	–	–	
1980		x	Chehalis River Only	1975	4.1	–	–	+	–	–	–	0.044	0.048	0.087	
2000		x	" "	1990	4.9	0.1	0.1	+	0.21	0.49	0.01	0.143	0.059	0.033	
2020		x	" "	2010	5.7	0.8	0.8	+	–	–	0.08	0.132	0.077	0.054	
									0.21	0.49	0.09	0.31	0.184	0.174	1.47
CHEHALIS															
Present		x	N.F. New. R. & Chehalis	existing	3.8	–	–	+	–	–	–				
1980		x	R.	1975	4.1	–	–	+	1.19	0.49	–	0.044	0.048	0.087	
2000		x	" "	1990	4.9	0.1	0.1	+	–	–	0.01	0.143	0.059	0.033	
2020		x	" "	2010	5.7	0.8	0.8	+	–	–	0.08	0.132	0.077	0.054	
									1.19	0.49	0.09	0.319	0.184	0.174	2.45
Other Public Water Supplies	90%	10%													
Present	x	x	continue existing trend	existing	10.5	–	–	+	–	–	–	–	–	–	
1980	x	x	" "	1975	11.3	–	–	+	–	–	–	0.132	0.001	0.001	
2000	x	x	" "	1990	13.6	–	–	+	–	–	–	0.385	0.001	0.001	
2010	x	x	" "	2010	15.7	–	–	+	–	–	–	0.396	0.001	0.001	
												0.913	0.003	0.003	0.92

** Source development does not include diversion structure, intake, and transmission lines—no estimate of cost of facilities has been made at this time.
* Total does not include diversion structure, intake and transmission line.
† Based on increased population.

South Coastal Basins



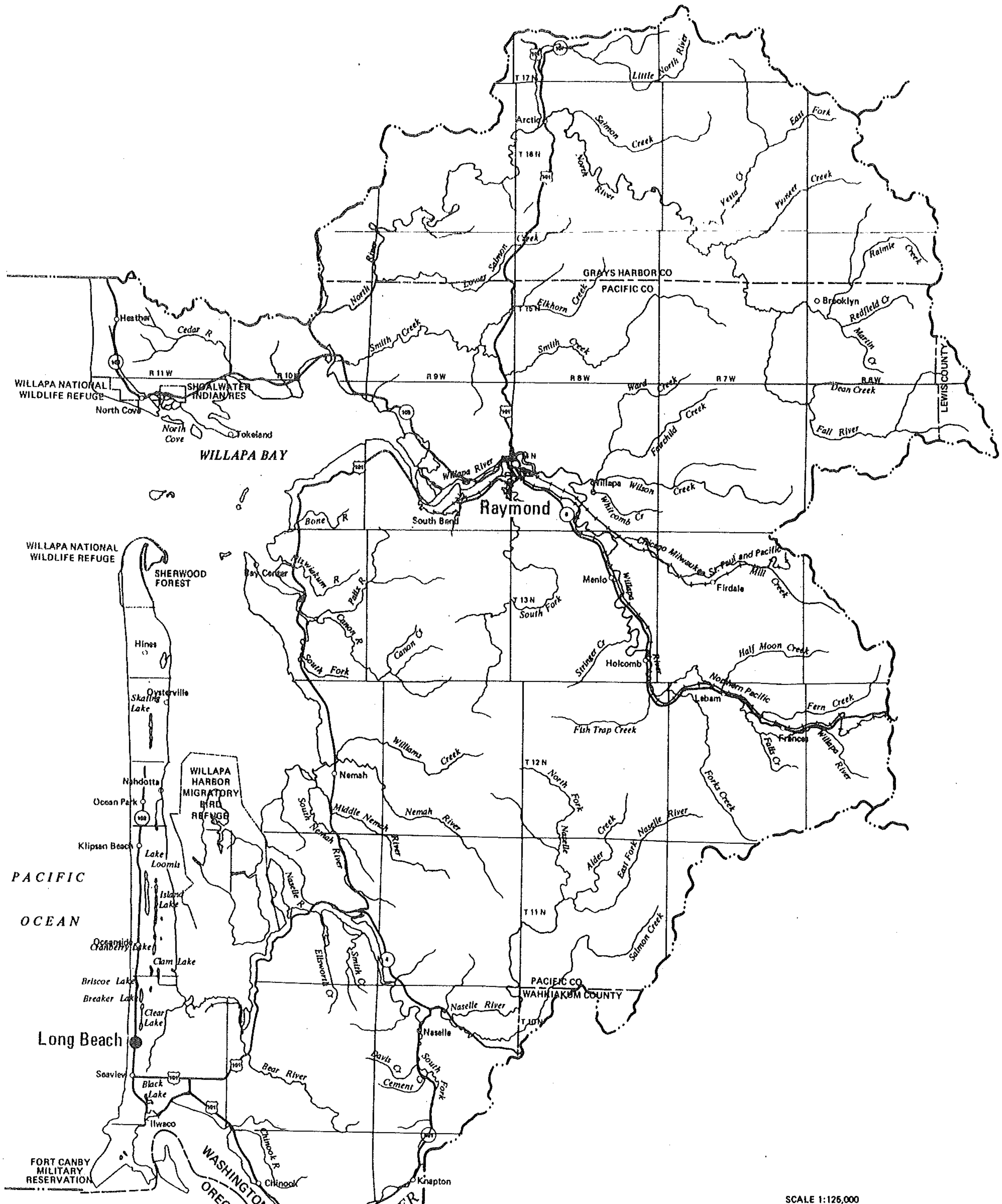


Figure 13. South Coastal Basin — Willapa Area, WRIA 24

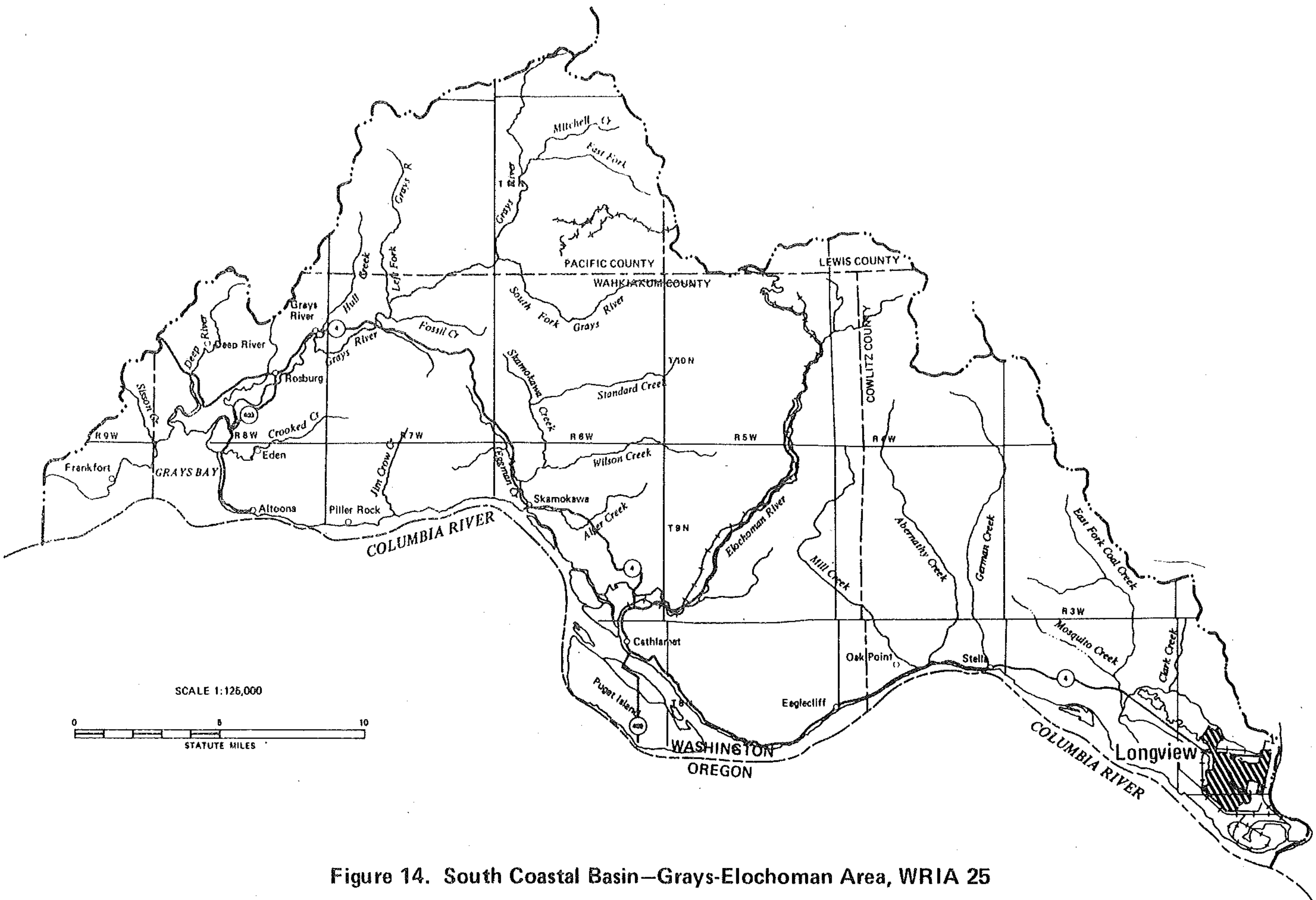


Figure 14. South Coastal Basin—Grays-Elochoman Area, WRIA 25

SOUTH COASTAL BASIN

INTRODUCTION

The South Coastal Basin is located in the southwestern portion of the State. It is bordered on the west by the Pacific Ocean, the south by the Columbia River, the east by the Cowlitz Basin, and on the north by the Chehalis Basin. The Basin occupies over 1,400 square miles of Pacific, Wahkiakum, Cowlitz, and Grays Harbor counties and includes the Willapa and Cathlamet watershed areas. The majority of the Basin is sparsely populated with communities located along the Columbia River, the Pacific beaches, and around Willapa Bay.

Steady population growth is projected primarily around the existing communities but substantial increases are not anticipated. Industrial growth is expected to continue primarily in the wood products area, with water use projected to more than double through the study period.

PRESENT STATUS

Present water use is within the supply capabilities of the existing source developments. The Basin is largely rural with a small percentage of total water use supplied from individual wells and small municipal distribution systems. Surface water sources have been developed as almost the sole source of supply for the community systems in the Basin.

WATER USE

Total water use in the South Coastal Basin presently averages 211 mgd. Of this amount, the municipal and rural demand averages about 7.0 mgd. Industrial water requirements, which make up the remainder, are more than thirty times the amount used for domestic purposes. See Tables 32 and 33 for 1970 water use.

MUNICIPAL

The present average municipal water use of 6.9 mgd is supplied to a total of 45,800 consumers in the Basin for an average municipal per capita consumption of 150 gpcd. Longview, the largest user with 3.6 mgd, serves 30,000 persons for a per capita use of 120 gpd. Raymond, second largest user with 0.48 mgd, serves 3,670 persons and has a per capita water usage of 130 gpd. The Long Beach system uses 0.27 mgd in serving 3,500 persons in the communities of Long Beach and Seaview for a per capita use of 77 gpd. The remaining smaller communities use an average of 1.64 mgd, serve 8,630 people, and show a per capita water use of 190 gpd.

RURAL-INDIVIDUAL

Water use by about 9,900 rural-individual consumers is estimated at 0.5 mgd. This is based on an estimated average per capita use of 55 gpd.

INDUSTRIAL

Industrial water use currently averages about 204 mgd, about 97 percent of the total water used in the Basin. The major industrial users are

Table 32. Municipal and Rural Water Use for 1970 — South Coastal Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Longview	120	30,000	3.60	3.60	5.04	8.10			
Raymond	131	3,670	0.91	0.48	0.67	0.89			
Long Beach	77	3,500	0.27	0.27	0.43	0.58			
South Bend	360	2,000	0.72	0.72	1.01	1.29			
Cathlamet	132	1,900	0.25	0.25	0.35	0.44			
Naselle	230	870	0.20	0.20	0.28	0.75			
Ilwaco	262	650	0.17	0.17	0.23	0.43			
Chinook	250	400	0.10	0.10	0.13	0.18			
Ocean Park	133	600	0.08				0.08	0.12	0.15
Small Rural Communities	55	2,210	0.12	0.04	0.08	0.12	0.08	0.16	0.24
Rural-Individual	55	9,900	0.495	0.05	0.10	0.15	0.445	0.89	1.335
Total	159	55,700	6.92	5.87	8.33	12.91	0.605	1.17	1.725

Notes: All figures are rounded.
Rural — Max monthly = 2.0 (Avg daily); Max daily = 3.0 (Avg daily)
Municipal — Max monthly = 1.4 (Avg daily)
Chinook includes 100 gpcd plus 60,000 gpd (industry; Max monthly = 1.3 (Avg daily), Max daily = 1.8 (Avg daily)

Table 33. South Coastal Basin Industrial Water Use for 1970 (mgd)

Name	Type	Source	Ave Daily	Max. Monthly	Max. Daily
Weyerhaeuser Longview	Wood Products	Columbia River	117	129	146
Longview Fibre Longview	Pulp and Paper	Columbia River	70	77	87.5
Reynolds Metal Longview	Aluminum	Wells	8.3	8.3	10.4
International Paper Longview	Wood Products	Wells	1.3	1.4	1.6
Weyerhaeuser Raymond	Lumber	Old Armstrong Creek	7.35	8.10	9.2
Others	Assume Wood Related	—	0.13	0.20	0.23
Total			204.1	224.0	254.9

Notes: Chemical and metal industries; average daily = maximum monthly wood-related industries; maximum monthly = 1.0 (average daily). All figures are rounded.

the Weyerhaeuser Companies in Longview, 117 mgd, and Raymond, 7.4 mgd. The Longview Fibre Mill averages 70 mgd, and other smaller metal and pulp and paper mills use water at an average rate of 16 mgd. Refer to Table 33 for a listing at the present industrial water uses.

WATER SUPPLIES

Surface water is used to meet nearly all the Basin's municipal, rural-individual, and industrial water requirements. All but one of the eight larger community systems use surface water as a source and supply about 95 percent of the total water used.

MUNICIPAL

Surface water sources supply eight cities and communities including the major municipal systems of Longview, Raymond and Long Beach with 6.2 mgd, serving a population of about 43,000 persons.

Longview

The Longview system supplies water to the City of Longview and the North Longview Service area of the Cowlitz County PUD. (See Cowlitz Basin.) The 30,000 customers in the City of Longview use an average of about 3.6 mgd for a per capita use of 120 gpd. The North Longview service area contains about 4,000 people and is served with about 0.33 mgd, bringing the total average water supplied by the system to about 4 mgd.

The principal source of water for the Longview system is the Cowlitz

River. However, a connection to the City of Kelso's water system provides water in case of emergency. The water obtained directly from the Cowlitz River receives complete treatment at the filtration plant, rated at 9 mgd, with the intake structure rated at 18 mgd.

The majority of the City's service area operates as a gravity system in one lower pressure zone. The exceptions are the Hillcrest and Ammons Drive areas. Both areas are located at a higher ground elevation and operate in different pressure zones.

The City's principal storage facilities serving the lower zone consist of five concrete reservoirs with a combined capacity of 12.0 mgd. in addition a 1.0 mg reservoir serves the Hillcrest area, a 0.15 mg reservoir serves the Ammons Drive area, and a 0.2 mg reservoir serves the Coal Creek area.

Raymond

The Raymond municipal water system supplies an average of 0.91 mgd to its customers. Of this amount, about 0.48 mgd is supplied to the 3,700 people in the service area, for a per capita use of 130 gpd. The remainder is supplied to industry on a year round basis. In the summer months, the Weyerhaeuser mill's water demand increases and adds to the normally high domestic demand during this period.

The major source of water supply is an impounding reservoir on Butte Creek, with a firm capacity of 0.25 mgd. In the summer, supplemental water is obtained from the South Fork of the Willapa River with the combined capacity of the two sources being over 4.6 mgd.

The water from both sources is chlorinated, fluoridated, and stored in three open reservoirs with a total capacity of 7.1 million gallons.

Water quality is presently a problem in the Raymond area. The Butte Creek watershed is partially owned by the City, with logging interests owning the remainder. There is no population on the watershed, but logging operations are carried on from time to time, causing degradation of the water quality and creating a potential contamination problem. The South Fork of the Willapa River is less subject to turbidity problems than Butte Creek, however, it is warm in the summer, and subject to contamination because the watershed is primarily populated farm land.

Long Beach

The Long Beach water department serves the City of Long Beach and the adjacent community of Seaview located to the south. The total population of about 3,500 is served with an average of 0.27 mgd for a per capita consumption of 77 gpcd. During the summer months the average total demand is doubled due to the heavy recreational use.

The system receives its supply from Matlock and Yeatton Creeks which have a combined capacity of 0.42 mgd. The supply is chlorinated and distributed from two reservoirs with a combined capacity of 0.35

million gallons.

Other Public Water Supplies

Six smaller municipal water supplies provide an average of 1.55 mgd to 6,400 people for an average per capita use of 240 gpcd. All but one of the systems use surface water as their source of supply.

RURAL-INDIVIDUAL

An estimated 9,900 persons obtain about 0.5 mgd from about 2,000 individual systems of which about 90 percent are supplied by ground water.

INDUSTRIAL

The largest industrial water users in the Basin are the Weyerhaeuser Company in Longview with an average use of 117 mgd, the Longview Fibre plant with an average use of 70 mgd, the Reynolds Metal plant in Longview with an average use of 8.3 mgd and the Weyerhaeuser Company in Raymond with an average use of 7.4 mgd. The Longview Weyerhaeuser Company and Longview Fibre obtain their supplies from the Columbia River while the Reynolds plant obtains its water from company owned wells, and the Raymond Weyerhaeuser Company owns a private water system supplied from Armstrong Creek which is rated at over 10 mgd. The Company's water use often exceeds the firm capacity of its supply facilities, and during the summer months the supply must be supplemented with water obtained from the Raymond municipal system, with water for drinking and miscellaneous plant uses purchased from Raymond on a year round basis. Other industrial water users in the Basin purchase water from local municipal systems.

WATER RIGHTS

The recorded surface water rights in the Basin total about 380 mgd. Longview has rights for 7 cfs on the Cowlitz River and has submitted an application to withdraw an additional 100 cfs. The City of Raymond has rights for over 20.9 mgd, composed of 17.6 mgd on the South Fork of the Willapa River, 1.44 mgd on Butte Creek, with the remainder on Clearwater Creek, which is no longer in use. Long Beach has water rights totaling 0.13 mgd on Matlock Creek, with no recorded rights on Yeatton Creek.

Ground water rights total about 78 mgd, with the majority of the rights for commerical or industrial use.

A summary of surface and ground water rights as of September 30, 1966, is given in Table 34 for the entire South Coastal Basin (excluding Longview).

WATER RESOURCES

Adequate water resources exist in the South Coastal Basin for all foreseeable requirements throughout the study period. Surface water alone will provide many times the demand, even under the worst expected

Table 34. Water Rights (cfs)—South Coastal Basin

Type	Municipal	Individual and Community Domestic	Industrial and Commercial	Totals
Surface	189.60*	75.38	324.15	589.13
Ground	9.40	13.30	96.28	118.98
Total	198.00	88.68	420.43	708.11

Notes:

Municipal: Municipal Supplies, Fish Propagation, Stock (game birds), Fire Protection, Recreation.

Individual and Community Domestic: Single Domestic, Stock (undefined), Irrigation (undefined, lawn, garden), Domestic/Private Contractor.

Industrial and Commercial: Irrigation (cranberry farming), Heat Exchange, Railway, Power Generation Stock (dairying), Industrial, Commercial (undefined).

*Does not include Longview's water rights on Cowlitz River.

drought conditions.

SURFACE WATER

Surface water resources are more than adequate to provide a plentiful supply of municipal and industrial water. In addition, because the streams in the Basin originate in the isolated mountains in the eastern portion of the Basin, gross contamination is unlikely to occur.

Quantity

The average runoff of the South Coastal Basin is approximately 6,900 cfs. The average flow of the Willapa River at Willapa is 660 cfs, draining an area of 258 square miles. The average flow of the Elochoman River at Cathlamet is 374 cfs and the average flow of the Naselle River at Naselle is 431 cfs, all figures are for the period of 1959-67.

Variation in annual discharge during the same period included high and low flows of 850 and 410 cfs on the Willapa River, 510 and 220 cfs on the Elochoman River, and 570 and 260 cfs on the Naselle River.

The Basin minimum runoff quantity is about 3,900 cfs with a 50 year recurrence interval, and 3,500 cfs with a 100 year recurrence interval. Maximum runoff occurs during the six month period of October through March, with low flows occurring in June, July, and August.

See Table 35 for a low flow frequency analysis made by the U.S. Geological Survey, for various stations in the South Coastal Basin.

Table 35. Low Flow Frequency—South Coastal Basin

River	Location	Recurrence Interval —Years	7 Day Low Flow —cfs	30 Day Low Flow —cfs
Naselle	Near Naselle	1.05	64.0	76.0
		5	23.5	28.5
		10	20.5	25.0
		20	19.0	23.5
Willapa	At Leban	1.05	11.5	14.5
		5	6.5	8.4
		10	4.3	5.5
		20	3.4	4.4
Willapa	At Willapa	1.05	45.0	60.0
		5	23.0	26.0
		10	20.0	24.0
		20	18.5	22.5
Elocho-man	Near Cathlamet	1.05	43.0	52.5
		5	23.0	27.5
		10	21.0	24.0
		20	19.0	22.0

The 7-day and 30-day low flows for recurrence intervals of 1.05, 5, 10, and 20 years for eight selected stations in the Basin are shown.

Quality

Water quality data was obtained from the U.S. Geological Survey for selected rivers and stations in the South Coastal Basin. The data includes stations on the Naselle, Willapa and Elochoman Rivers. See Table 36 for a detailed listing of the data.

Chemical-Physical

The chemical quality of the surface water in the South Coastal Basin is generally good. The water is soft, low in dissolved solids, and high in dissolved oxygen concentrations. Calcium and magnesium ion concentrations, water hardness indicators, never exceeded 8.0 mg/l through the period of 1959-67. Average dissolved oxygen concentrations are high, ranging from 10.6 mg/l on the Willapa River at Labam to 11.3 mg/l on the Naselle River near Naselle. The average dissolved solids content ranges from 64 to 35 mg/l on the Willapa River, 48 to 37 mg/l on the Naselle River, and 54 to 47 mg/l on the Elochoman River.

During high runoff periods, the streams in the more populated areas of the Basin are highly turbid. Average color values are low, with a maximum recorded value of 15 units.

Bacteriological

The majority of the streams in the Basin except for the lower reaches

Table 36. Chemical Analysis By Rivers – South Coastal Basin (From 1959 to 1967)

Item	Flow (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Chloride (Cl)	Sulfate (SO_4)	Fluoride (F)	Bicarbonate (HCO_3)	Nitrate (NO_3)	Diss. Solids	Specific Conductance (µmho)	Orthophosphate (PO_4)	Silica (SiO_2)	Iron (Fe)	pH	Coliform Org. (MPN)	Hardness as CO_3
WILLAPA RIVER AT LEBAM																		
Maximum	274	5.5	1.5	5.5	1.0	4.5	4.8	0.2	27	2.0	54	66	0.06	16.0	0.48	7.2	4,600	19
Mean	191	4.4	1.0	4.7	0.6	3.8	3.3	0.1	20	1.3	47	57	0.03	14.5	0.25	6.9	751	15
Minimum	138	3.5	0.6	4.1	0.4	3.5	1.5	0	14	0.4	42	48	0	12.0	0.05	6.6	0	11
WILLAPA RIVER NEAR WILLAPA																		
Maximum	848	6.5	2.1	7.2	1.6	5.2	5.2	0.2	34	3.2	64	82	–	14.0	–	7.5	4,600	19
Mean	660	4.5	1.5	3.5	0.7	4.6	4.1	0.2	23	1.2	48	62	–	12.3	–	7.0	676	17
Minimum	506	3.2	0.4	3.2	0.4	4.0	3.0	0	10	0.1	35	41	–	11.0	–	6.4	36	10
NASELLE RIVER NEAR NASELLE																		
Maximum	573	5.5	1.7	5.7	1.0	5.0	4.6	0.2	28	1.7	48	65	–	13.0	–	7.6	930	20
Mean	431	4.4	1.2	4.5	0.4	4.1	3.4	0.1	21	0.8	41	56	–	11.2	–	7.2	180	16
Minimum	264	2.8	0.6	3.6	0.2	3.5	2.0	0	12	0.1	37	41	–	9.6	–	6.7	0	11
ELOCHOMAN RIVER NEAR CATHLAMET																		
Maximum	513	6.5	1.3	4.6	0.6	6.8	2.2	0.1	25	0.2	54	67	–	14.0	–	7.4	–	22
Mean	374	6.0	1.1	4.4	0.5	5.4	2.2	0.1	25	0.2	51	63	–	14.0	–	7.3	–	20
Minimum	219	5.5	0.9	4.1	0.4	4.0	2.2	0.1	24	0.2	47	58	–	14.0	–	7.2	–	27

of the Willapa River have good bacteriological quality. The average MPN in the Willapa River at Lebam is 761. On the Nasalle River near Naselle and on the Bear River near Naselle the average MPN is 268 and 640 respectively.

Contamination in the lower reaches of the Willapa River is attributed to municipal and industrial waste discharges. The cities of Raymond and South Bend discharge waste water produced by about 6,000 persons into the river after treating in sewage lagoons. In addition, industrial waste water discharge averages about 7.4 mgd.

GROUND WATER

The ground water of the Basin is generally of good quality, with recharge occurring from precipitation and infiltration along streams and rivers. Withdrawals have not been large enough along the coast to cause salt water intrusion, but this could become a problem if future ground water development becomes extensive.

With the exception of the Longview area, studies indicate that ground water availability in the remainder of the Basin is generally low, and not capable of supporting a large development. However an adequate quantity exists to meet the needs of the small, rural-individual users.

Quality

Dissolved solids content is typically less than 200 ppm. In Table 37 water analyses for various wells in the Basin with depths ranging from

Table 37. Ground Water Quality – South Coastal Basin

Owner	Location	Depth (ft)	Date	Temp. (°F)	Concentration (mg/l)															Specific Conductance (μmho)	pH
					Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved Solids	Hardness (as CO_3)		
Ralph McGough	12/11W-15P	10	12/9/59	–	20	0.12	4.0	1.8	8.2	0.5	25	0	3.0	9.0	0.1	0.6	0	59	17	82	6.3
Harbor Seafoods	13/10W-8R1	455	5/26/60	–	32	0.04	19.0	4.1	14.0	2.9	101	0	1.4	9.0	0	0.7	0.94	137	64	188	8.0
State of Wash.	9/5W-32	244	4/26/61	52	46	1.1	14.0	7.2	20.0	3.3	125	0	4.0	4.2	0.3	0.1	0.35	160	64	209	7.6

10 feet to 455 feet are shown. Hardness is generally less than 90 mg/1 as $CaCO_3$. Throughout the Basin, pH values range from 8.0 to 6.0. The silica content fluctuates between 20 and 50 mg/1. Iron content in the water is generally low, however, some wells in the coastal areas and near Longview do have high iron problems.

Bacteriological quality is not presently a problem, however, in the rural and unincorporated areas in the coastal area the shallow wells that serve as a source for domestic supply are subject to contamination from septic tank drainfields.

Quantity

In the coastal area, the sand deposits that underlie the coastal plain adjacent to Willapa Bay are very permeable and are used extensively as a source of ground water. Shallow large diameter wells yield as much as several hundred gallons per minute. However, the satisfactory yield of a well depends upon maintaining a delicate balance between withdrawals, induced inflow, and seasonal recharge. Losing the balance leads to migration of organically colored and iron bearing water toward the well, as well as possible salt water intrusion. Characteristically, in the Coastal areas the iron and color content of the water increases rapidly below the 500 foot depth. However, with proper spacing and operation, it is expected that the ground water reserves are capable of supporting the projected water needs for the area.

Except for the Longview area, which is recharged from the Columbia

River, ground water availability near urbanized centers is not considered of adequate quantity to support large municipal or industrial use. However, a sufficient quantity is available to meet small rural-individual needs.

PRESENT AND FUTURE NEEDS

As in any area, future water requirements in the Basin will be determined by the rate of growth of population, industry, and agriculture. Surveys indicate that a steady growth of these factors can be expected through the study period. Details of the growth, projected to the year 2020, are given in Figures 15 through 17 and Tables 39 through 45.

Water supply appears adequate for the Basin through the year 2020. The total surface water runoff averages about 2,200 mgd, which is over 40 times the projected water use by the year 2020. Most low population density rural regions that are beyond the service area of the major water supply systems have adequate ground and surface water supplies for the year 2020.

PROJECTED POPULATION GROWTH

The projected population in the South Coastal Basin for the years 1970 through 2020 is shown graphically in Figure 15. The 1970 population of the Basin (55,700) is projected to increase to about 76,500 by the year 2020. The most rapid growth in population is expected to occur in and

Table 38. Chemical Analysis By Water Distribution Systems—South Coastal Basin

Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Sodium (Na)	Potassium (K)	Calcium (Ca)	pH	Conductance (μmho)	Turb. (JTU)	Color (std units)	Odor	Magnesium (Mg)	Free O_2	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Sulfite (SO_3)	Chlorine (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite (NO_2)	Orthophosphate (PO_4)	Total Solids	Total Hardness	$CaCO_3$ Hardness	Noncarbonate Hardness	Calcium Hardness	Magnesium Hardness
		CHINOOK WATER DISTRICT—SURFACE														FEBRUARY 3, 1969												
10.0	–	0.16	–	14.9	5.5	7.2	7.5	116	12	25	–	3.4	–	65.9	–	8.2	–	3.5	0.05	0.89	–	–	78.4	32.0	–	–	–	–
		ILWACO WATER DEPARTMENT—SURFACE, LAKE														DECEMBER 6, 1968												
11.8	–	1.08	–	8.47	2.2	12	7.2	185	7	45	–	4.4	–	17.1	–	21.9	–	38.5	0.02	0.18	–	0.19	–	48	–	–	–	–
		LONG BEACH WATER DEPARTMENT—SURFACE														JUNE 20, 1968												
12.5	–	0.15	–	4.67	1.72	3.2	6.3	84	3	–	–	1.46	–	7.32	–	–	–	11.0	0.17	0.44	–	0.98	–	22	–	–	–	–
		RAYMOND WATER DEPARTMENT—SURFACE														SEPTEMBER 30, 1968												
9.5	–	0.26	–	0.19	1.05	17.6	7.0	84	3	11	–	0.49	–	29.3	–	4.9	–	10.5	0.98	1.5	–	1.5	–	24	–	–	–	–
		NASELLE WATER COMPANY—SURFACE														NOVEMBER 29, 1965												
12.3	–	0.22	–	1.85	0.56	5.6	7.5	56	22	18	–	4.37	–	4.88	–	10	–	8	–	5.76	–	0.41	51.9	32	–	–	–	–
		SOUTH BEND WATER DEPARTMENT—SURFACE														JUNE 19, 1968												
18.8	–	0.06	–	2.37	0.31	7.6	7.3	78	3	5	–	1.21	–	39	–	–	–	8	0.05	0.53	–	0.29	–	24	–	–	–	–
		(water department—source)														(date)												
			–	21	5.4	9.5	7.4	257	–	5	–	12	–	92	–	6.0	–	31	0.1	0.7	–	0.29	155	72	–	–	–	–
		LONGVIEW WATER DEPARTMENT—														OCTOBER 7, 1968												
0.8	–	0.08	0.001	8.3	1.4	10.0	7.0	12.8	1	3	–	1.4	–	29.3	–	2.3	–	–	12.5	0.53	–	–	–	36.0	–	–	–	–

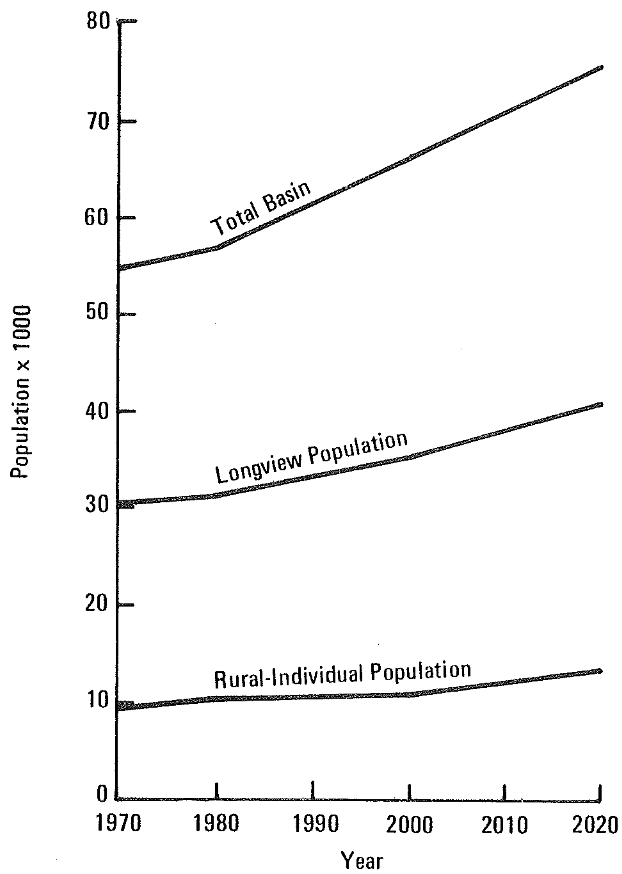


Figure 15. South Coastal Basin Population Projection

around the larger urbanized areas, primarily around Longview.

PROJECTED INDUSTRIAL GROWTH

Industrial water use projections were obtained from the Municipal and Industrial Water Supply Appendix of the Columbia-North Pacific Framework Study. The projections indicate that the present industrial water use of 204 mgd will be increased to reach an average use of 467 mgd by the year 2020, with peak industrial water use projected to be 514 mgd. See Table 39 for details of the industrial water use through the projection period.

PROJECTED WATER REQUIREMENTS

Based on projections of population and industrial growth, total water requirements in the Basin are predicted to reach 480 mgd by the year 2020, representing an increase of about 200 percent over 1970 usage. Figure 16 illustrates the total Basin domestic use as well as the water use of Raymond and Long Beach. Figure 17 shows the average total Basin water use, industrial use, and domestic use.

Municipal

Municipal water requirements, presently 7 mgd, are projected to reach 13 mgd by the year 2020. Municipal needs will account for about 3 percent of the total Basin water use. Municipal per capita water use is projected to be 142 gallons per day (gpd) by the year 1980, 162 gpd by 2000, and 178 gpd by 2020. The scale will be used for projecting the water needs for all systems showing a 1970 domestic

Table 39. Projections of Total Industrial Water Use— South Coastal Basin (mgd)

Year	Average Daily*	Maximum Monthly
1970	204	224
1980	286	314
2000	406	446
2020	467	514

Notes:

Projections based on 80% of total industrial water needs being used by wood-related industries.

See footnotes on "1970 Industrial Water Use".

*1970 values based on inventory data. All projections obtained from Appendix XI "M. & I. Water Supply" Columbia-North Pacific Region Comprehensive Framework Study - August 1970.

All figures are rounded.

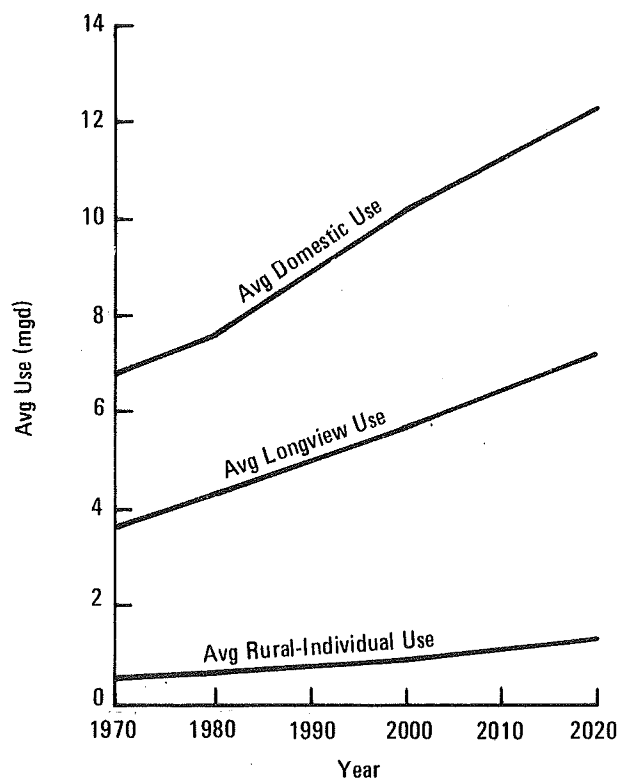


Figure 16. Domestic Water Use — South Coastal Basin

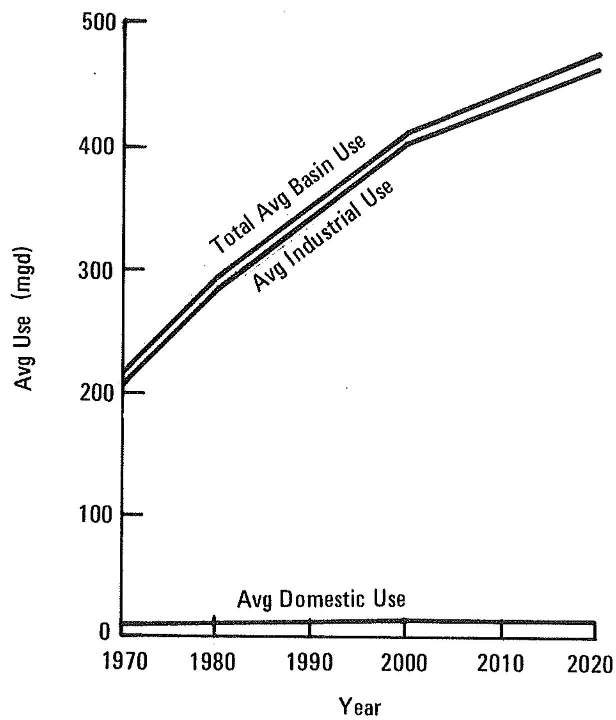


Figure 17. Total Water Use — South Coastal Basin

per capita consumption of 150 gallons per capita per day (gpcd) or less. For the systems showing a domestic per capita use of between 150 and 180 gpcd, the 1970 gpcd figure will be used for the projections with no increase until it matches the above scale. For those systems showing an excessive domestic gpcd figure of over 180 gpcd, it is assumed that their consumption will be reduced to be consistent with the scale by 1980, through increased metering and maintenance of the systems.

Rural-Individual and Small Rural Community Systems

Rural-Individual and Small Rural Community water requirements presently average 0.5 mgd, or 55 gpcd. By 1980 all water use is projected to be supplied by ground water, with water use projected to reach about 0.6 mgd, based on 60 gpcd. The per capita consumption is projected to increase uniformly at 1 gpcd per year throughout the study period, with the 2020 average water use reaching over 1.34 mgd. The increase in per capita consumption is based on a projected increase in irrigation and standard of living.

Industrial

Industrial consumers are projected to continue to account for about 97 percent of the total Basin water use through 1980. Further water use is projected to increase at a uniform rate until reaching an average use of over 467 mgd by 2020. The major industrial growth is expected to be in the Raymond area and along the Columbia River near Longview. See Table 39 for details of the projected industrial water use.

Table 40. Municipal and Rural Water Use for 1980 — South Coastal Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Longview	142	30,900	4.37	4.37	5.70	7.90			
Raymond	142	3,800	1.00	0.54	0.70	0.97			
Long Beach*	142	3,600	0.51	0.51	0.66	0.92			
South Bend	142	2,060	0.29	0.29	0.37	0.52			
Cathlamet	142	1,960	0.28	0.28	0.36	0.50			
Naselle	142	900	0.13	0.13	0.17	0.23			
Ilwaco	142	670	0.10	0.10	0.12	0.17			
Chinook	**	410	0.104	0.04	0.05	0.07			
Ocean Park	142	620	0.09				0.09	0.120	0.160
Small Rural Communities	60	2,280	0.137	0.041	0.082	0.123	0.096	0.192	0.288
Rural-Individual	60	10,100	0.60				0.60	1.20	1.80
Total		57,300	7.62	6.30	8.21	11.41	0.79	1.51	2.25

Notes: All figures are rounded.
Avg daily = 1.42 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)
*Long Beach (recreational): Avg daily = 1.3 (Population served); Max monthly = 1.6 (Avg daily), Max daily = 2.5 (Avg daily)
**See note for 1970

Table 41. Municipal and Rural Water Use for 2000 — South Coastal Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Longview	162	35,500	5.75	5.75	7.47	10.30			
Raymond	162	4,400	1.40	0.72	0.94	1.30			
Long Beach*	162	4,200	0.68	0.68	0.88	1.22			
South Bend	162	2,400	0.39	0.39	0.51	0.70			
Cathlamet	162	2,200	0.36	0.36	0.47	0.65			
Naselle	162	1,050	0.17	0.17	0.22	0.31			
Ilwaco	162	770	0.13	0.13	0.17	0.23			
Chinook	**	470	0.07	0.05	0.07	0.09			
Ocean Park	162	710	0.12				0.12	0.16	0.22
Small Rural Communities	80	2,700	0.22	0.07	0.21	0.28	0.15	0.30	0.45
Rural-Individual	80	11,600	0.93				0.93	1.86	2.79
Total		66,000	10.22	8.32	10.94	15.08	1.20	2.32	3.46

Note: All figures are rounded.
Avg daily = 1.3 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)
*See note for 1980
**See note for 1970

Table 42. Municipal and Rural Water Use for 2020 – South Coastal Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Longview	178	41,200	7.34	7.34	9.54	13.20			
Raymond	178	5,100	1.91	0.91	1.18	1.64			
Long Beach*	178	4,900	0.87	0.87	1.13	1.57			
South Bend	178	2,800	0.50	0.50	0.65	0.90			
Cathlamet	178	2,500	0.46	0.45	0.59	0.81			
Naselle	178	1,200	0.21	0.21	0.27	0.38			
Ilwaco	178	900	0.16	0.16	0.21	0.29			
Chinook	**	550	0.11	0.11	0.14	0.20			
Ocean Park	178	820	0.15				0.15	0.20	0.27
Small Rural Communities	100	3,130	0.31	0.10	0.20	0.30	0.21	0.42	0.63
Rural-Individual	100	13,400	1.34				0.34	2.68	4.02
Total		76,600	13.35	10.65	13.91	19.29	1.70	3.30	4.92

Notes: All figures are rounded.
Avg daily = 1.3 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)
*See note for 1980
**See note for 1970

MEANS TO SATISFY NEEDS

GENERAL

The total average daily water use is projected to reach 480 mgd by the year 2020. This is an increase of about 233 mgd over the average 1970 use. Peak water requirements are projected to be over 534 mgd compared to the 1970 peak use of 237 mgd. Table 43 gives a listing of the system improvements needed in the Basin, to provide adequate water to meet the peak demand requirements.

No need for water from outside the Basin is apparent. However, increasing urban and recreational growth in the Long Beach Peninsula area, along with that area's lack of abundant high quality water, make a regional water supply and transmission system a possibility. In addition, due to the high population densities in the Longview-Kelso area and the fact that a surface water development requires a high initial capital outlay, a regional surface water development taking advantage of economy of scale should be considered.

In the future, the major water users are projected to locate around the existing urbanized areas. The increased water use will be met primarily by expanded surface water supplies. The surface water developments will require complete treatment, raising the cost over that of a similar ground water development. However, high quality ground water in many areas is not adequate to meet large scale development.

Table 43. South Coastal Basin Water Supply Capital Improvements

System	Plan Level	Population	Average Annual Use (mgd)	Optimum System Capacity (mgd)	Previous System Capacity (mgd)			Needed Capital Improvements ($ x 10^6/mgd)			Year of Improvements
					Source	Distrib	Storage	Source	Distrib	Storage	
Longview	exist	30,000	3.60	8.0							
	1980	30,900	4.37	20.3	9.0	9.0	9.0	11.3	+	11.3	1975
	2000	35,500	5.75	23.4	20.3	20.3	20.3	3.1	+	3.1	1990
	2020	41,200	7.34	27.1	23.4	23.4	23.4	3.7	+	3.7	2010
Raymond	exist	3,670	0.91	2.42							
	1980	3,800	1.00	2.50	4.6	4.6	4.6	0.85	+	0.5	1975
	2000	4,400	1.40	2.90	4.6	4.6	4.6	–	+	–	1990
	2020	5,100	1.91	3.36	4.6	4.6	4.6	–	+	–	2010
Long Beach	exist	3,500	0.27								
	1980	3,600	0.51	2.37	0.42	0.42	0.42	1.95	+	1.95	1975
	2000	4,200	0.68	2.76	2.37	2.37	2.37	0.39	+	0.39	1990
	2020	4,900	0.87	3.22	2.76	2.76	2.76	0.46	+	0.46	2010
Other Public Water Supplies	exist	8,630	1.64	5.67							
	1980	8,900	1.13	5.86	6.08	6.08	6.08	–	+		
	2000	10,300	1.46	6.70	6.08	6.08	6.08	0.62	+	0.62	1990
	2020	12,000	2.10	7.90	6.70	6.70	6.70	1.20	+	1.20	2010

Notes:
*Domestic + Average Industrial
1. Optimum System Capacity: Represents 1.6 gpm/ service plus max monthly industrial use.
2. Previous System Capacity: System capacity of the previous plan level.
3. Needed Capital Improvements: Capital improvements needed to meet optimum system capacity.
+ Based on population growth.

Table 44. South Coastal Basin Water Supply—Present and Future Needs (mgd)

System	Peak Municipal and Industrial Demand			
	1970	1980	2000	2020
Longview	30,000	30,900	35,500	41,200
Optimum	19.8	20.3	23.4	27.1
Existing	9.0	9.0	20.3	23.4
Needs	–	11.3	3.1	3.7
Raymond	3,670	3,800	4,400	5,100
Optimum	2.42	2.50	2.90	3.36
Existing	4.6	4.6	4.6	4.6
Needs	–	–	–	–
Long Beach	3,500	3,600	4,200	4,900
Optimum	–	2.37	2.76	3.22
Existing	0.42	0.42	2.37	2.76
Needs	–	1.95	0.39	0.46
Other Smaller Systems	8,630	8,900	10,300	12,000
Optimum	5.67	5.86	6.70	7.90
Existing	6.08	6.08	6.08	6.70
Needs	–	–	0.62	1.20
Total Needs	–	13.25	4.11	5.36

Notes: Optimum = 1.6 gpm/service plus maximum monthly industrial use (652 gpcd); Existing = Plant capacity. All figures are rounded.

Table 45. Summary of Projected Water Use (mgd) — South Coastal Basin

System	Date	Population	Surface Water Use		Ground Water Use		Total Use	
			Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly
Municipal	1970	45,800	5.82	8.23	0.16	0.28	5.98	8.41
	1980	47,200	6.30	8.21	0.19	0.31	6.49	8.52
	2000	54,400	8.32	10.94	0.27	0.46	8.59	11.40
	2020	63,200	10.65	13.91	0.36	0.62	11.01	14.53
Individual-Rural	1970	9,900	0.05	0.10	0.45	0.90	0.50	1.00
	1980	10,100	–	–	0.60	1.20	0.60	1.20
	2000	11,600	–	–	0.93	1.86	0.93	1.86
	2020	13,400	–	–	1.34	2.68	1.34	2.68
Total	1970	55,700	5.87	8.33	0.61	1.18	6.48	9.41
	1980	57,300	6.30	8.21	0.79	1.51	7.09	9.72
	2000	66,000	8.32	10.94	1.20	2.32	9.52	13.26
	2020	76,600	10.65	13.91	1.70	3.30	12.35	17.21

Note: All figures are rounded.

BASIN PLANS

The cities of Longview, Raymond and Long Beach are expected to supply about 85 percent of the total projected municipal water requirements for the entire Basin by the year 2020. With smaller systems supplying the remainder to about 11,900 persons.

The projections for future needs are based on a more economical and efficient use of water as a valuable resource. To provide for the economical use of the present and future water supplies, it is recommended that all systems provide for 100 percent metering, and increased maintenance by the year 1980. Present trends indicate that a program of more economical and efficient use of water tends to stabilize or reduce the per capita consumption.

Longview

By the year 1975, Longview will need to develop additional supply capacity totaling 11.3 mgd to meet the supply requirements of the projected 1980 population, based on the Division of Health's recommendations of providing 1.6 gpm/service, source capacity.
In addition, a parallel increase in both storage and distribution capacity must also be accomplished. The increase is recommended to assist in meeting peak residential and industrial demands and fire fighting requirements, based on providing at least one day's storage at peak usage.

Additional improvements of 3.1 mgd and 3.7 mgd in supply development are needed by the years 1990 and 2010 respectively. In addition, parallel developments increasing both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

Surface water supplies are ample and are of good quality, while ground water is considered inadequate in both quantity and quality; therefore, the alternate plans for Longview both consider the Cowlitz River as the source of supply. The alternatives consider a combined water treatment plant to meet the needs of Longview, Kelso and the PUD, or a smaller single purpose facility to meet the needs of Longview only.

The combined facility would provide water at a lower cost due to the increased economy of scale involved in the larger combined plant.

The single purpose facility would provide water equal in quality to that of the combined facility. However, the unit cost of building the smaller single purpose treatment plant would be greater.

Raymond

The Raymond municipal system has adequate source and storage capacity to meet the optimum system capacity requirements of the projected population through 2020, based on optimum source and storage capacity of 1.6 gpcd plus Maximum Monthly Industrial Use. However, extensive improvements in the distribution system, storage, and water treatment facilities are needed to increase the quality and efficient operation of the system.

Surface water will continue supplying the needs of Raymond; however, in the future complete treatment of surface water must be provided. It is uneconomical to provide treatment on two surface sources; therefore, it is recommended that a treatment plant with ultimate capacity of 5 mgd be built at the existing water intake site on the South Fork of the Willapa River. The Butte Creek source, due to its unreliable firm capacity, should be abandoned.

Ground water resources have been investigated as a possible alternative source, however, an insufficient amount was found. It was therefore concluded that no possibility for developing ground water as an alternative municipal source existed.

Abandonment of the Butte Creek source and Reservoir would reduce the system pressure and storage capacity. Therefore, improvements on the existing reservoirs, as well as adding new elevated facilities must be accomplished to maintain adequate service.

Distribution facilities should be planned and installed to serve the regional areas with special consideration also given to reconditioning of existing mains and providing metering, adequate pressure, and fire protection.

Long Beach

By the year 1975, Long Beach will need to expand its source of supply by 1.95 mgd to meet the source requirements of the projected 1980 population, based on the Division of Health's recommendations of providing 1.6 gpm/service source capacity. In addition, a parallel increase in both storage and distribution capacity must be provided in order to assist in meeting peak residential demands and fire fighting requirements. Based on providing at least one day's storage at peak use, 1.6 gpm per service.

Additional improvements of 0.4 and 0.5 mgd in source development are needed by the years 1990 and 2010 respectively. In addition, parallel developments increasing both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

Abundant high quality water is not available in the Long Beach Peninsula region; in addition, the growing population and heavy summer recreational development pose potential water supply problems. It is believed that the ultimate solution to the water needs is a regional water district approach, using surface water as its source. The Bear River is a possible source due to its proximity (5 miles from Long Beach) and flow measurements indicate an average flow of 10.9 mgd. However, additional flow and quality data are needed to determine the year-round reliability of the stream. In addition, a feasibility study of a regional water district is needed.

In the interim, the City of Long Beach must develop additional supply capacity in order to meet the projected needs through the year 2020.

Future expansion capability of the existing source is unknown; however, it is not expected to provide optimum source capacity throughout the projection period. A study of the ultimate firm capacity of the source must be initiated. It is recommended that the full capacity of the existing source be developed to supply the average daily needs of the community, with shallow ground water development used to meet peaking requirements. Ground water availability in the area is generally good, however, quality is widely divergent. The major problem attending the withdrawal of water from the shallow sands is the deterioration of quality with use. Therefore, stage development of a well system should be used, and ultimately water treatment is likely to be needed.

The cost figures given in Table 46 represent expansion of the existing surface water source by 1 mgd, with the remaining requirements met by ground water developments.

Other Public Water Supplies

The Washington State Division of Health's Public Water Supply Facilities Inventory was used to obtain the combined system capacities of the other public water supplies in the Basin. The inventory data indicates a combined existing capacity of 6.1 mgd. Additional combined system capacity improvements of 0.6 mgd by 1990 and 1.2 mgd by 2010 will meet the optimum requirements projected for the years 2000 and 2020, respectively.

Presently, 89 percent of the water supplied is from surface sources.

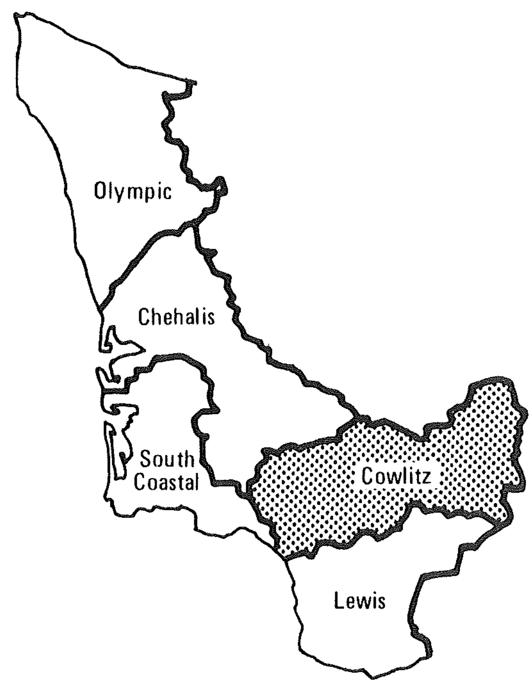
This percentage was used in determining cost estimates for the future. Surface water developments require complete treatment, raising the initial capital costs over that of ground water developments. Those communities using ground water are projected to continue using that source throughout the projection period.

Table 46. Estimate of Capital Costs for Needed Improvements—South Coastal Basin

Plan Level	Source GW	Source SW	Development	Year of Devel. (mgd)	Opt. Water Use (mgd)	NEEDED IMPROVEMENT (mgd) Source	Storage	Distrib.	CAPITAL COST (millions of dollars) Source	Treat.	Storage	Distrib.	MAINT. & OPER. (millions of dollars) Source	Treat.	Total
LONGVIEW															
Present		x	Individual Intake and	existing											
1980		x	Treatment, Cowlitz R.	1975	20.3	11.3	11.3	+	*	1.36	1.13	0.10	0.01	0.11	
2000		x	" "	1990	23.4	3.1	3.1	+	*	0.56	0.31	0.51	–	0.03	
2020		x	" "	2010	27.1	3.7	3.7	+	*	0.67	0.37	0.63	–	0.04	
										2.59	1.81	1.24	0.01	0.18	5.83
Note: See below for Alternative.															
RAYMOND															
Present		x	Butte Cr. S.F. Willapa R.												
1980		x	build treat. plant on S.		2.50	5.0	–	+	*	0.85	0.50	0.01	0.001	0.009	
2000		x	Fork Willapa R.		2.90	–	–	+	*	–	–	0.07	0.001	0.011	
2020		x	" "		3.36	–	–	+	*	–	–	0.08	0.002	0.012	
										0.85	0.50	0.16	0.004	0.032	1.55
LONG BEACH															
Present		x	Matlock & Yeatton Cr.												
1980	x	x	Inc. Surf capacity by 1 mgd & G.W. Develop.		2.37	1.95	1.95	+	0.08	0.26	0.20	0.01	0.002	0.015	
2000	x		G.W. Development		2.76	0.39	0.39	+	0.03	0.02	0.04	0.06	–	0.003	
2020	x		" "		3.22	0.46	0.46	+	0.04	0.02	0.05	0.08	–	0.003	
									0.15	0.30	0.29	0.15	0.002	0.021	0.91
Other Public Water Supplies		90%													
Present	x	x	Local G & S Water Use												
1980	x	x	" "		5.86	0	0	+				0.03			
2000	x	x	" "		6.70	0.62	0.62	+	0.004	0.13	0.06	0.154	0.00	0.005	
2020	x	x	" "		7.90	1.20	1.20	+	0.01	0.27	0.14	0.187	0.001	0.011	
									0.014	0.40	0.20	0.371	0.001	0.016	1.002
LONGVIEW, KELSO, PUD															
Present		x	Mutual Source Develop.												
1980		x	between Longview, Kelso,		20.3	21.3	11.3	+	*	1.02	1.13	0.10	0.01	0.11	
2000		x	Cowlitz Co. PUD		23.4	9.3	2.1	+	*	0.40	0.31	0.51	–	0.03	
2020		x	" "		87.1	11.1	3.7	+	*	0.45	0.37	0.63	–	0.04	
										1.87	1.81	1.24	0.01	0.18	5.11

*Included in teatment cost.
+Based on population growth.

Cowlitz Basin



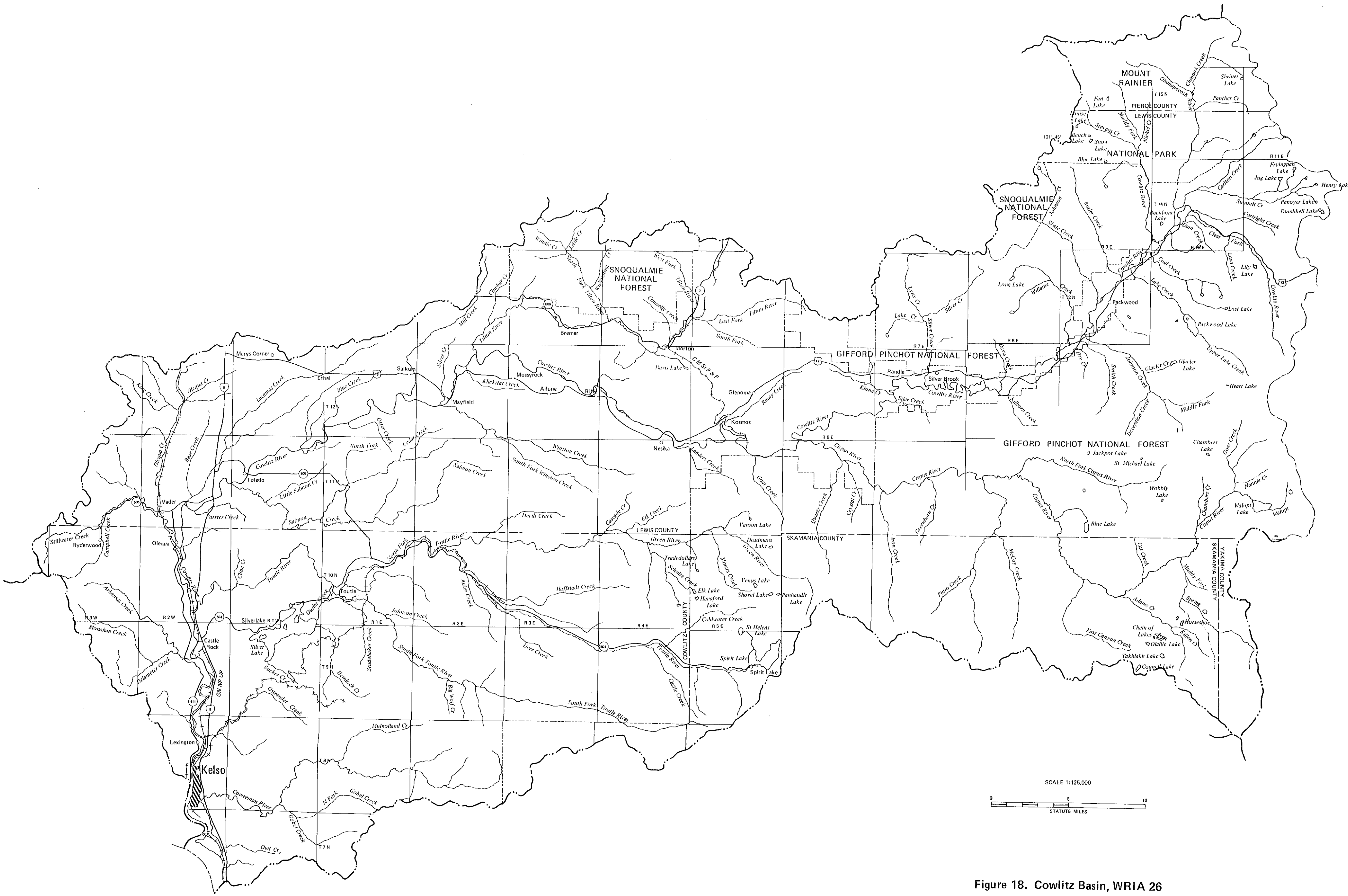


Figure 18. Cowlitz Basin, WRIA 26

COWLITZ BASIN

INTRODUCTION

The Cowlitz Basin is located in the Southwestern portion of the State and bordered by the Lewis Basin on the South, the Chehalis and Nisqually Basin on the North, and the Cascade Divide on the East. The Basin occupies 2,500 square miles of which over half is in Lewis County. The remaining area is in Cowlitz and Skamania Counties. The Southwestern portion of the basin is industrialized with the economy of the remaining area oriented towards lumbering and agriculture.

The population of the Basin is projected to be increased by 34 percent by the year 2020, with the majority of the population and industrial growth expected to occur around the existing urban center near Kelso and along Interstate Highway 5. Water use is projected to increase by over 200 percent, exceeding present water supply system capabilities.

PRESENT STATUS

Present water use is well within the supply capabilities of the existing source developments. The eastern portion of the Basin is lightly populated, and a substantial percentage of total water used is supplied from individual wells and small community distribution systems. The western portion of the Basin contains the major population centers with the municipal water systems using surface water to meet their needs.

WATER USE

Total water use in the Cowlitz Basin presently averages about 10.2 mgd. Of this amount, the domestic use averages about 3.8 mgd. Industrial water requirements, which make up the remainder, total 6.4 mgd, or over 60 percent of the total water use in the Basin. See Tables 47 and 48 for a breakdown of basin water use as of 1970.

MUNICIPAL

The present average municipal water use of over 3.8 mgd is supplied to a total of 26,500 municipal consumers in the Basin for an average municipal per capita consumption of 114 gpd. Kelso, the largest system with an average use of 1.41 mgd, serves 12,200 people and has a domestic per capita use of 116 gpd. The Cowlitz County PUD system uses an average of 0.47 mgd in serving about 6,500 people for a total per capita use of 73 gpd. Five smaller municipal systems use an average of 0.94 mgd, serve 5,140 people, and show a per capita water use of 183 gpd.

RURAL-INDIVIDUAL

Water use by about 15,300 rural-individual and small rural community consumers is estimated at 0.84 mgd. This is based on an estimated average per capita consumption of 55 gpd.

INDUSTRIAL

Table 47. Municipal and Rural Water Use for 1970 – Cowlitz Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic Average Daily	Surface Water Use (mgd) Domestic Max Monthly	Surface Water Use (mgd) Domestic Max Daily	Ground Water Use (mgd) Domestic Average Daily	Ground Water Use (mgd) Domestic Max Monthly	Ground Water Use (mgd) Domestic Max Daily
Kelso	107	12,200	1.41	1.41	1.98	3.00			
Cowlitz County PUD	69	6,500	0.47	0.47	0.66	0.85			
Castle Rock	157	1,590	0.25	0.25	0.35	0.75			
Morton	344	1,250	0.43	0.43	0.60	1.29			
Packwood	30	1,000	0.03	0.03	0.04	0.08			
Mossyrock	123	650	0.08				0.08	0.11	0.39
Toledo	231	650	0.15				0.15	0.21	0.45
Other Rural Communities	55	2,760	0.16	0.01	0.02	0.03	0.15	0.28	0.42
Rural-Individual	55	15,300	0.84	0.08	0.16	0.24	0.76	1.52	2.28
Total	90	41,900	3.82	2.68	3.81	6.24	1.14	2.12	3.54

Notes: All figures are rounded.
Municipal: Avg daily from facilities inventory
Max daily from facilities inventory
Max monthly = 1.4 (Avg daily)
Rural : Avg daily = 55 gpcd Max monthly = 2.00 (Avg daily),
Max daily = 3.0 (Avg daily)

Table 48. Cowlitz Basin Industrial Water Use (mgd) for 1970

Name	Type	Source	Avg Daily	Max. Monthly	Max. Daily
Others	Assume wood-related	–	6.4	7.0	8.0
Total			6.4	7.0	8.0

Notes: Maximum monthly = 1.10 (avg daily). All figures are rounded.
* Assume 50% surface use.

Industrial water use in the Basin presently averages 6.4 mgd. Although no major industrial users are located in the basin. The total water use is a combination of many smaller, primarily wood-related industries that are located throughout the Basin. Refer to Table 48 for a listing of the present industrial water use.

WATER SUPPLIES

Surface water provides 60 percent or 6 mgd of the total average daily water requirement in the Basin. Ground water is used to furnish the remainder.

MUNICIPAL

The two major systems in the Basin, Kelso, and Cowlitz County PUD No. 1, rely on surface water for their source of supply. Three smaller municipal systems also use surface water as their source of supply with the remainder of the small communities using ground water as their source of supply.

Kelso

The Kelso system supplies water to the City of Kelso and five other systems located outside the City's boundaries, including the Davis Terrace Water Association, the Rainbow Addition, Haussler Road, Williams and Finney Road, the Cowlitz Gardens Service Area.
The latter three zones are service areas of the Cowlitz County PUD No. 1. The 12,200 customers in the City of Kelso use an average

of 1.41 mgd, for an average per capita consumption of 127 gpd. The smaller systems outside the city limits are supplied with an average of 0.13 mgd, bringing the average total production of the Kelso system to 1.26 mgd.

The principal source of water supply for the Kelso system is the Cowlitz River. A connection of the City of Longview's water system (in the South Coastal Basin) provides water to the City of Kelso in case of emergency.

The water obtained from the Cowlitz River is treated at the City's filtration plant, with a design capacity of 2.5 mgd. Storage capacity within the city totals 2.75 mgd, being composed of four reservoirs.

COWLITZ COUNTY PUD NO. 1

The PUD owns and operates four water systems in Cowlitz County, with a combined storage capacity of 972,000 gallons. The largest of the four systems is located generally to the north of the City of Longview and is designated as the North Longview Service Area. The service area includes the residential communities of Columbia Heights, Beacon Hill, Lexington, Mountain View and Sunset Way (LUD No. 1). The three smaller systems within the County are located northerly and easterly of the City of Kelso and are called the Haussler Road Service area (LUD No. 2), the Williams and Finney Road Service Area (LUD No. 3), and the Cowlitz Gardens Service Area. All water supplies used by PUD's service areas are purchased from others. The source of water supply for the North Longview Service Area is the City of Longview's water system; whereas, the source of water supply for the Haussler Road Service Area, the Williams and Finney Road Service Area and the Cowlitz Gardens Service Area is the City of Kelso's water system. All purchased water is metered, with the City of Longview supplying about 70 percent of the total water purchased.

Other Public Water Supplies

Five small municipal water suppliers provide an average of 0.94 mgd to 5,140 people, for an average of 183 gpd. Of this total, four of the systems use surface water, providing 3,840 people with 0.71 mgd.

INDUSTRIAL

No major water-using industries have been identified; however, numerous small wood-related industries are found throughout the Basin. Their combined water use is estimated to be 6.4 mgd, based on figures obtained from the Columbia-North Pacific Framework Study.

RURAL-INDIVIDUAL

An estimated 15,300 persons obtain water from about 5,100 individual systems. It is estimated that 90 percent of these systems use ground water as a source.

WATER RIGHTS

The recorded surface water rights in the Basin total about 33,400 cfs.

The City of Longview (outside the Basin) has rights for 7 cfs on the Cowlitz River and has submitted an application to withdraw an additional 100 cfs. Similarly, Kelso has rights to 3 cfs on the Cowlitz River with an application for additional rights totaling 30 cfs. The remainder of the rights in the Basin are primarily for industrial or power generation purposes.

A summary of surface and ground water rights as of September 30, 1966, follows for the entire Cowlitz Basin in Table 49.

WATER RESOURCES

Water resources in the Cowlitz Basin are capable of supplying all foreseeable demands for municipal and industrial water in the future. The water is generally of good quality throughout the urban area, therefore precluding any major water shortages in the foreseeable future.

SURFACE WATER

Surface water resources are more than adequate to meet the projected municipal and industrial water requirements. In addition, much of the watershed area in the eastern sector of the Basin is isolated, thus, gross contamination is not anticipated.

Quantity

The major drainage system to be found within the watershed is that of

Table 49. Water Rights (cfs) — Cowlitz Basin

Type	Municipal	Individual and Community Domestic	Industrial and Commercial	Totals
Surface	384.98*	69.98	32,896.71	33,351.67
Ground	7.30	28.16	0.67	36.13
Total	392.28	98.14	32,897.38	33,387.80

Notes:

Municipal: Municipal Supplies, Fish Propagation, Stock (game birds), Fire Protection, Recreation.

Individual and Community Domestic: Single Domestic, Stock (undefined), Irrigation (undefined, lawn, garden) Domestic/ Private Contractor.

Industrial and Commercial: Irrigation (cranberry farming), Heat Exchange, Railway, Power Generation Stock (dairying) Industrial, Commercial (undefined).

*Includes Longview's rights on Cowlitz River.

the Cowlitz River. It has a drainage area of 2,480 square miles or all but 23 square miles of the total Basin area. The Cowlitz River, which has its main source located on Mt. Rainier, flows west through the northern part of the watershed and then flows south with its mouth being located at Kelso on the Columbia River. The average annual flow of the Cowlitz River is approximately 9,400 cfs at Kelso. The flow of the Upper Cowlitz River ranges from 1,632 cfs at Packwood to 9,144 cfs at Castle Rock. The maximum recorded flow at Castle Rock is 13,350 cfs, while the minimum is 4,881 cfs. Major tributaries of the Cowlitz River are the Coweeman River (127 sq. mi.), Toutle River (512 sq. mi.), Olequa Creek (101 sq. mi.), Lacamas Creek (41 sq. mi.), Cispus River (433 sq. mi.), and Tilton River (159 sq. mi.).

The highest runoff is normally during the winter, but a rapid reduction is not reached until after the early summer peak. The period of November through June contains greater than mean annual rate of flow with a reduction during July through October.

A river low flow frequency analysis made by the U.S. Geological Survey, is given for various stations in the Cowlitz Basin. The seven day and 30 day low flows for recurrence intervals of 1.05, 5, 10, and 20 years for six selected stations in the Basin are shown in Table 50.

Quality

Water quality data, obtained from the U.S. Geological Survey, is

Table 50. Low Flow Frequency—Cowlitz Basin

River	Location	Recurrence Interval —Years	7 Day Low Flow —cfs	30 Day Low Flow —cfs
Cowlitz	At Packwood	1.05	600	740
		5	290	380
		10	240	285
		20	195	230
Cowlitz	Near Kosmos	1.05	1,600	1,900
		5	850	1,000
		10	720	860
		20	610	730
Cowlitz	At Mossy-rock	1.05	1,700	1,900
		5	900	1,050
		10	760	910
		20	670	800
Cowlitz	Below Mayfield Dam	1.05	2,000	2,300
		5	1,100	1,250
		10	950	1,100
		20	840	960
Cowlitz	At Castle Rock	1.05	2,750	3,100
		5	1,500	1,700
		10	1,320	1,500
		20	1,170	1,300
Toutle	Near Silver Lake	1.05	580	670
		5	340	380
		10	310	340
		20	290	315

Table 51. Chemical Analysis By Rivers – Cowlitz Basin (From 1959 to 1967)

Item	Flow (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Chloride (Cl)	Sulfate (SO_4)	Fluoride (F)	Bicarbonate (HCO_3)	Nitrate (NO_3)	Diss. Solids	Specific Conductance (μmho)	Orthophosphate (PO_4)	Silica (SiO_2)	Iron (Fe)	pH	Coliform Org. (MPN)	Hardness as CO_3
COWLITZ RIVER NEAR TOLEDO																		
Maximum	–	8.4	1.9	4.6	0.9	4.0	3.2	0.2	36	0.9	60	79	0.05	16.0	0.43	7.8	930	28
Mean	–	6.1	1.1	3.0	0.5	1.6	2.0	0.1	28	0.3	45	54	0.02	13.2	0.19	7.2	127	20
Minimum	–	4.0	0.4	2.0	0	0.2	0	0	19	0	30	36	0	8.8	0.07	6.9	0	12
COWLITZ RIVER NEAR KELSO																		
Maximum	–	8.0	1.9	5.6	0.9	3.2	3.4	0.2	38	0.8	61	80	0.06	17.0	0.56	7.6	930	27
Mean	–	5.7	1.2	3.3	0.5	1.9	2.0	0.1	27	0.3	45	54	0.03	13.9	0.22	7.2	180	19
Minimum	–	3.5	0.5	2.1	0	0.8	0.2	0	18	0	30	36	0	9.1	0.06	6.8	0	11
TOULTE RIVER NEAR CASTLE ROCK																		
Maximum	–	6.5	2.0	7.6	1.5	5.8	4.0	0.2	36	0.7	68	81	0.09	22.0	0.31	7.7	750	23
Mean	–	4.4	1.2	4.4	0.6	3.2	2.0	0.1	25	0.2	47	54	0.04	16.3	0.11	7.2	117	16
Minimum	–	3.0	0.2	2.4	0.1	1.2	0.2	0	15	0	33	33	0	12.0	0.02	6.7	0	10
COWLITZ RIVER NEAR COSMOS																		
Maximum	7,005	8.0	1.7	3.9	0.8	2.0	4.0	0.2	37	0.4	58	72	0.08	18.0	0.37	7.7	360	26
Mean	4,999	6.2	1.0	2.8	0.4	1.1	2.1	0.1	28	0.1	43	53	0.03	13.3	0.13	7.3	65	19
Minimum	3,747	3.5	0.5	1.8	0.1	0.2	0.2	0	18	0	28	31	0	8.1	0.02	6.9	0	11

shown in Table 51. The stations included are, the Cowlitz River at Toledo, Kelso, and Cosmos, and the Toutle River near Castle Rock.

Chemical-Physical. The chemical quality of surface waters in the Cowlitz Basin is generally good. The dissolved solids concentration of the water of most streams averages less than 50 mg/l, with maximum dissolved solids content being generally less than 80 mg/l. Calcium and bicarbonate are the predominate dissolved ions with the hardness of the water generally less than 20 mg/l.

The Cowlitz River is nearly always milky in appearance because of silt associated with the glaciers of Mt. Rainier, Mt. St. Helens, and Mt. Adams, with turbidity of the Cowlitz River ranging from 0 to 85 JTU. Generally, turbidities of other streams in the Basin are low except for short periods of discharge from storm runoff and spring snowmelt.

A salinity study of the Columbia River, made by the Corps of Engineers in 1959 and recently by Oregon State University, indicate that salt water from the ocean tides extends as far as 25 miles upstream from the mouth during periods of low flow. The Longview area is approximately 60 miles upstream, therefore salinity is not expected to be a problem in the foreseeable future.

Bacteriological. The bacteriological quality of the Rivers within the Basin is high, with quality decreasing slightly in the lower reaches of the streams due to increased development. The Most Probable Number of

Coliform organisms per 100 mg (MPN) averages 67 MPN near Cosmos, while downstream near Kelso the average is 178 MPN.

The upper reaches of the streams in the Basin originate in sparsely populated mountainous areas; thus, undue contamination is not expected to occur.

GROUND WATER

The availability of ground water in the Basin is somewhat questionable insofar as a source of sizeable development for community or municipal water supplies. Limited geological studies have been made, with the results of the studies indicating generally low quality and quantity. However, an adequate amount of ground water is available to meet small community and rural-individual use.

Quantity

Capacities of wells located near the urbanized areas are generally limited due to suspected lack of large rechargable underground water basins. Throughout the remainder of the Basin, rural-individual and small community ground water use is extensive and of adequate quantity to meet the small domestic needs projected through the study period.

Quality

The ground water quality in the Basin is generally poor. The water obtained from the wells located near Kelso vary in iron content from

Table 52. Ground Water Quality — Cowlitz Basin

Owner	Location	Depth (ft)	Date	Temp. (°F)	Concentration (mg/l)															Specific Conductance (μmho)	pH
					Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved Solids	Hardness (as CO_3)		
City of Toledo	11/W-8E2	79	8/25/53	52	42.0	0.17	13.0	6.5	12.0	2.0	101	0	1.9	3.0	0.2	0.1	—	126	59	156	7.3
U.S. Government (Forests)	12/7-9Q	66	6/20/58	47	29.0	0.02	12.0	2.4	4.6	0.7	58	0	1.5	2.5	0.1	0.1	—	78	40	98	7.4
L.P. Schwarzkofe	12/2W-10M	100	1/23/53	50	38.0	1.60	6.4	2.8	7.2	1.2	51	0	1.2	2.4	0.1	0.1	—	81	27	87	6.8
C.E. Farr	12/1-9Q1	143	12/2/53	51	7.9	0.14	4.0	3.3	4.9	11.0	16	0	2.5	5.0	0.3	28.0	—	75	24	126	6.6
O.A. Doudonsky	9/2W-27Q	8	4/26/61	50	47.0	0.01	23.0	6.5	8.8	1.4	120	0	2.6	2.2	0.2	0.6	0.82	151	84	193	7.2
E.S. Ashe	9/2W-14SE 1/4	35	1/27/60	44	15.0	0.32	4.0	0.7	2.7	0.4	16	0	1.4	3.0	0.1	1.4	0.04	45	13	44	6.8

Table 53. Chemical Analysis By Water Distribution Systems—Cowlitz Basin

Sillica ($Si\ O_2$)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Sodium (Na)	Potassium (K)	Calcium (Ca)	pH	Conductance (μmho)	Turb. (JTU)	Color (std units)	Odor	Magnesium (Mg)	Free O_2	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Sulfite (SO_3)	Chlorine (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite (NO_2)	Orthophosphate (PO_4)	Total Solids	Total Hardness	$CaCO_3$ Hardness	Noncarbonate Hardness	Calcium Hardness	Magnesium Hardness
KELSO WATER DEPARTMENT—SURFACE																JANUARY 8, 1969												
17.5	–	0.4	–	0.95	1.25	4.8	6.7	52	4	5	–	7.8	–	12.2	–	19.2	–	8.0	1.0	0.62	–	0.03	–	32.0	–	–	–	–
COWLITZ COUNTY PUD NO. 1—LONGVIEW & KELSO																JANUARY 16, 1969												
8.0	–	0.16	–	264	–	7.6	7.3	65	35	2	–	0.73	–	43.9	–	4.9	–	3.0	1.09	0.62	–	0.02	–	22	–	–	–	–
PACKWOOD WATER COMPANY INC.—SURFACE																JULY 15, 1970												
26.6	–	0	–	3.6	1.8	4.4	7.4	54	2.3	8	–	2.7	–	29.3	–	3.5	–	0.25	0.07	0.18	–	0.32	–	22.0	–	–	–	–
MORTON WATER DEPARTMENT—SURFACE																JULY 14, 1970												
16.25	–	0.02	–	3.2	0.51	3.6	7.4	42.5	0.57	15	–	3.2	–	23.2	–	4.9	–	1.0	0.04	0	–	0	–	22.0	–	–	–	–
HIGH VALLEY PARK—WELLS																JULY 13, 1970												
18.4	–	0.24	–	3.5	1.2	8.0	7.58	74	1.7	7	–	2.9	–	40.3	–	6.3	–	0.5	0.09	0.73	–	0	–	32	–	–	–	–
TOLEDO WATER DEPARTMENT—WELLS																JULY 2, 1970												
2.1	–	0.08	–	7.9	1.6	16.4	7.6	123	0.43	15	–	1.7	–	63.4	–	0	–	5.25	0.33	3.9	–	0.17	–	48.0	–	–	–	–

about 0.50 to 36 mg/l.

In order to provide an adequate domestic water supply, treatment must be provided in many cases.

PRESENT AND FUTURE NEEDS

Future water requirements in the basin will be determined by the rate of growth of population, industry, agriculture, and the efficient use of water. Surveys indicate that steady growth of these factors can be expected through the study period. Details of the projected growth to the year 2020 are given in Tables 54 through 58 and Figures 19, 20, and 21.

Water supply appears to be adequate through the year 2020. The total surface water runoff averages about 6,011 mgd, which is over 250 times the projected water use by the year 2020. Most low population density rural regions that are beyond the service area of the major water supply systems have adequate ground and surface water supplies for the year 2020.

PROJECTED POPULATION GROWTH

The projected population in the Cowlitz Basin for the years 1970 through 2020 is shown graphically in Figure 19. The projection indicates that the 1970 population will increase by about 34 percent by the year 2020. The 1970 population of 41,900 is projected to

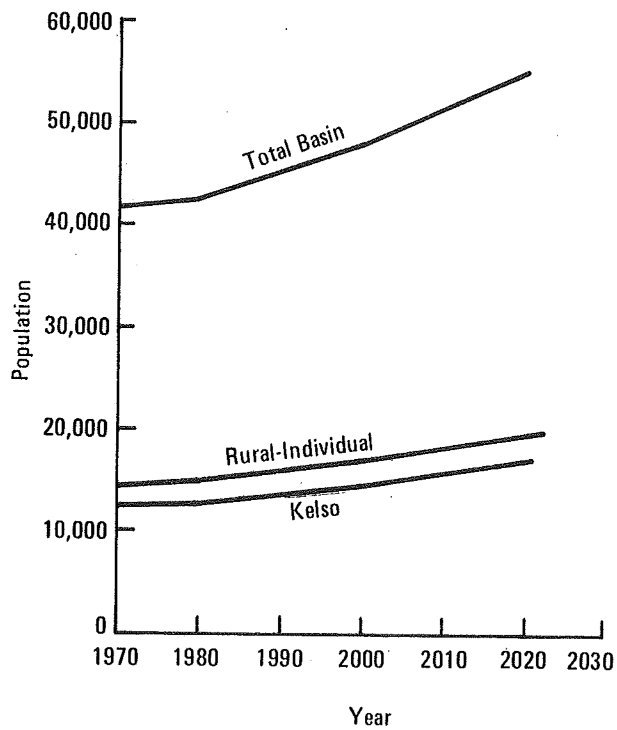


Figure 19. Cowlitz Basin Projected Population

increase to about 56,000 by 2020. The majority of the increase in population is expected to occur in and around the larger urbanized areas.

PROJECTED INDUSTRIAL GROWTH

Industrial water use projections were obtained from the Municipal and Industrial Water Supply Appendix of the Columbia-North Pacific Framework Study. The projections indicate that the present industrial water use of 6.4 mgd will be more than doubled, ultimately to reach an average use of 14.7 mgd by the year 2020, with peak usage projected to be about 16 mgd. Refer to Table 54 for details of the industrial water use through the study period.

PROJECTED WATER REQUIREMENTS

Based on projections of population and industrial growth, it is anticipated that by the year 2020, total basin water requirements will reach approximately 23 mgd, an increase of over 220 percent over present requirements. Figure 20 illustrates total average Municipal use compared to the total Basin water use. Figure 21 illustrates the future water use trends, including average total Basin use, average industrial usage, and average domestic use. See Tables 55, 56, and 57 for itemization of the projected domestic water usage.

Municipal

Municipal water requirements, presently 3.8 mgd, are projected to reach over 8 mgd by the year 2020. Municipal needs will account for

Table 54. Projections of Total Industrial Water Use— Cowlitz Basin (mgd)

Year	Average Daily*	Maximum Monthly
1970	6.4	7.0
1980	9.0	9.8
2000	12.8	13.9
2020	14.7	16.0

Notes:

Projections based on 80% of total industrial water needs being used by wood-related industries.

See footnotes on "1970 Industrial Water Use".

*1970 values based on inventory data. All projections obtained from Appendix XI "M. & I. Water Supply" Columbia-North Pacific Region Comprehensive Framework Study — August 1970.

All figures are rounded.

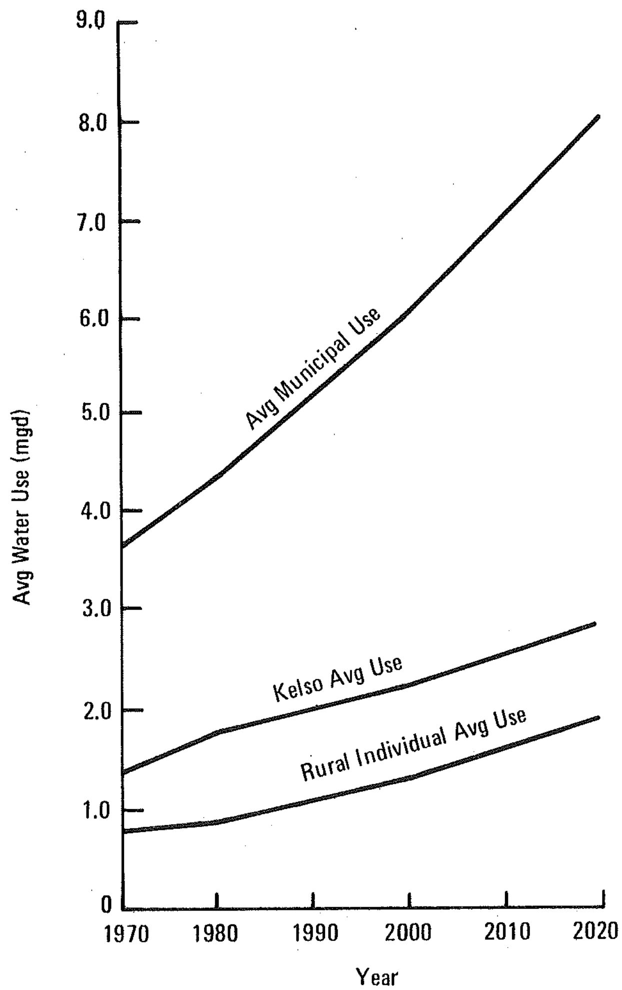


Figure 20. Municipal Water Use Compared to Total Cowlitz Basin Water Use

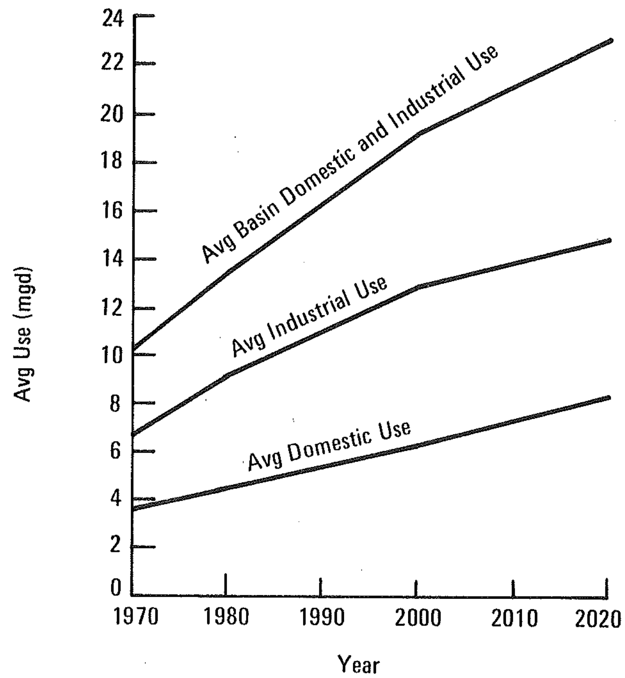


Figure 21. Cowlitz Basin Projected Water Use

Table 55. Municipal and Rural Water Use for 1980 – Cowlitz Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic Average Daily	Max Monthly	Max Daily	Ground Water Use (mgd) Domestic Average Daily	Max Monthly	Max Daily
Kelso	142	12,400	1.76	1.76	2.29	3.16			
Cowlitz County PUD	142	6,600	0.94	0.94	1.22	1.70			
Castle Rock	142	1,600	0.23	0.23	0.30	0.41			
Morton	142	1,270	0.19	0.19	0.25	0.34			
Packwood	142	1,010	0.14	0.14	0.18	0.25			
Mossyrock	142	660	0.09				0.09	0.12	0.16
Toledo	142	660	0.09				0.09	0.12	0.16
Small Rural Communities	60	2,800	0.17	0.02	0.04	0.06	0.15	0.30	0.45
Rural-Individual	60	15,500	0.93				0.93	1.86	2.80
Total		42,500	4.54	3.28	4.28	5.92	1.26	2.40	3.57

Notes: All figures are rounded.
Avg daily = 1.3 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)

Table 56. Municipal and Rural Water Use for 2000 – Cowlitz Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic Average Daily	Max Monthly	Max Daily	Ground Water Use (mgd) Domestic Average Daily	Max Monthly	Max Daily
Kelso	162	14,300	2.32	2.32	3.02	4.17			
Cowlitz County PUD	162	7,600	1.23	1.23	1.60	2.22			
Castle Rock	162	1,900	0.31	0.31	0.40	0.56			
Morton	162	1,500	0.24	0.24	0.31	0.43			
Packwood	162	1,300	0.21	0.21	0.27	0.38			
Mossyrock	162	750	0.12				0.12	0.16	0.22
Toledo	162	750	0.12				0.12	0.16	0.22
Small Rural Communities	80	3,300	0.26	0.03	0.06	0.09	0.23	0.46	0.69
Rural-Individual	80	17,700	1.41				1.41	2.82	4.23
Total		48,400	6.22	4.34	5.66	7.85	1.88	3.60	5.36

Notes: All figures are rounded.
Avg daily = 1.62 (Population served
(Max daily = 1.8 (Avg daily)
(Max monthly = 1.3 (Avg daily)

Table 57. Municipal and Rural Water Use for 2020 – Cowlitz Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Kelso	178	16,600	2.96	2.96	3.85	5.33			
Cowlitz County PUD	178	8,800	1.57	1.57	2.04	2.82			
Castle Rock	178	2,200	0.39	0.39	0.51	0.70			
Morton	178	1,750	0.31	0.31	0.40	0.56			
Packwood	178	1,510	0.25	0.25	0.32	0.45			
Mossyrock	178	870	0.16				0.16	0.21	0.29
Toledo	178	870	0.16				0.16	0.21	0.29
Small Rural Communities	100	3,800	0.38	0.04	0.08	0.12	0.34	0.68	1.02
Rural-Individual	100	19,600	1.96				1.96	3.92	5.88
Total		56,000	8.14	5.52	7.20	9.98	2.62	5.02	7.48

Notes: All figures are rounded.
Avg daily = 1.3 (Population served)
Max daily = 1.8 (Avg daily)
(Max monthly = 1.3 (Avg daily)

about 36 percent of the total Basin water use. Municipal per capita water use is projected to be 142 gallons per day (gpd) by 1980, 162 gpd by 2000, and 178 gpd by 2020. The scale will be used for projecting the water needs for all systems showing a 1970 domestic per capita consumption of 150 gallons per capita per day (gpcd) or less. For the systems showing a domestic per capita use of between 150 and 180 gpcd, the 1970 gpcd figure will be used for the projections with no increase until it matches the above scale. For those systems showing an excessive domestic gpcd figure of over 180 gpcd, it is assumed that their consumption will be reduced to be consistent with the scale by 1980, through increased metering and maintenance of the systems.

Industrial

Industrial consumers are projected to continue to account for about 64 percent of the total Basin water use through 1980. Future water use is projected to increase at a uniform rate until reaching an average daily use of 14.7 mgd by 2020. The major industrial growth is expected to be in the general area near Kelso, along the Columbia River.

Rural-Individual and Small Rural Community Systems

Rural-individual and Small Rural Community water requirements presently average 0.84 mgd or 55 gpcd. By 1980 all water use is projected to be supplied by ground water, and water use is projected to reach about 0.93 mgd., based on 60 gpcd. The per capita consumption is projected to increase uniformly at 1 gpcd per year throughout the study period, with the 2020 average water use reaching about 2 mgd. The increase in per capita consumption is based on a projected increase in irrigation and standard of living.

MEANS TO SATISFY NEEDS

GENERAL

The average daily municipal and industrial water use is projected to reach 22.8 mgd by the year 2020. This is an increase of 12 mgd over the 1970 use. Peak water requirements are projected to be over 33 mgd. Table 61 gives a listing of the system improvements needed in the Basin to provide adequate water to meet the peak demand requirements.

No need for water from outside the Basin is apparent because a plentiful source of surface water is available near the urbanized areas. Due to the high population densities in the Longview-Kelso area and the fact that a complete treatment must be provided for surface water developments, regional water systems and interties should be planned to effectively and adequately accommodate the population densities developing in these areas.

In the future, the major water users are expected to locate around the existing urbanized areas along the Columbia River. The increased municipal water use will be met primarily through expanded surface water development, with industries expanding existing facilities in order to meet their needs. The smaller rural communities in the Basin

Table 58. Cowlitz Basin Water Supply—Present and Future Needs (mgd)

System	Peak Municipal and Industrial Demand			
	1970	1980	2000	2020
Kelso	12,200	12,400	14,300	16,600
Optimum	8.0	8.2	9.4	11.0
Existing	2.6	2.6	8.2	9.4
Needs	—	5.6	1.2	1.6
Cowlitz Co. PUD	6,500	6,600	7,600	8,800
Optimum	4.3	4.35	5.0	5.8
Existing	—	—	4.35	5.0
Needs	—	4.35	0.65	0.8
Other Smaller Systems	7,900	8,000	8,800	11,000
Optimum	5.2	5.25	5.80	7.20
Existing	4.6	4.60	5.25	5.80
Needs	—	0.65	0.55	1.40
Total Needs	—	10.6	2.40	3.8

Notes: Optimum = 1.6 gpm/service plus maximum monthly in industrial use (658 gped); Existing = Plant capacity.
All figures are rounded.

Table 59. Summary of Projected Water Use (mgd) — Cowlitz Basin

System	Date	Population	Surface Water Use		Ground Water Use		Total Use	
			Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly
Municipal	1970	26,600	2.60	3.65	0.38	0.60	2.98	4.25
	1980	27,000	3.28	4.28	0.33	0.54	3.61	
	2000	30,700	4.34	5.66	0.47	0.78	4.81	6.44
	2020	36,400	5.52	7.20	0.66	1.10	6.18	8.30
Individual-Rural	1970	15,300	0.08	0.16	0.76	1.52	0.84	1.68
	1980	15,500	—	—	0.93	1.86	0.93	1.86
	2000	17,700	—	—	1.41	2.82	1.41	2.82
	2020	19,600	—	—	1.96	3.92	1.96	3.92
Total	1970	41,900	2.68	3.81	1.14	2.12	3.82	5.93
	1980	42,500	3.28	4.28	1.26	2.40	4.54	6.68
	2000	48,400	4.34	5.66	1.88	3.60	6.22	9.26
	2020	56,000	5.52	7.20	2.62	5.02	8.14	12.22

Note: All figures are rounded.

are projected to continue using 90 percent ground water to meet their needs.

BASIN PLANS

The projections for future municipal and industrial needs are based on a more efficient use of water with the recognition that it is a valuable resource. To provide for the economical use of the present and future water supplies, it is recommended that all systems incorporate 100 percent metering, also increased maintenance and inspection by the year 1980. Further, in the Longview-Kelso area, population density is such that a regional water system should be considered due to the increased economy of scale. Present trends indicate that a program of more economical and efficient use of water tends to stabilize or reduce the rate of growth in the per capita consumption of water.

Kelso

By the year 1975, Kelso will need to develop additional supply capacity totaling 5.6 mgd to meet the supply requirements of the projected 1980 population, based on the Division of Health's recommendations of providing 1.6 gpm/service, source capacity. In addition, a parallel increase in both storage and distribution capacity must also be accomplished. The increase is recommended to assist in meeting peak residential and industrial demands and fire fighting requirements, based on providing at least one day's storage at peak usage.

Additional improvements of 1.2 mgd and 1.6 mgd in supply development are needed by the years 1990 and 2010 respectively. In addition, parallel developments increasing both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

Surface water supplies are ample and are of good quality, while ground water is considered inadequate in both quantity and quality; therefore, the alternate plans for Kelso both consider the Cowlitz River as the source of supply. The alternatives consider a combined water treatment plant to meet the needs of Longview, Kelso and the PUD, or a smaller single purpose facility to meet the needs of Kelso only.

The combined facility would provide water at a lower cost due to the increased economy of scale involved in the larger combined plant.

The single purpose facility would provide water equal in quality to that of the combined facility. However, the unit cost of building the smaller single purpose treatment plant would be greater.

Cowlitz County PUD

The water supply situation of the PUD is unique in that no sources are owned by the District. Therefore, arrangements must be made with both Kelso and Longview to provide financial assistance for source expansion. By the year 1975, the PUD must have increased its firm source of supply by 4.35 mgd. In addition, storage and distribution

Table 60. Cowlitz Basin Water Supply Capital Improvements

System	Plan Level	Population	Average Annual Use (mgd)	Optimum System Capacity (mgd)	Previous System Capacity (mgd)			Needed Capital Improvements ($ x 10^6/mgd)			Year of Improvements
					Source	Distrib	Storage	Source	Distrib	Storage	
Kelso	exist	12,200	1.41	8.0							
	1980	12,400	1.76	8.2	2.6	2.6	2.6	5.6	+	5.6	1975
	2000	14,300	2.32	9.4	8.2	8.2	8.2	1.2	+	1.2	1990
	2020	16,600	2.96	11.0	9.4	9.4	9.4	1.6	+	1.6	2010
Cowlitz County PUD	exist	6,500	0.47	4.3							
	1980	6,600	0.94	4.35	4.3	4.3	4.3	0.05	+	0.05	1975
	2000	7,600	1.23	5.0	4.35	4.35	4.35	0.65	+	0.65	1990
	2020	8,800	1.57	5.8	5.0	5.0	5.0	0.8	+	0.8	2010
Other Public Water Supplies	exist	7,900	1.10	5.2							
	1980	8,000	0.91	5.25	4.6	4.6	4.6	0.65	+	0.65	1975
	2000	8,800	1.26	5.80	5.25	5.25	5.25	0.55	+	0.55	1990
	2020	11,000	1.65	7.20	5.80	5.80	5.80	1.40	+	1.40	2010

Notes:

1. Optimum System Capacity: Represents 1.6 gpm/ service plus max monthly industrial use.
2. Previous System Capacity: System capacity of the previous plan level.
3. Needed Capital Improvements: Capital improvements needed to meet optimum system capacity.

Table 61. Estimate of Capital Costs for Needed Improvements—Cowlitz Basin

Plan Level	Source GW	Source SW	Development	Year of Devel. (mgd)	Opt. Water Use (mgd)	NEEDED IMPROVEMENT (mgd) Source	Storage	Distrib	CAPITAL COST (millions of dollars) Source	Treat.	Storage	Distrib.	MAINT. & OPER. (millions of dollars) Source	Treat	Total
KELSO															
Present		x	Individual Intake and	existing	8.0										
1980		x	Treatment	1975	8.2	5.6	5.6	+	*	0.95	0.56	0.02	0.006	0.05	
2000		x	" "	1990	9.4	1.2	1.2	+	*	0.25	0.12	0.21	0.002	0.01	
2020		x	" "	2010	11.0	1.6	1.6	+	*	0.34	0.16	0.25	0.002	0.02	
										1.54	0.84	0.48	0.01	0.08	2.95
Alternative															
Present		x	Mutual Source Develop.	existing	8.0										
1980		x	ment with Kelso, Long-	1975	8.2	5.6	5.6	+	*	0.51	0.56	0.02	0.006	0.05	
2000		x	view and Cowlitz Co.	1990	9.4	1.2	1.2	+	*	0.16	0.12	0.21	0.002	0.01	
2020		x	PUD	2010	11.0	1.6	1.6	+	*	0.19	0.16	0.25	0.002	0.02	
										0.86	0.84	0.48	0.01	0.08	2.27
COWLITZ CO.															
PUD-Present		x	Aid in developing a	existing	4.3										
1980		x	source with Longview or	1975	4.35	4.35	4.35	+	*	0.48	0.44	0.03	–	–	
2000		x	Kelso	1990	5.0	5.0	5.0	+	*	0.70	0.50	0.33	–	–	
2020		x	" "	2010	5.8	5.8	5.8	+	*	0.75	0.58	0.40	–	–	
										1.93	1.52	0.76	0.01	0.05	4.27
Alternative															
Present		x	Mutual Source Develop-	existing	4.3	–	–								
1980		x	ment with Cowlitz Co.	1975	4.35	4.35	4.35	+	*	0.39	0.44	0.03	–	–	
2000		x	PUD, Kelso, Longview	1990	5.0	5.0	5.0	+	*	0.65	0.50	0.33	–	–	
2020		x	" "	2010	5.8	5.8	5.8	+	*	0.70	0.58	0.40	–	–	
										1.74	1.52	0.76	0.01	0.05	4.08
Other Public Water Supplies															
Present	x	x	Local G.W. & S.W. use	existing	5.2	–	–								
1980	x	x	" "	1975	5.25	0.65	0.65	+	*	0.02	0.07	0.01	–	–	
2000	x	x	" "	1990	5.8	0.55	0.55	+	*	0.02	0.07	0.09	–	–	
2020	x	x	" "	2010	7.2	1.40	1.40	+	*	0.03	0.08	0.24	–	–	
										0.07	0.22	0.34	0.01	0.01	0.65

*Included in treatment cost.
+Based on population growth.

capacities must be increased by compatible amounts to meet the 1980 optimum requirements.

Additional increases of 0.65 mgd and 0.8 mgd in firm source capacity are needed by the year 1990 and 2010 respectively. In addition, parallel developments increasing both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

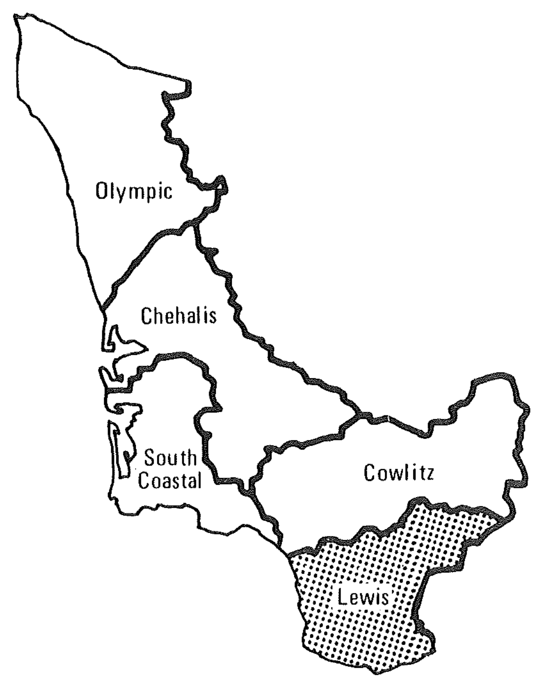
The alternatives to provide supply water for Kelso also apply for the PUD in that it is dependent on the Kelso system. The combined plant would necessitate construction of over two miles of transmission mains by the PUD. However, the PUD's share of the combined plant and the transmission main development is about equal to its share of a smaller plant. An advantage of the combined plant and transmission lines is that the PUD would no longer be dependent on Longview's arterial mains.

Other Public Water Supplies

The Washington State Division of Health's Public Water Supply Facilities Inventory was used to obtain the combined system capacities of the other public water supplies in the Basin. The inventory date indicates a combined existing capacity of 4.6 mgd. By 1975, improvements totaling 0.65 mgd, must be provided to meet the optimum requirements projected for 1980. Additional combined system capacity improvements of 0.55 mgd by 1990 and 1.4 mgd by 2010 will meet the optimum requirements projected for the year 2000 and 2020, respectively.

Presently 55 percent of the water supplied is from surface sources. This percentage was used in determining cost estimates for the future. Surface water developments require complete treatment, raising the initial capital costs over that of ground water developments. Those communities using ground water are projected to continue using that source throughout the study period.

Lewis Basin



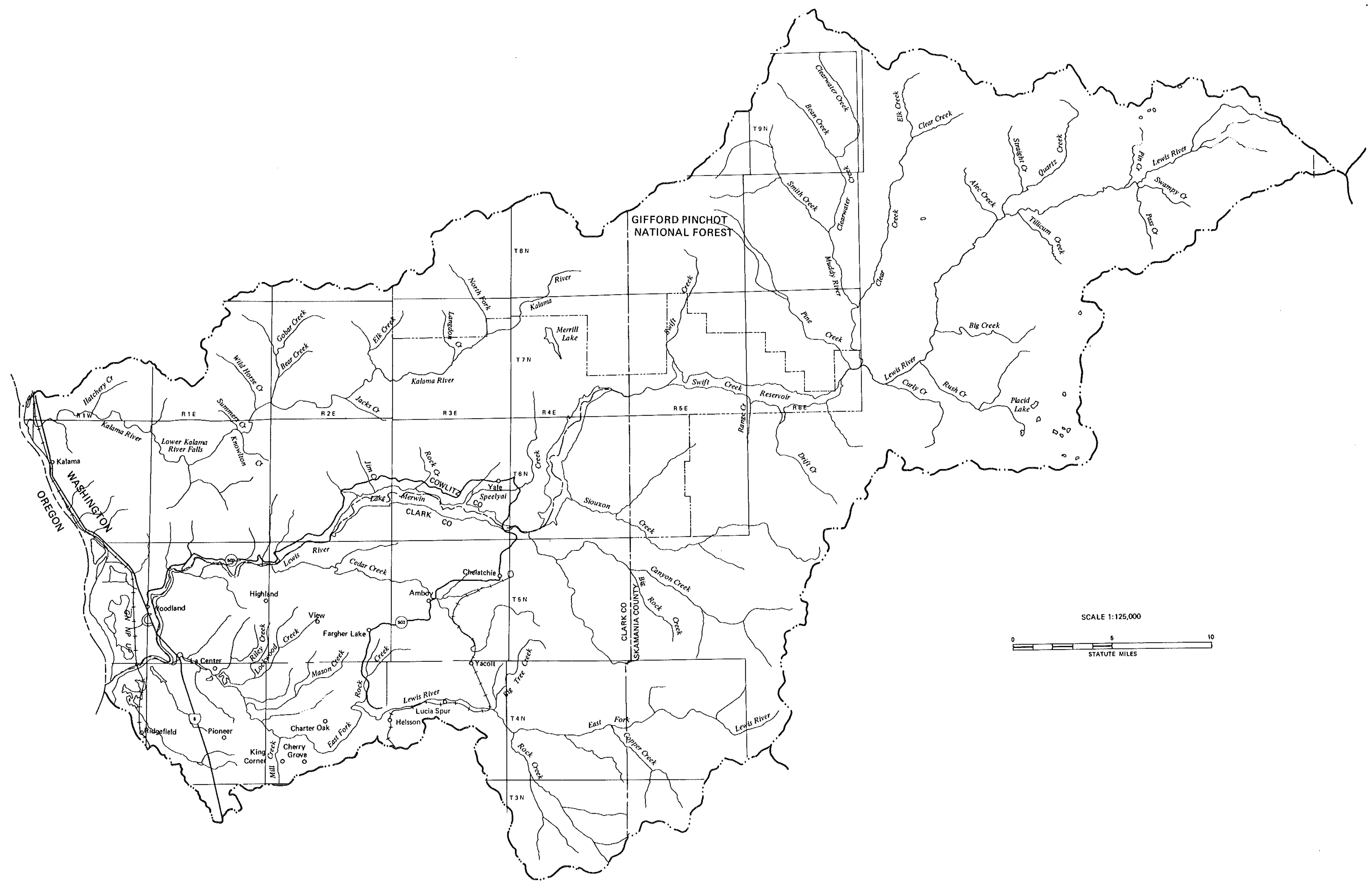


Figure 22. Lewis Basin—Lewis Area, WRIA 27

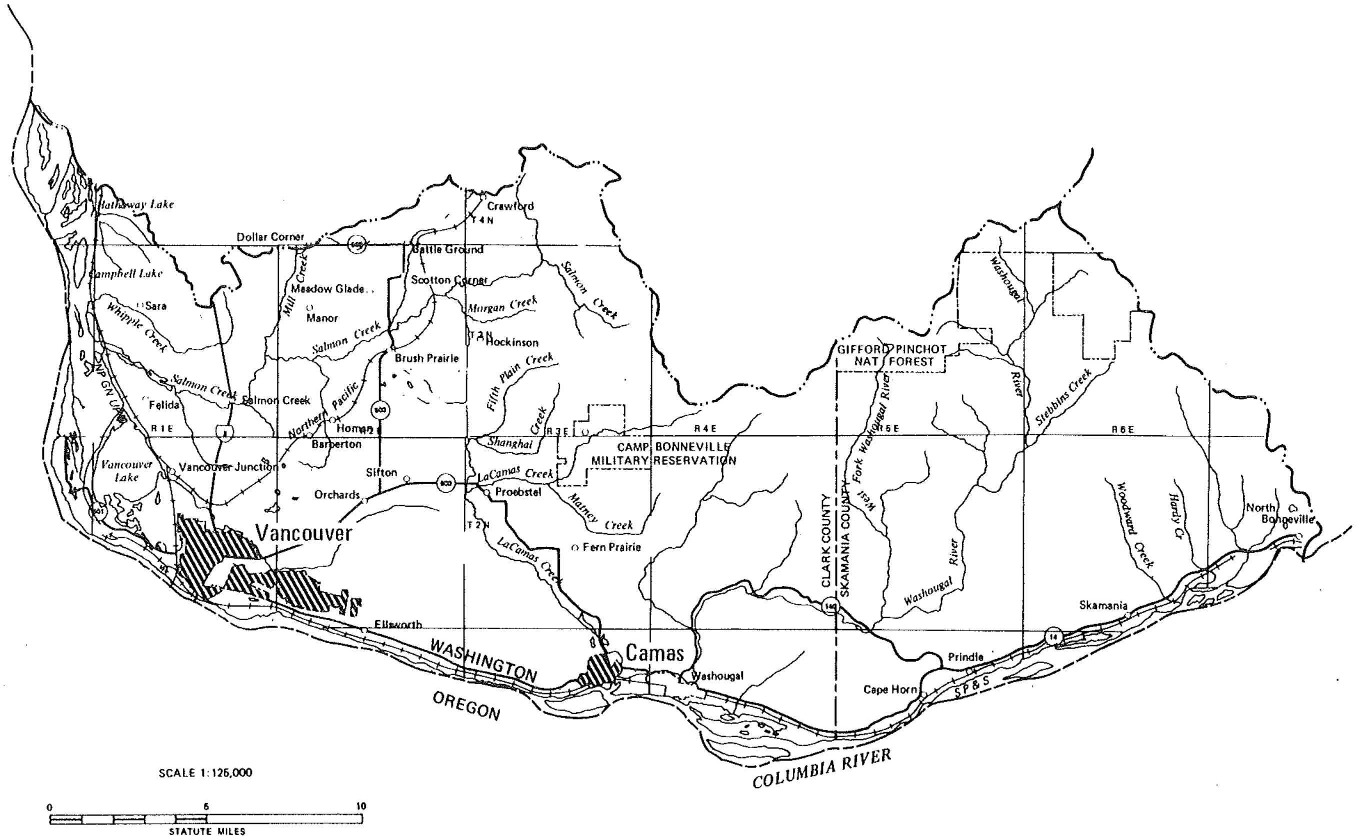


Figure 23. Lewis Basin—Salmon-Washougal Area, WRIA 28

LEWIS BASIN

INTRODUCTION

The Lewis Basin is located in the southwest portion of the State, bordered by the Columbia River to the south and west, the Cowlitz Basin on the north and the Klickitat Basin to the east. The Basin is made of the Kalama, Lewis, Vancouver, and the Wind River-White Salmon watersheds. The Basin occupies over 2,600 square miles in Cowlitz, Clark, and Skamania counties. The Basin is heavily populated and industrialized along the Columbia River. The remainder of the Basin is sparsely populated with economic activity primarily centering around lumbering and agriculture.

The population is projected to nearly double by the year 2020, with most of the growth occurring near the existing population centers. Industrial growth is expected to continue in close proximity to the Columbia River. The development is expected to be primarily based on the pulp and paper industry. Projections indicate that water use will be more than doubled by the year 2020, and will far exceed present water supply system capabilities.

PRESENT STATUS

Present water use is within the supply capabilities of the existing source developments. The major urban areas are located near abundant ground and surface water sources with the potential of supplying many times the peak day municipal and industrial demand.

WATER USE

Total water use in the Lewis Basin presently averages 219 mgd. Of this amount, the domestic use averages about 16 mgd. Industrial water use which makes up the remainder, is over ten times greater than the domestic use. Refer to Table 62 for a listing of basin water use for 1970.

Municipal

The present average municipal water use of over 13 mgd is supplied to a total of 180,500 municipal consumers in the Basin for an average municipal per capita consumption of 120 gpd. Vancouver, the largest user with 6.4 mgd, serves 74,000 persons and has a domestic per capita use of 86 gpd. The Clark County PUD No. 1 uses 2.5 mgd in serving 14,700 persons for a per capita use of 170 gpd. Twelve smaller municipalities use an average of 4.6 mgd, serve 20,700 people and show a per capita water use of 222 gpd.

Industrial

Industrial water use in the Basin averages 184 mgd. The major industrial users are the Crown Zellerbach Plant in Camas with an average daily use of 92 mgd, and the Alcoa Aluminum and Boise Cascade plants in Vancouver with a total average use of 37.8 mgd. Other major pulp and paper, chemical and metal industries use an

Table 62. Municipal and Rural Water Use for 1970 – Lewis Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Vancouver	86	74,000	10.6*				6.36	8.90	11.50
Clark County PUD NO. 1	169	14,700	2.51+				2.48	3.93	4.96
Camas	241	7,600	2.14†	0.9	0.9	0.9	0.83	1.60	2.40
Washougal	288	5,200	1.50				1.50	1.95	3.80
Battle Ground	131	1,450	0.19				0.19	0.24	0.38
Ridgefield	189	1,320	0.25				0.25	0.35	0.75
Meadowglade	92	650	0.06				0.06	0.08	0.10
LaCenter	98	410	0.04				0.04	0.06	0.12
Kalama	113	1,850	0.21	0.21	0.29	0.63			
Woodland	106	1,600	0.17	0.17	0.24	0.30			
Yacolt	62	650	0.04	0.04	0.05	0.07			
Small Rural Communities	55	990	0.05				0.05	0.10	0.15
Rural-Individual	55	27,500	1.51	0.15	0.30	0.45	1.36	2.72	4.08
Total	102	137,900	19.27	1.48	1.78	2.14	13.25	20.20	28.50

Notes: All figures are rounded.
† 90% Domestic use
* 60% Domestic Use
Municipal – Max monthly = 1.4 (Avg daily)
Rural – Max monthly = 2.0 (Avg daily), Max daily = 3.0 (Avg daily)
+ 95% Domestic use

average total of 54.2 mgd. See Table 63 for a listing of the present industrial water use.

Rural-Individual and Small Rural Community Systems

Water use by about 42,800 rural-individual and small rural community consumers is estimated as 2.35 mgd. This is based on an estimated average per capita consumption of 55 gpd.

WATER SUPPLIES

Ground water provides 47 percent of the average daily municipal, industrial, and rural-individual water requirements of the Basin. Surface water provides the remaining 53 percent.

MUNICIPAL

Ground water is used to supply eight municipal systems including the three major systems of Vancouver, Clark County PUD, and Camas. Surface water is used by several small municipal systems, including Kalama, Woodland and Yacolt.

Vancouver

The Vancouver municipal water system supplies an average of 10.6 mgd. to 74,000 persons. Of this amount, the domestic use averages about 60 percent of the total, for an average domestic per capita use of 86 gpd. The remaining 40 percent is supplied to local industries for sanitary, drinking and small industrial water needs, bringing the total average

Table 63. Lewis Basin Industrial Water Use for 1970 (mgd)

Name	Type	Source	Avg. Daily	Max. Monthly	Max. Daily
Crown Z. Camas	Pulp and Paper	Columbia River	92.0	101	115
Alcoa Vancouver	Alum. Red	Wells	16.0	16.0	20.0
Boise Cascade Vancouver	Pulp and Paper	Wells	21.8	24.0	27.2
FMC Corp. Vancouver	Chemical	Wells	14.0	14.0	17.5
Dow Chemical Co. Kalama	Chemical	Columbia River	11.6	11.6	14.5
Great Western Vancouver	Metal	City Wells	4.1	4.1	5.1
Others	Assume Wood Rel.	Wells	24.5	27.0	30.7
Total			184.0	197.7	230.0

Notes: Chemical and metal industries; average daily = maximum monthly wood-related industries; maximum monthly = 1.10 (average daily). All figures are rounded.

per capita use to 143 gpd.

Vancouver obtains its water supply from 16 wells and the Ellsworth Springs, with a total combined capacity of 37.8 mgd, which is three times the average daily usage. The Vancouver water system is composed of four main pressure levels within its distribution network with a combined storage capacity of over 17.6 million gallons.

Camas

The Camas water system serves water to both of the major industries in the area for nonproduction use, as well as the 7,600 municipal consumers. The average total water use is 2.14 mgd. Of this total, 90 percent or 1.83 mgd is used by the municipal consumers for a per capita use of 241 gpd.

The water supply for the City of Camas comes from both surface water and ground water sources. The surface water supply originates in the watersheds of Boulder Creek and Jones Creek, two upland tributaries of the Little Washougal River. The combined firm source capacity of the two creeks is 2.3 mgd.

The ground water is obtained from four wells with a combined production rate of 5.2 mgd.

During the winter, the surface water source is capable of providing 1.8

mgd which is the hydraulic capacity of the pipeline. In the summer high use period, the combined usable stream flow drops to approximately 0.9 mgd. In addition, the available ground water production drops to about 4.8 mgd, giving a combined firm water source capacity of 5.7 mgd during dry periods.

The surface water supply is piped about 5.3 miles to the Lacamas Lake Filtration Plant rated at 1.8 mgd. After treatment, the water flows to the Prune Hill Reservoir, with total storage capacity of approximately 1.8 million gallons.

Clark County PUD No. 1

The PUD provides about 14,700 persons with an average of 2.51 mgd for an average per capita usage of 169 gpd. The District serves approximately 10 square miles of the suburban and rural area in the Hazel Dell area north of the City of Vancouver.

The water supply is obtained from a system of nine wells located in the service area, with a combined capacity of 6.8 mgd. Of the nine wells, six are provided with chlorine treatment. Storage totals approximately 1.4 million gallons.

Other Public Water Supplies

Eleven smaller municipal water supplies provide an average of 2.46 mgd to 13,100 people for an average of 188 gpcd. Of this total seven of the systems use ground water, providing 9,000 people with 2.04 mgd.

INDUSTRIAL

The largest individual water users are the Crown Zellerbach plant in Camas and the Boise Cascade pulp and paper mill in Vancouver, requiring 92.0 and 21.8 mgd, respectively. Other important industrial water users are the Alcoa and FMC Corporation Plants in Vancouver, with water use averaging 16 mgd and 14 mgd, respectively. Privately owned ground water sources are generally used by the industries, however, the Crown Zellerbach mill obtains about two-thirds of its water supply from LaCamas Lake. Water for sanitary, drinking and other small nonproduction uses is supplied by the Vancouver and Camas systems to the industries in the respective areas.

RURAL-INDIVIDUAL

An estimated 41,900 persons obtain water from about 1,400 individual systems. It is estimated that 90 percent of these systems are supplied by ground water.

WATER RIGHTS

The recorded ground water rights in the Basin total over 428 cfs, with the City of Vancouver having water rights for 33.2 cfs. Camas has rights for 5.64 cfs, and Clark County PUD No. 1 has water rights for 12.5 cfs. The remainder of the ground water rights in the Basin are allocated primarily for industrial or individual domestic purposes.

Surface water rights in the Basin total 10,539 cfs. About 90 percent of the surface water rights are allocated to power generation and industrial use. The largest water rights within the basin are on the Lewis River, associated with the three major dams, Swift Dam with rights for 2,600 cfs. Yale Dam with 3,000 cfs, and Ariel Dam with 4,000 cfs. The amount of surface water yet available without conflict is adequate to meet the Basin's municipal and industrial water needs throughout the study period.

Surface and ground water rights applications, permits, and certificates for municipal, industrial and domestic water supply and irrigation purposes as of September 30, 1966, in the Lewis Basin are summarized in Table 64.

WATER RESOURCES

Water resources in the Lewis Basin are capable of supplying all demands for Municipal and Industrial water in the foreseeable future. The water is generally of good quality for domestic and industrial uses.

SURFACE WATER

Surface water resources are more than adequate to provide a plentiful supply of water to the basin, even under the most adverse conditions.

Quantity

The entire basin is drained by the Columbia River and its tributaries.

Table 64. Water Rights (cfs)—Lewis Basin

Type	Municipal	Individual and Community Domestic	Industrial and Commercial	Totals
Surface	251.86	144.45	10,142.26	10,538.57
Ground	47.55	183.20	198.00	428.75
Total	299.41	327.65	10,340.26	10,967.32

Notes:

Municipal: Municipal Supplies, Fish Propagation, Stock (game birds), Fire Protection, Recreation.

Individual and Community Domestic: Single Domestic, Stock (undefined), Irrigation (undefined, lawn, garden), Domestic/ Private Contractor.

Industrial and Commercial: Irrigation (cranberry farming), Heat Exchange, Railway, Power Generation, Stock (dairying), Industrial, Commercial(undefined).

The Columbia serves as a control for movement of the water in the Basin. All surface streams discharge into it, and it is base level for ground water so that any ground water leaving the Basin does so by discharging into the Columbia River or its tributaries. In some areas, particularly Vancouver-Camas, the Columbia River water recharges the aquifers bordering the river.

The principal tributaries in the Basin are the Lewis, Kalama and Washougal Rivers. The Lewis River drains the mountains in the eastern portion of the Basin. The principal water use is for power generation with practically no withdrawals from the river. The average discharge half a mile below Ariel Dam, about 19 miles from the mouth of the river, is about 4,700 cfs. The Kalama River originates in the northeastern portion of the Basin and flows westerly through the northern part of the Basin before emptying into the Columbia River. It has a drainage area of 205 square miles, with an average discharge of 1,090 cfs near Kalama. The Washougal River heads in the foothills in the southeastern portion of the Basin and enters the Columbia River at Camas. Average flow at the station 8.5 miles upstream from the mouth of the river is nearly 900 cfs.

The precipitation storage by the glacial activity and extensive snowfields on Mt. Adams and Mt. St. Helens is responsible for leveling out the flow from the Basin. The discharge during the period of November through June exceeds the mean annual rate of flow with the low flow period occurring during July through October. The average total discharge of the rivers in the Basin is estimated at 9400 cfs.

A river low flow frequency analysis made by the U.S. Geological Survey is given for various stations within the Lewis Basin. The seven-day and thirty-day flows for recurrence intervals of 1.05, 5, 10 and 20 years for five selected stations in the Basin are shown in Table 65.

Quality

Water quality data was obtained from the U.S. Geological Survey for selected rivers and sites in the Lewis Basin. The data includes stations on the Lewis River at Ariel and Woodland and on the Washougal River near Washougal. In addition a station exists above Kalama on the Kalama River. Table 66 gives a detailed listing of the results of the tests over a period of eight years from 1959 to 1967.

Chemical-Phyical. The surface water available for municipal and industrial purposes is generally of good to excellent quality. However, turbidity and suspended sediment problems dictate that the water receive complete treatment for all domestic and some industrial uses.

All of the streams contain few dissolved minerals. With the exception of the main stem of the Columbia River, the dissolved solids concentration of the water of most streams averages less than 40 mg/l, and the average hardness is usually less than 15 mg/l depicting

Table 65. Low Flow Frequency—Lewis Basin

River	Location	Recurrence Interval —Years	7 Day Low Flow —cfs	30 Day Low Flow —cfs
Lewis	Trout Lake	1.05	160	190
		5	96	110
		10	81	94
		20	67.5	79
Lewis	Above Muddy R. near Cougar	1.05	400	450
		5	260	285
		10	240	260
		20	220	240
Lewis	Near Cougar	1.05	950	1,100
		5	685	720
		10	620	670
		20	570	630
Lewis	Near Amboy	1.05	1,250	1,400
		5	840	910
		10	780	850
		20	780	810
Lewis	At Ariel	1.05	1,200	1,500
		5	725	860
		10	670	770
		20	625	710
Washougal	Near Washougal	1.05	103	130
		5	51.0	58
		10	47	53
		20	44	50
Panther Creek	Near Carson	1.05	74	81
		5	49	52
		10	46.5	49.5
		20	45	47.5

Table 66. Chemical Analysis By Rivers – Lewis Basin (From 1959 to 1967)

Item	Flow (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Chloride (Cl)	Sulfate (SO_4)	Fluoride (F)	Bicarbonate (HCO_3)	Nitrate (NO_3)	Diss. Solids	Specific Conductance (μmho)	Orthophosphate (PO_4)	Silica ($Si\ O_2$)	Iron (Fe)	pH	Coliform Org. (MPN)	Hardness as CO_3
LEWIS RIVER AT ARIEL																		
Maximum	7,065	4.5	0.7	2.5	0.7	1.2	1.6	0.2	20	0.2	38	40	0.03	15.0	0.8	7.4	36	12
Mean	4,789	3.8	0.5	2.2	0.4	1.0	1.2	0.1	19	0.1	32	36	0.01	13.9	0.5	6.9	3	11
Minimum	2,840	3.5	0.2	1.9	0.2	0.5	0.8	0	18	0	29	33	0	12.0	0.1	6.5	0	10
LEWIS RIVER AT WOODLAND																		
Maximum	–	4.5	1.6	3.1	1.0	2.5	1.8	0.2	23	0.8	40	48	0.04	15.0	0.33	7.5	930	16
Mean	–	3.8	0.8	2.7	0.5	1.6	0.9	0.1	20	0.2	35	39	0.02	13.4	0.11	7.1	160	13
Minimum	–	3.0	0.3	2.2	0.1	0.5	0	0	16	0	27	32	0	12.0	0.05	6.7	0	10
WASHOUGAL RIVER NEAR WASHOUGAL																		
Maximum	1,139	3.5	1.1	2.6	0.7	1.5	2.4	0.1	22	1.6	38	42	0.06	13.0	0.15	7.6	930	13
Mean	871	2.4	0.5	1.8	0.3	1.0	0.7	0	14	0.3	25	27	0.03	9.8	0.06	7.0	386	9
Minimum	659	1.6	0	1.4	0	0.5	0	0	9	0.1	20	20	0.01	7.5	0	6.3	0	6
KALAMA RIVER ABOVE KALAMA																		
Maximum	1,704	7.0	1.5	4.7	0.7	4.2	2.0	0.2	28	1.3	54	66	0.09	20.0	0.18	7.6	11,000	
Mean	1,176	4.6	0.9	3.2	0.4	2.6	0.6	0.1	22	0.5	42	47	0.04	15.6	0.08	7.2	664	
Minimum	712	3.5	0.2	2.0	0.1	1.2	0	0	16	0	31	33	0	12.2	0.01	6.8	0	

soft and corrosive water qualities. Calcium and bicarbonate are the predominate dissolved ions. The maximum dissolved solids content is usually less than 60 mg/l. The main stem of the Columbia River shows relatively little variation in chemical quality, with the dissolved solids content since 1958 ranging from approximately 70 to 160 mg/l.

The average dissolved oxygen concentration in the streams in the Basin is high, with an average of 10.8 mg/l in the Lewis River and 11.2 mg/l in the Kalama River. The average turbidities of the rivers, excluding the Columbia, is generally under five units, with a maximum of 20 units recorded on the Lewis River.

A salinity study of the Columbia River made by the Corps of Engineers in 1959, and recently by Oregon State University indicate that salt water from the ocean tides extends as far as 23 miles upstream from the mouth during periods of low flow. However, the Basin is approximately 80 miles upstream, with the Vancouver area approximately 95 miles upstream. It is therefore, not anticipated the salinity will be a problem in the foreseeable future unless substantial diversions are made from the Columbia River.

Bacteriological. Observed coliform densities indicate that levels are generally low; however, the main stem of the Columbia River exhibits bacterial concentrations well above the recommended limit of 200 MPN for water contact recreation. On the Lewis River, the MPN ranges from an average of 3 at Ariel to 930 at Woodland, while on the Kalama

River near Kalama, the average MPN is 723.

GROUND WATER

There are substantial ground water resources in the Lewis Basin favorably situated with respect to the major population and industrial areas.

Quantity

The ground water resources can be divided into two general classes; first, induced river infiltration areas in the lowlands along the Columbia and Lewis Rivers, and second, precipitation recharge areas in the upland plains and in the Troutdale Bench.

The largest source of ground water presently used is from induced river infiltration in the lowland area along the Columbia River, extending from below Vancouver to above Washougal. In a 7 or 8 mile strip adjacent to the river including the Vancouver shoreland, there is an extensive highly permeable aquifer in hydraulic contact with the Columbia River. Based on surveys and confirmation by the U.S. Geological Survey, the aquifer has a potential capacity of approximately 50 to 100 mgd per mile of frontage along the river. At the present time, about 60 mgd is pumped from this strip for industrial and municipal supply, leaving a large potential source of supply. In the vicinity of Camas and Washougal, a similar six-mile stretch may have a potential yield of at least several hundred million gallons per day, based on the U.S. Geological

Survey report. Approximately 40 million gallons per day are used in this area at the present time.

In the upland plains area, recharge is derived chiefly from precipitation that falls on the area, with some additional recharge obtained from the adjacent mountains to the east and north. By studying the relationship between stream flow and precipitation and observing the discharge in the numerous springs between Vancouver and Prune Hill, it has been estimated by Robinson, Roberts and Associates, ground water geologists, that about 105,000 acre feet of precipitation per year reach the deeper aquifers. This is equivalent to about 720,000 gallons per day per square mile, or a total of over 100 million gallons per day. At the present time, about 20 mgd is used for irrigation and domestic supplies.

In the remainder of the Basin, primarily sparsely populated hill and mountain areas, the aquifers underlying the area generally do not yield large amounts of water. However, wells with capacity of up to 1.15 mgd have been recorded in this area, with other smaller wells showing an adequate amount to meet small domestic needs.

Quality

The quality of ground water in the Lewis Basin is generally of good to excellent quality for most uses. The concentration of dissolved solids usually is less than 150 mg/l. The water is primarily of the calcium magnesium bicarbonate type and generally is soft or only moderately hard with a range of from 14 to 66 mg/l as $CaCO_3$ with high iron content being the most common ground water quality problem encountered. For a listing of the chemical quality of various wells in the Basin, see Table 67.

PRESENT AND FUTURE NEEDS

GENERAL

Future water requirements in the Basin will be determined primarily by the rate of growth of population, industry, agriculture, and the efficient use of water. Surveys indicate that a steady growth of these factors can be expected through the study period. Details of this growth, projected to the year 2020, are given in Tables 69 through 72 and Figures 24 and 25.

Some reports based on data presented in the U.S. Geological Survey report have been misleadingly optimistic about the abundance and availability of ground water reserves in the Basin. Recent experience in the Greater Vancouver area indicates that considerable field study is yet needed to both document the status of existing ground water resources and research the location and quantity of remaining ground water resources. This information is especially needed in the upland plains area of the Basin (Clark County PUD area and northward) before a sound decision can be made regarding whether future needs can be met through further development of local ground water resources,

Table 67. Ground Water Quality — Lewis Basin

Owner	Location	Depth (ft)	Date	Temp. (°F)	Concentration (mg/l)															Specific Conductance (μmho)	pH
					Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved Solids	Hardness (as CO_3)		
Crown Zellerbach	1/3/-11G5	123	1/27/60	45	14.0	0	3.5	1.2	1.6	0.6	19	0	1.2	1.0	0	0.6	0.06	33	14	41	6.9
City of Vancouver Well No. 3	2/1-23Q3	280	9/7/55	–	47.0	0.03	7.7	5.3	5.3	4.1	70	0	8.8	3.5	0.1	12.0	–	145	64	168	7.0
City of Vancouver (Spring)	2/2-334S	–	5/17/49	50	50.0	0.2	15.0	5.2	4.2	5.6	64	0	11.0	2.9	0.2	7.2	–	129	59	140	–
Lloyd Webb	4/2-20A1	71	6/2/60	55	39.0	2.1	6.5	1.8	5.0	0.8	40	0	0.6	0.8	0.1	0.5	0.01	77	24	72	6.3
U.S. Government (U.S.F.S.)	5/3-12P	195	3/19/58	53	27.0	0.18	9.4	1.8	4.4	0.5	48	0	0.6	2.0	0.1	0.3	–	67	31	83	7.2
Jerry Peterson	5/1W-22R	34	4/26/61	55	41.0	0.13	15.0	6.8	5.8	2.1	75	0	10.0	2.2	0.2	3.4	0.01	134	66	158	6.5
U.S. Government (U.S.F.S.)	4/7-4	176	8/8/60	–	4.9	4.6	8.0	1.7	1.3	0.6	39	0	3.8	9.0	0.1	0	–	70	27	114	9.3
U.S. Government (U.S.F.S.)	7/6-26	312	8/25/59	47	43.0	0.24	8.0	2.3	8.6	2.1	56	0	1.8	2.8	0.1	0.3	–	93	30	102	7.1

Table 68. Chemical Analysis By Water Distribution Systems—Lewis Basin

Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Sodium (Na)	Potassium (K)	Calcium (Ca)	pH	Conductance (µmho)	Turb. (JTU)	Color (std units)	Odor	Magnesium (Mg)	Free O_2	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Sulfite (SO_3)	Chlorine (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite (NO_2)	Orthophosphate (PO_4)	Total Solids	Total Hardness	$CaCO_3$ Hardness	Noncarbonate Hardness	Calcium Hardness	Magnesium Hardness
VANCOUVER WATER DEPARTMENT—WELL-SPRING																JANUARY 18, 1969												
12.5	–	0.26	–	3.1	6.44	18.4	7.2	182	2.5	2	–	5.3	–	73.2	–	12.4	–	7.0	0.26	12.2	–	0.11	–	68	–	–	–	–
CLARK COUNTY PUD NO. 1—WELL (Sample No. 5)																JANUARY 15, 1969												
42.5	–	0.38	0	5.8	4.2	32.7	7.5	138	1.0	3	–	9.7	–	–	–	0.5	–	4.0	0.22	0	0	0.42	166	122	–	–	–	–
BATTLE GROUND WATER SYSTEM—WELLS																DECEMBER 2, 1968												
15	–	0.32	–	4.7	3.12	23.2	7.4	188	1.5	5	–	7.3	–	142	–	0.10	–	1.5	0.74	5.85	–	0.14	–	88	–	–	–	–
CAMAS WATER SYSTEM—WELLS, SURFACE																DECEMBER 10, 1968												
8.6	–	0.02	–	6.03	1.1	5.6	7.0	55	2	4	–	2.4	–	37.0	–	3.1	–	4.0	1.1	0.04	–	0.11	–	50	–	–	–	–
WASHOUGAL WATER DEPARTMENT—WELLS																DECEMBER 6, 1968												
25	–	0.33	–	2.8	4.6	12	6.8	126	3	5	–	4.4	–	44.0	–	4.8	–	3.5	0.05	7.3	–	0.22	–	48	–	–	–	–
YACOLT WATER DEPARTMENT—SURFACE																FEBRUARY 15, 1965												
24	–	0.08	–	–	–	2.8	7.1	190	4	2	–	1.0	–	11.5	–	0.03	–	1.3	0.31	0.89	–	0.03	–	30	–	–	–	–
KALAMA WATER DEPARTMENT—SURFACE																JANUARY 20, 1969												
10	–	6.2	–	0.80	0.71	6.4	6.7	66	4	25	–	4.4	–	29.3	–	4.1	–	2.5	0.72	1.2	–	0.04	–	34	–	–	–	–
WOODLAND WATER DEPARTMENT—SPRING																NOVEMBER 15, 1963												
36.4	–	0.03	–	2.6	0.62	11.8	7.4	127	2	2	–	5.2	–	81.0	–	1.3	–	2.4	0.02	0.66	–	0.2	88.2	59	–	–	–	–
WOODLAND WATER DEPARTMENT—SURFACE																NOVEMBER 15, 1963												
24	–	0.10	–	11.3	0.88	11.1	7.0	158	13	12	–	2.3	–	81.3	–	19.5	–	1.5	0.18	0.52	–	0.2	99	44	–	–	–	–

additional development of regional ground water resources with transmission water source short areas, or new development of surface sources which would include complete treatment.

PROJECTED POPULATION GROWTH

The projected population in the Lewis Basin for the years 1970 through 2020 is shown graphically in Figure 24. This projection indicates a steady growth for the period of 1970 through 2020. The 1970 population of 137,900 is projected to increase to 214,400 by 2020, for about 55 percent growth during the study period. The majority of the anticipated increase in population is expected to occur in and around the existing urban areas along the Columbia River.

PROJECTED INDUSTRIAL GROWTH

Industrial water use projections were obtained from the Municipal and Industrial Water Supply Appendix of the Columbia-North Pacific Framework study. The projections indicate that the present industrial water use of 184 mgd will be more than doubled to reach an average use of 382 mgd by the year 2020, with peak industrial water use projected to be 413 mgd. See Table 69 for details of the industrial water use through the study period.

PROJECTED WATER REQUIREMENTS

Based on projections of population and industrial growth, it is anticipated that by the year 2020, total basin water requirements

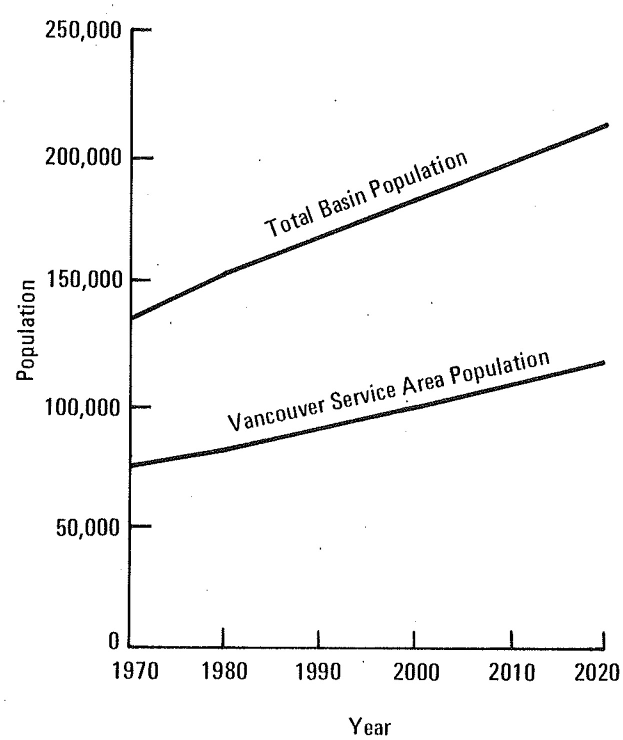


Figure 24. Population Projection — Lewis Basin

**Table 69. Projections of Total Industrial Water Use—
Lewis Basin (mgd)**

Year	Average Daily*	Maximum Monthly
1970	184	198
1980	233	251
2000	333	360
2020	382	413

Notes:

Projections based on 80% of total industrial water needs being used by wood-related industries.

See footnotes on "1970 Industrial Water Use".

*1970 values based on inventory data. All projections obtained from Appendix XI "M. & I. Water Supply" Columbia-North Pacific Region Comprehensive Framework Study — August 1970.

All figures are rounded.

will reach approximately 412 mgd, doubling present requirements. Figure 25 illustrates total average municipal use compared to the total basin water use. Figure 25 also illustrates the future water use trends, including average total basin use, average industrial usage, and average domestic use. See Tables 70, 71, and 72 for itemization of the projected water usage by systems and rural use.

Municipal

Municipal water requirements, presently 13.2 mgd, are projected to reach 30 mgd by the year 2020. Municipal needs will account for over 7 percent of the total basin water use.

Average municipal per capita water use is projected to be 142 gallons per day (gpd) by 1980, 162 gpd by 2000, and 278 gpd by 2020. This scale is used for projecting the water needs for all systems showing a 1970 domestic per capita consumption of 150 gallons per capita per day (gpcd) or less. For the systems showing a 1970 domestic per capita use of between 150 and 180 gpcd, the 1970 gpcd figure will be used for the projections with no increase, until it matches the above scale. For those systems showing an excessive domestic gpcd figure of over 180 gpcd, it is assumed that their consumption will be reduced to be consistent with the scale by 1980, through increased metering and maintenance of the systems.

Industrial

Industrial consumers are expected to continue to be the major water

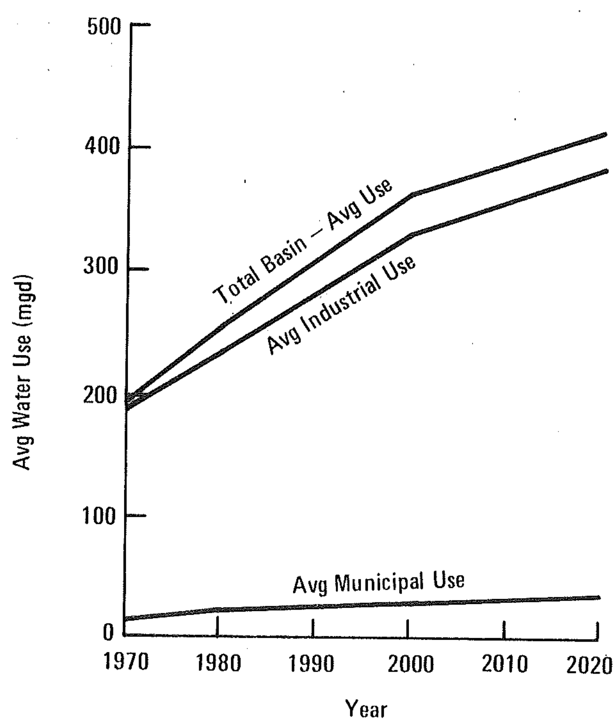


Figure 25. Lewis Basin Projected Water Use

Table 70. Municipal and Rural Water Use for 1980 — Lewis Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic Average Daily	Surface Water Use (mgd) Domestic Max Monthly	Surface Water Use (mgd) Domestic Max Daily	Ground Water Use (mgd) Domestic Average Daily	Ground Water Use (mgd) Domestic Max Monthly	Ground Water Use (mgd) Domestic Max Daily
Vancouver*	142	81,400	19.30				11.60	15.00	20.80
Clark County PUD No. 1*	169	16,100	2.74				2.61	3.38	4.70
Camas*	142	8,300	1.32				1.19	1.54	2.14
Washougal	142	5,700	0.81				0.81	1.06	1.46
Battle Ground	142	1,600	0.23				0.23	0.29	0.40
Ridgefield	142	1,450	0.21				0.21	0.27	0.37
Meadowglade	142	720	0.10				0.10	0.13	0.18
LaCenter	142	450	0.07				0.07	0.09	0.12
Kalama	142	2,420	0.33	0.33	0.44	0.60			
Woodland	142	1,760	0.25	0.25	0.33	0.45			
Yacolt	142	720	0.10	0.10	0.13	0.18			
Small Rural Communities	60	1,080	0.08				0.08	0.15	0.23
Rural-Individual	60	30,100	1.81				1.81	3.62	5.43
Total	125	151,800	27.35	0.68	0.90	1.23	18.71	25.53	35.83

Notes: All figures are rounded.
Avg daily = 1.3 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)
*% of Domestic Use based on 1970 data.

Table 71. Municipal and Rural Water Use for 2000 – Lewis Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Vancouver*	162	99,100	26.60				15.90	20.60	28.60
Clark County PUD No. 1*	170	19,600	3.34				3.17	4.14	5.71
Camas *	162	10,100	1.83				1.64	2.12	2.95
Washougal	162	10,100	1.12				1.12	1.46	2.02
Battle Ground	162	1,950	0.31				0.31	0.41	0.56
Ridgefield	162	1,760	0.29				0.29	0.37	0.51
Meadowglade	162	880	0.14				0.14	0.19	0.25
LaCenter	162	550	0.09				0.09	0.11	0.16
Kalama	162	2,900	0.46	0.46	0.60	0.82			
Woodland	162	2,150	0.35	0.35	0.45	0.61			
Yacolt	162	860	0.14	0.14	0.19	0.25			
Small Rural Communities	80	1,300	0.14				0.14	0.28	0.42
Rural-Individual	80	36,700	2.94				2.94	5.86	8.80
Total		184,700	37.75	0.95	1.24	1.69	26.74	35.54	49.98

Notes: All figures are rounded.
Avg daily = 1.62 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)
*% of Domestic Use based on 1970 data.

Table 72. Municipal and Rural Water Use for 2020 – Lewis Basin

System	Qty (gpcd)	Population Served	Avg. Uses Industrial and Domestic (mgd)	Surface Water Use (mgd) Domestic			Ground Water Use (mgd) Domestic		
				Average Daily	Max Monthly	Max Daily	Average Daily	Max Monthly	Max Daily
Vancouver*	178	115,000	34.20				20.50	26.60	36.90
Clark County PUD No. 1*	178	22,700	4.25				4.04	5.25	7.26
Camas*	178	11,800	2.31				2.08	2.70	3.74
Washougal	178	8,050	1.43				1.43	1.86	2.57
Battle Ground	178	2,260	0.40				0.40	0.52	0.72
Ridgefield	178	2,050	0.36				0.36	0.47	0.65
Meadowglade	178	1,020	0.18				0.18	0.23	0.32
LaCenter	178	650	0.14				0.14	0.18	0.25
Kalama	178	3,360	0.60	0.60	0.78	1.08			
Woodland	178	2,500	0.45	0.45	0.59	0.81			
Yacolt	178	1,000	0.17	0.17	0.22	0.31			
Small Rural Communities	100	1,510	0.15				0.15	0.30	0.45
Rural-Individual	100	42,500	4.25				4.25	8.50	12.75
Total		214,400	48.89	1.22	1.59	2.40	33.51	46.61	65.61

Notes: All figures are rounded.
Avg daily = 1.78 (Population served)
Max daily = 1.8 (Avg daily)
Max monthly = 1.3 (Avg daily)
*% of Domestic Use based on 1970 data.

users in the Basin, and by the year 2020 are projected to comprise over 90 percent of the total Basin water use. The present industrial water use of 184 mgd is projected to reach 382 mgd by the year 2020. With the anticipated industrial growth expected to develop around the existing industrial centers along the Columbia River, the increased water need is projected to be supplied about equally by ground and surface water developments, owned by the industries.

Rural-Individual and Small Rural Community Systems

Rural-Individual and Small Rural Community water requirements presently average 2.3 mgd or 55 gpcd. By 1980 all water use is projected to be supplied by ground water, and water use is projected to reach about 1.8 mgd, based on 60 gpcd. The per capita consumption is projected to increase uniformly at 1 gpcd per year throughout the study period, with the 2020 average water use reaching 4.3 mgd. The increase in per capita consumption is based on a projected increase in irrigation and standard of living.

MEANS TO SATISFY NEEDS

GENERAL

The average daily municipal and industrial water use is projected to reach 417 mgd by the year 2020. This is an increase of about 213 mgd over the 1970 use. Peak water requirements are projected to be over 461 mgd. Table 73 gives a listing of the system improvements needed in the Basin, to provide adequate water to meet the peak

Table 73. Lewis Basin Water Supply—Present and Future Needs (mgd)

System	Peak Municipal and Industrial Demand			
	1970	1980	2000	2020
Vancouver	74,000	81,400	99,100	115,000
Optimum	27.0	60.7	73.4	88.9
Existing	35.8	35.8	60.7	73.4
Needs	—	24.9	12.7	15.5
Camas	7,600	8,300	10,100	11,800
Optimum	5.31	5.66	6.81	7.76
Existing	5.7	5.7	5.7	6.81
Needs	—	—	1.1	0.95
Clark Co. PUD No. 1	14,700	16,100	19,600	22,700
Optimum	6.0	10.7	12.9	14.9
Existing	6.1	6.1	10.7	12.9
Needs	—	4.6	2.2	2.0
Other Smaller Systems	14,700	15,900	19,200	23,200
Optimum	9.65	10.1	12.7	15.3
Existing	14.31	14.3	14.3	14.3
Needs	—	—	—	1.0
Total Needs	—	29.5	16.0	19.43

Notes: Optimum = 1.6 gpm/service plus maximum monthly industrial use (658 gped); Existing = Plant capacity. All figures are rounded.

Table 74. Summary of Projected Water Use (mgd) — Lewis Basin

System	Date	Population	Surface Water Use		Ground Water Use		Total Use	
			Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly	Avg. Daily	Max. Monthly
Municipal	1970	110,400	1.34	1.48	11.89	17.48	13.23	18.96
	1980	121,700	0.68	0.90	16.90	21.91	17.58	22.81
	2000	148,000	0.95	1.24	23.80	29.68	24.75	30.92
	2020	171,900	1.22	1.59	29.26	38.11	30.48	39.70
Individual-Rural	1970	27,500	0.15	0.30	1.36	2.72	1.51	3.02
	1980	30,100	—	—	1.81	3.62	1.81	3.62
	2000	36,700	—	—	2.94	5.86	2.94	5.86
	2020	42,500	—	—	4.25	8.50	4.25	8.50
Total	1970	137,900	1.49	1.78	13.25	20.20	14.74	21.98
	1980	151,800	0.68	0.90	18.71	25.53	19.39	26.43
	2000	184,700	0.95	1.24	26.74	35.54	27.69	36.78
	2020	214,400	1.22	1.59	33.51	46.61	34.73	48.20

Note: All figures are rounded.

demand requirements.

In the future, the major water users are projected to locate around the existing urbanized areas along the Columbia River.

BASIN PLANS

The City of Vancouver and Clark County PUD No. 1 will supply over 50 percent of the Basin's domestic requirements. The majority of the smaller rural communities are projected to continue using ground water as their source of supply. Self supplied industry using equal amounts of ground and surface water will continue to require over 90 percent of the Basin water requirements. This need should be met through expansion of existing facilities.

The projections for future needs are based on a more efficient use of water with the recognition that it is a valuable resource. To provide for the economical use of the present and future water supplies, it is recommended that all systems incorporate 100 percent metering and increased maintenance by the year 1980. Further, in the Greater Vancouver, Camas and Washougal areas, regional water systems and interties should be planned to efficiently and adequately accommodate the population densities developing in these areas. Present trends indicate that a program of more economical and efficient use of water tends to stabilize or reduce the per capita consumption of water.

Vancouver

By the year 1975, Vancouver will need to add new sources of supply totaling 24.9 mgd to meet the source requirements of the projected 1980 population based on the Division of Health's recommendations of providing 1.6 gpm per service of source capacity. In addition, a parallel increase in both storage and distribution capacity must be provided in order to assist in meeting peak residential demands and fire fighting requirements, based on providing at least one day's storage at peak usage.

Additional improvements of 12.7 mgd and 15.5 mgd in source development are needed by the years 1990 and 2010, respectively. In addition, parallel developments increasing both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

Alternate plans listed in the following table assume either further local ground water development or a surface water development utilizing the Columbia River to meet the projected water requirements through the study period.

Ground water availability in the Vancouver area has been good. The lower initial cost of ground water development would provide the most economical source of high quality water, if adequate future supplies can be obtained.

An adequate amount of surface water is available from the nearby

Columbia River. However, the initial surface water development must provide for complete treatment, thereby raising the initial cost considerably beyond that of the ground water development cost.

Clark County PUD No. 1

The local water supply situation of Clark County PUD No. 1 is somewhat different from that of Vancouver. Recent ground water exploratory work has indicated that the availability of adequate supplies is spotty, pointing toward the need for better documentation of the ground water resources in this region.

Also, the PUD serves a suburban area with little industrial water demand, and the cost of distribution improvements per service is higher due to the reduced density of population.

By the year 1975, additional source development of 4.6 mgd must be provided to meet projected optimum capacity for 1980. In addition, both storage and distribution capacity must be increased by a similar amount.

Additional improvements of 2.2 and 2.7 mgd in source development are needed by the years 1990 and 2010, respectively. In addition, parallel developments increasing both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

Basin water plans considered to meet the projected water needs are based on either further ground water development or surface water development using the Lewis River if ground water reserves are insufficient.

Studies indicate that the potential ground water available along the Columbia River is adequate to meet the water requirements throughout the study period. The water from along the Columbia River would be obtained from essentially sea level elevation and would have to be pumped to all water areas. However, this plan is capable of providing an abundant high quality source of supply without the need for complete treatment.

The development of the local ground water would provide good quality water, while the initial development costs would be low as compared to a surface water development.

The Lewis River development would provide an adequate source of water to meet the requirements of the county for the foreseeable future. In addition, once such a development is initiated, it can be expanded to meet all projected needs. Two alternate development plans for the Lewis River have been proposed. One would consist of a 40-mile aqueduct system from Swift Reservoir. This would be an all-gravity system. The other plan calls for 30 miles of aqueduct from Yale Reservoir.
The plan would necessitate pumping the water against a 200-foot head. Further, complete treatment must be provided for either plan.

In order to make this an economically feasible project, it would be necessary to construct a large aqueduct system, one with a capacity of 100 mgd or greater. This is more than three times the peak requirement of all municipal water systems in the Basin.

Unit cost data from the R. W. Beck and Associates report dated June 1966 indicates that ground water development would be the least expensive alternative.

Camas

Except for scale, the water supply situation of the City of Camas is similar to that of Vancouver. By the year 1975, increases in supply capacity of 0.2 mgd with parallel improvements in distribution and storage capcities are needed to provide the projected 1980 optimum system capacity requirements.

Additional improvements of 1.1 and 1.5 mgd in source development are needed by the years 1990 and 2010, respectively. In addition, parallel improvements increasing both distribution and storage capacities must be provided to meet the optimum system capacity requirements projected for the year 2020.

Water plans to meet the projected growth consider either utilizing the existing sources of supply, with augmentation by means of drilling new wells, or the installation of a Ranney collector on the Columbia River.

Ground water is of adequate quality and quantity to meet the future needs of the Camas area. However, a well testing program should be initiated to test the potential for well locations in the East Camas area. The advantages of lower first costs, increased pumping reliability by relying on several locations rather than one, and higher quality water would be realized.

The Ranney collector would provide an adequate supply of water using river infiltration. However, a higher initial cost for development, and the greater possibility of contamination exists.

Other Public Water Supplies

Studies of the Washington State Division of Health's Public Water Supply Facilities Inventory were used to obtain the combined plant capacity of the other public water supplies in the Basin. The inventory data indicated plant capacities available to meet the future peak needs of the systems.

However, based on engineering studies and the continuing need for general upgrading of existing water systems, it is estimated that on a Basin wide level, increased source developments totaling about 2 mgd will be needed by smaller water systems to meet the optimum system capacities projected for the year 2020. Parallel developments increasing and improving storage and distribution capacities by a similar amount will be needed to meet the anticipated optimum requirements through the study period.

Due to the availability of good quality ground water throughout the communities of Washougal, Battle Ground, Ridgefield and LaCenter, it is throught that ground water will be adequate for the foreseeable future.

The City of Yacolt in the northern part of Clark County now obtains its supply from surface water sources. Ground water availability is unknown in the Yacolt area. Since the State Board of Health regulations require that complete treatment of the surface source be provided if it is to be continued in use, it is recommended due to possible dollar savings that ground availability be explored and used if adequate.

Table 75. Lewis Basin Water Supply Capital Improvements

System	Plan Level	Population	Average Annual Use (mgd)	Optimum System Capacity (mgd)	Previous System Capacity (mgd)			Needed Capital Improvements ($ x 10^6/mgd)			Year of Improvements
					Source	Distrib	Storage	Source	Distrib	Storage	
Vancouver	exist	74,000	10.6	27.0	–			–		–	–
	1980	81,400	19.3	60.7	35.8	35.8	35.8	24.9	+	24.9	1975
	2000	99,100	26.6	73.4	60.7	60.7	60.7	12.7	+	12.7	1990
	2020	115,000	34.2	88.9	73.4	73.4	73.4	15.5	+	15.5	2010
Clark County PUD No. 1	exist	14,700	2.51	6.0	–			–		–	–
	1980	16,100	2.74	10.7	6.1	6.1	6.1	4.6	+	4.6	1975
	2000	19,600	3.34	12.9	10.7	10.7	10.7	2.2	+	2.2	1990
	2020	22,700	4.25	15.6	12.9	12.9	12.9	2.7	+	2.7	2010
Camas	exist	7,600	2.14	5.31	–			–		–	–
	1980	8,300	1.32	5.7	5.5*	5.5	5.5	0.2	+	0.2	1975
	2000	10,100	1.83	6.8	5.7	5.7	5.7	1.1	+	1.1	1990
	2020	11,800	2.31	8.3	6.8	6.8	6.8	1.5	+	1.5	2010
Other Public Water Supplies	exist	14,100	2.51	9.26	–			–	–	–	–
	1980	15,900	2.18	10.5	14.3	14.3	14.3	–	+	–	–
	2000	19,200	3.04	12.6	14.3	14.3	14.3	–	+	–	–
	2020	23,200	3.88	15.3	14.3	14.3	14.3	1.0	+	1.0	2010

Notes:

1. Optimum System Capacity: Represents 1.6 gpm/service plus max monthly industrial use.
2. Previous System Capacity: System capacity of the previous plan level.
3. Needed Capital Improvements: Capital improvements needed to meet optimum system capacity.

* Firm water at the source.

\+ Based on population growth.

Table 76. Estimate of Capital Costs for Needed Improvements—Lewis Basin

Plan Level	Source GW	Source SW	Development	Year of Devel. (mgd)	Opt. Water Use (mgd)	NEEDED IMPROVEMENT (mgd) Source	Storage	Distrib.	CAPITAL COST (millions of dollars) Source	Treat.	Storage	Distrib.	MAINT. & OPER. (millions of dollars) Source	Treat.	Total
VANCOUVER															
Present	x		Local G.W. Development	existing	27.0	–	–	–	–	–	–	–	–	–	
1980	x		" "	1975	60.7	24.9	24.9	+	1.60	0.06	2.49	0.81	0.03	0.005	
2000	x		" "	1990	73.4	12.7	12.7	+	0.86	0.03	1.27	1.40	0.03	0.004	
2020	x		" "	2010	88.9	15.5	15.5	+	1.05	0.03	1.55	1.71	0.04	0.005	
									3.51	0.12	5.31	3.92	0.10	0.01	12.97
Alternative															
Present	x		Local G.W. Development	existing	27.0	–	–	–	–	–	–	–	–	–	
1980			Intake & Treat. Columbia	1975	60.7	24.9	24.9	+	*	2.0	2.49	0.81	0.01	0.09	
2000			R.	1990	73.4	12.7	12.7	+	*	1.53	1.27	1.40	0.01	0.09	
2020			" "	2010	88.9	15.5	15.5	+	*	1.70	1.55	1.71	0.01	0.11	
										5.23	5.31	3.92	0.03	0.29	14.78
CLARK CO. PUD NO. 1															
Present	x		Local G.W. Development	existing	6.0	–	–	–	–	–	–	–	–	–	
1980	x		" "	1975	10.7	4.6	4.6	+	0.31	0.001	0.46	0.50	0.002	0.000	
2000	x		" "	1990	12.9	2.2	2.2	+	0.15	0.000	0.22	1.12	0.003	0.001	
2020	x		" "	2010	15.6	2.7	2.7	+	0.18	0.001	0.27	1.35	0.005	0.001	
									0.64	0.00	0.95	2.97	0.01	0.000	4.57
Alternative															
Present	x		Local G.W. Development	existing	6.0	–	–	–	–	–	–	–	–	–	
1980		x	Intake & Treat. Lewis R.	1975	10.7	4.6	4.6	+	6.34	0.83	0.46	0.50	0.002	0.001	
2000		x	" "	1990	12.9	2.2	2.2	+	–	0.44	0.22	1.12	0.003	0.013	
2020		x	" "	2010	15.6	2.7	2.7	+	–	0.54	0.27	1.35	0.003	0.015	
									6.34	1.81	0.95	2.97	0.01	0.03	12.11
CAMAS															
Present	x	x	Local G.W. and S.W.	existing	5.3	–	–	–	–	–	–	–	–	–	
1980	x		Local G.W. Development	1975	5.7	0.2	0.2	+	0.014	0.000	0.02	0.09	0.000	0.000	
2000	x		" "	1990	6.8	1.1	1.1	+	0.075	0.002	0.11	0.18	0.002	0.000	
2020	x		" "	2010	8.3	1.5	1.5	+	0.102	0.003	0.15	0.20	0.005	0.000	
									0.19	0.01	0.28	0.47	0.01	0.000	0.96
CAMAS															
Present	x	x	Local G.W. and S.W. (6.4 mgd)	existing	5.3	–	–	–	–	–	–	–	–	–	
1980	x		Ranney Collector,	1975	5.7	0.02	0.02	+	0.65	0.012	0.02	0.09	0.012	0.000	
2000	x		Columbia	1990	6.8	1.1	1.1	+	–	–	0.11	0.18	0.014	0.000	
2020	x		" "	2010	8.3	1.5	1.5	+	0.20	0.004	0.15	0.20	0.018	0.000	
									0.85	0.016	0.28	0.47	0.044	0.000	1.66
Other Public Water Supplies	80%	20%													
Present	x	x	Local G. & S. Water	existing	9.3	–	–	–	–	–	–	–	–	–	
1980	x	x	" "	1975	10.5	–	–	+	–	–	–	–	–	–	
2000	x	x	" "	1990	12.6	1.0	1.0	+	0.07	–	0.10	0.72	–	–	
2020	x	x	" "	2010	15.3	1.0	1.0	+	0.06	0.03	0.10	0.90	–	–	
									0.13	0.03	0.20	1.62			1.98

*Included in treatment cost.
†Based on population growth.

Glossary

GLOSSARY

ACRE-FOOT (ac-ft.). – A unit commonly used for measuring the volume of water or sediment; equal to the quantity of water required to cover one acre to a depth of one foot and equal to 43,560 cubic feet or 325,851 gallons.

ALLUVIUM – Soil material, such as sand, silt, or clay, that has been deposited by water.

AQUIFER – A rock formation, bed, or zone containing water that is available to wells. An aquifer may be referred to as a water-bearing formation or water-bearing bed.

ARTESIAN WATER – Ground water under sufficient pressure to rise above the level at which the water-bearing bed is reached in a well. The pressure in such an aquifer commonly is called artesian pressure, and the rock containing artesian water is an artesian aquifer.

BASE FLOW See Base Runoff

BASE RUNOFF Sustained or fair weather runoff. In most streams, base runoff is composed largely of ground water effluent. The term base flow is often used in the same sense as base runoff. However, the distinction is the same as that between streamflow and runoff. When the concept in the terms base flow and base runoff is that of the natural flow in a stream, base runoff is the logical term.

BASIN A geographic area drained by a single major stream.

cfs (Cubic Foot per Second) – A unit of discharge for measurement of flowing liquid equal to a flow of one cubic foot per second past a given section. Also called second-foot.

CAPITAL EXPENDITURES Outlays for plant and equipment which are normally charged to fixed asset accounts.

CHANNEL STORAGE The volume of water at a given time in the channel or over the flood plain of the streams in a drainage basin or river reach. Channel storage is sometimes significant during the progress of a flood event.

CHLORINATION – The application of chlorine to water, sewage, or industrial wastes generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

COLIFORM BACTERIA – A species of genus escherichia bacteria, normal inhabitant of the intestine of man and all vertebrates.

CONSTRUCTION COST – The total cost of construction, including real estate, engineering, design, administration and supervision.

CONSUMPTIVE USE – The quantity of water discharged to the atmosphere or incorporated in the products in the process of vegetative growth, food processing, industrial processes, or other use. Hence, the amount of water no longer directly available.

CONSUMPTIVE USE IRRIGATION – All withdrawals are considered to be consumptive unless the full amount of the withdrawal is returned to the source.

COOLING WATER CONSUMPTION (POWER) – The cooling water which is lost to the atmosphere, caused primarily by evaporation due to the temperature rise in the cooling water as it passes through the condenser. The amount of consumption (loss) is dependent on the type of cooling employed – flow-through, cooling ponds, or cooling tower.

COOLING WATER LOAD – Heat energy dissipated by the cooling water.

COOLING WATER REQUIRED (POWER) – The amount of water needed to pass through the condensing unit in order to condense the steam to water.

CORRELATION – The process of establishing a relation between two or more related variables. It is a simple correlation if there is only one independent variable; multiple correlation if there is more than one independent variable.

CUBIC FEET PER SECOND PER DAY (cfs-day) – The volume of water represented by a flow of one cubic foot per second for 24 hours. It equals 86,400 cubic feet, 1.983471 acre-feet, or 646,317 gallons.

CUBIC FEET PER SECOND (cfs)– A unit expressing rate of discharge. One cubic foot per second is equal to the discharge of a stream having a cross section of one square foot and flowing at an average velocity of one foot per second. It also equals a rate of 448.8 gallons per minute.

DO (Dissolved Oxygen) – The oxygen dissolved in sewage water or other liquid, usually expressed in milligrams per liter or percent of saturation.

DEMAND–A need or desire. (Differs from the usual economic definition of demand under which a need is not necessarily reflected in a demand).

DISCHARGE – In its simplest concept, discharge means outflow; therefore, the use of this term is not restricted as to course or location and it can be used to describe the flow of water from a pipe or a drainage basin.

DISCHARGE, AVERAGE – The arithmetic average of the annual discharges for all complete water years of record whether or not they are consecutive. The term "average" is generally reserved for average of record and "mean" is used for averages of shorter periods; namely, daily mean discharge.

DIVERSION – The taking of water from a stream or other body of water into a canal, pipe, or other conduit.

DRAINAGE AREA – The drainage area of a stream, measured in a horizontal plane, which is enclosed by a drainage divide.

DRAINAGE BASIN – A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

DRAINAGE DIVIDE – The line of highest elevations which separates adjoining drainage basins.

DRAWDOWN (GROUND WATER) – The depression or decline of the water level in a pumped well or in nearby wells caused by pumping. It is the vertical distance between the static and the pumping level at the well.

DROUGHT – A period of deficient precipitation or runoff extending over an indefinite number of days, but with no set standard by which to determine the amount of deficiency needed to constitute a drought. Thus, there is no universally accepted quantitative definition of drought; generally, each investigator establishes his own definition.

ECONOMIC BASE STUDY – A study which evaluates the economic structure of the region to provide economic projections necessary for the appraisal of future water resource needs.

EFFECTIVE PRECIPITATION – That part of the precipitation falling on a crop area that is effective in meeting the consumptive use requirements of the crop.

EUTROPHICATION – The process of overfertilization of a body of water by nutrients which produce more organic matter than the self-purification processes can overcome.

FARM–A area operated as a unit of ten or more acres from which the sale of agricultural products totaled $50 or more annually, or an area operated as a unit of less than ten acres from which the sale of agricultural products total $250 or more annually during the previous year.

FLOOD – Any relatively high streamflow or an overflow or inundation that comes from a river or other body of water and causes or threatens damage.

FLOOD PEAK – The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge. Flood crest has nearly the same meaning but, since it connotes the top of the flood wave, it is properly used only in referring to stage.

FLOOD PLAIN – A strip of relatively smooth land bordering a stream that has been or is subject to flooding. It is called a "living" flood plain if it is overflowed in times of high water, but a "fossil" flood plain if it is beyond the reach of the highest flood.

FLOOD, PROBABLE MAXIMUM – The largest flood for which there is any reasonable expectancy in the geographical region involved.

FLOOD STAGE – The stage at which overflow of the natural banks of a stream begins to cause damage in the reach in which the stage is observed.

FLOWING WELL – An artesian well having sufficient head to discharge water above the land surface.

FOREST LAND – Land which is at least 10 percent stocked by forest trees of any size and land from which the trees have been removed to less than 10 percent stocking but which has not been developed for other use.

gpcd – Gallons per capita per day.

gpd – Gallons per day.

GAGING STATION – A particular site on a stream, canal, lake or reservoir where systematic observations of gage height or discharge are obtained.

GAGING STATION NUMBER An eight-digit number assigned to a gaging station which identifies the station in downstream order relative to other gaging stations and sites where streamflow data are collected. The first two digits designate the major drainage basin, the others the station.

GROUND (GW)—Water in the ground that is in the zone of saturation from which wells, springs and ground water runoff are supplied.

GROUND WATER OUTFLOW – That part of the discharge from a drainage basin that occurs through the ground water. The term "underflow" is often used to describe the ground water outflow that takes place in valley alluvium (instead of the surface channel) and thus is not measured at a gaging station.

HARDNESS – A characteristic of water; chiefly due to the existence there-in of the carbonates and sulfates and occasionally nitrates and chlorides of calcium, iron, and magnesium; which causes "curdling" of the water when soap is used, increased consumption of soap, deposition of scale in boilers, injurious effects in some industrial processes, and sometimes objectionable taste in the water. It is commonly computed from the amounts of calcium and magnesium in the water and expressed as equivalent calcium carbonate.

HYDROGEN ION CONCENTRATION – The weight of hydrogen ions in grams per liter of solution. Commonly expressed as the pH value that represents the logarithm of the reciprocal of the hydrogen ion concentration.

INDUSTRIAL WATER – The industrial category includes those major water-using industries whose size is related to a significantly larger population than that of the local area and whose water needs are normally supplied through a municipal distribution system. For the purposes of this analysis, these industries are the following:

Pulp and paper
Other major forest products
Food processing
Petroleum processing
Primary metals
Thermal and nuclear power

INFILTRATION – The flow of the fluid into a substance through pores or small openings. It connotes flow into a substance in contradistinction to the word percolation, which connotes flow through a porous substance.

INFILTRATION CAPACITY – The maximum rate at which the soil, when in a given condition, can absorb falling rain or melting snow.

INTERCEPTION (HYDROLOGY)—The process of storing rain or snow on leaves and branches or other objects which eventually evaporates back to the air.

JTU (Jackson Turbidity Units) – The JTU, as the name implies, is a measurement of the turbidity, or lack of transparency, of water. It is measured by lighting a candle under a cylindrical transparent glass tube and then pouring a sample of water into the tube until an observer looking from the top of the tube cannot see the image of the candle flame. The number of JTU's varies inversely with the height of the sample (e.g. a sample which measures 2.3 cm has a turbidity of 1,000 JTU's whereas a sample measuring 72.9 cm has a turbidity of 25 JTU's.)

LAND AREA – The solid portion of the earth's surface including bodies of water less than 40 acres and streams of less than 1/8 mile wide.

LAND USE – Primary occupier of a tract of land grouped into classes with similar characteristics, i.e., cropland, rangeland, forest land, or other.

LOW FLOW FREQUENCY CURVE – A graph showing the magnitude and frequency of minimum flows for a period of given length. Frequency is usually expressed as the average interval, in years, between recurrences of an annual minimum flow equal to, or less than that shown by the magnitude scale.

mgd – Millions of gallons per day.

mg/l – Milligrams pper liter.

MPN (Most probable number) – In the testing of bacterial density by the dilution method, that number of organisms per unit volume which, in accordance with statistical theory, would be more likely than any other possible number to yield the observed test result or which would yield the observed test result with the greatest frequency. Expressed as density of organisms per 100 ml.

MAXIMUM WATER SURFACE (RESERVOIR) – The maximum water surface elevation is the highest water surface elevation for which the dam is designed. It is also the top of the surcharge capacity.

MUNICIPAL WATER – The municipal category includes not only urban domestic water use but also those other civic, commercial, and small industrial uses which are typically supplied through a municipal distribution system and the magnitude of which is related to local population.

NEED–The lack of something usefull, required, or desired; the lack of water or water system facilities also adaptions and betterments and improvements.

NON–CONSUMPTIVE. Non-consumptive uses related to surface water only, are where no water is divereted from the confines of the surface water source area or channel, where the waters pass over, under, around or through an on stream project, or when being diverted (effectively) at the upstream edge of a project and being returned (effectively) to the channel at the downstream edge of project. It is considered non-consumptive water use when water diverted from a surface water source is returned to the same source at any location upstream from the point of diversion. Transportation losses, evaporation, seepage, are not considered consumptive.

NORMAL ANNUAL PRECIPITATION – Average annual precipitation during the base period, 1931-1960 inclusive.

OPERATION AND MAINTENANCE COSTS – Average annual costs of project operation and normal maintenance.

OPTIMUM WATER REQUIREMENT – 658 gallons per capita per day plus maximum monthly industrial water use.

pH – See Hydrogen ion concentration.

PARTIALLY CONSUMPTIVE. The use is partially consumptive when, in the case of surface water, the diverted water is returned to the source 25 feet or more downstream. Partially consumptive for ground water is the condition when the full amount withdrawn is returned to the same source aquifer(s).

PEAK – The maximum water used in a stated period of time. Usually it is the maximum amount experienced over an interval of a year, month, week, or day. It is used interchangeably with peak demand.

PERCOLATION – The movement, under hydrostatic pressure, of water through the interstices of a rock or soil.

PRECIPITATION As used in hydrology, precipitation is the discharge of water, in the liquid or solid state, out of the atmosphere, generally upon a land or water surface. It is the common process by which atmospheric water becomes surface or subsurface water. The term "precipitation" is also commonly used to designate the quantity of water that is precipitated.

RAINFALL – The quantity of water that falls as rain. Not synonymous with precipitation.

RECHARGE (GROUND WATER) – The addition of water to the zone of saturation. Infiltration of precipitation and its movement to the water table is one form of natural recharge; injection of water into an aquifer through wells is one form of artificial recharge.

RECURRENCE INTERVAL – The average number of years within which a given event will be equaled or exceeded.

RESERVOIR – A pond, lake or basin, either natural or artificial, for the storage, regulation, and control of water.

RESERVOIR, RE-REGULATING – A reservoir used to regulate the outflow from an upstream reservoir.

RESERVOIR, SINGLE-PURPOSE – A reservoir planned to serve only one purpose.

RIPARIAN – Pertaining to the banks of streams, lakes or tidewater.

RIVER REACH – Any defined length of a river.

RUNOFF – That part of rainfall or other precipitation that reaches watercourses or drainage systems.

RUNOFF, ADJUSTED MEAN ANNUAL – Average annual runoff adjusted for length of record by comparison with record at pivot stations.

RURAL POPULATION–All population not classed as urban (Rural population is divided into rural farm and rural nonfarm population.)

SALINITY – The relative concentration of salts, usually sodium chloride, in a given water sample. It is usually expressed in terms of the number of parts per thousand of chlorine (Cl). Parts per thousand = o/oo.

SEDIMENT – Fragmental or clastic mineral particles derived from soil, alluvial, and rock materials by processes of erosion; and transported by water, wind, ice, and gravity. A special kind of sediment is generated by precipitation of solids from solution (i.e., calcium carbonate, iron oxides). Excluded from the definition is vegetation, wood, bacterial and algal slimes, extraneous light-weight artifically-made substances such as trash, plastics, flue ash, dyes, and semi-solids.

SEDIMENT DISCHARGE – The rate at which dry weight of sediment passes a section of a stream or the quantity of sediment, as measured by dry weight or by volume, that is discharged in a given time.

SERVICE AREAS – An area described for planning purposes whose boundaries would include the future population or industrial activities which could logically and functionally obtain water supply from a central or integrated system or where the problems are so interrelated that the planning should be done on an integrated basis.

SILT – Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeters) to the lower limit of very fine sand (0.05 millimeters). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

STREAM INTERMITTENT – A stream that flows only part of the time or through only part of its reach.

STREAM PERENNIAL – A stream that flows continuously.

STREAMFLOW – The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. Streamflow is a more general term than runoff, as streamflow may be applied to discharge whether or not it is affected by diversion or population.

STREAMFLOW REGULATION – The artificial manipulation of the flow of a stream.

STORAGE – Water naturally or artificially impounded in surface or underground reservoirs.

STORAGE CAPACITY, ACTIVE (USABLE) – The volume normally available for release from a reservoir below the stage of the maximum controllable level. (Total capacity less inactive and dead capacity.)

STORAGE CAPACITY, CONSERVATION – Storage capacity available for all useful purposes such as municipal water supply, power, irrigation, recreation, fish and wildlife, etc., excluding joint use and exclusive flood control capacity.

STORAGE CAPACITY, DEAD – The volume of a reservoir below the sill or invert of the lowest outlet.

STORAGE CAPACITY, INACTIVE – The portion of live storage capacity from which water normally will not be withdrawn, in compliance with operating agreements or restrictions.

S.W.–Surface Water.

TDS – Total dissolved solids.

TOTAL ANNUAL AVERAGE COST–The sum of the annual equivalent of the fixed cost, the annual operation and maintenance costs, and the annual equivalent of major replacement costs.

TOURIST–An individual participating in recreation within a basin but residing outside that basin.

TURBIDITY – (1) A condition of a liquid due to fine visible material in suspension which may not be of sufficient size to be seen as individual particles by the naked eye, but which prevents the passage of light through the liquid. (2) A measure of fine suspended matter (usually colloidal) in liquids.

VALUE ADDED – Wages and salaries, interest payments, profits, and the like. Often represents the contribution of industries to the gross basin product used to measure production growth.