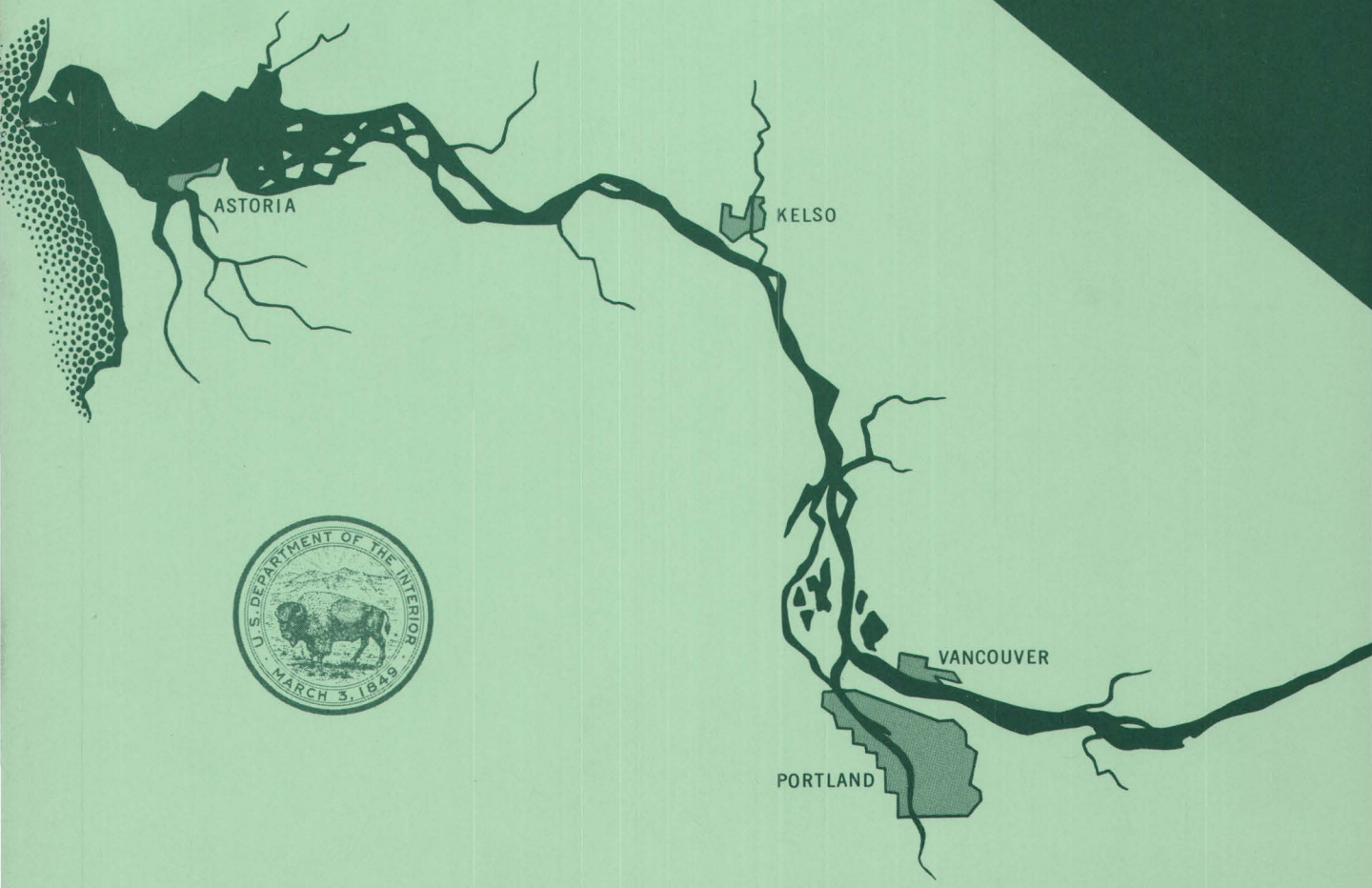
DISCHARGE IN THE LOWER COLUMBIA RIVER BASIN, 1928-65



GEOLOGICAL SURVEY CIRCULAR 550

Discharge in the Lower Columbia River Basin, 1928–65

By Hollis M. Orem

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DISCHARGE IN THE LOWER COLUMBIA RIVER BASIN, 1928–65

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Abstract

Estimates of monthly and annual mean discharge for five ungaged sites in the lower Columbia River are presented for water years 1928–65. These sites are Columbia River at Vancouver, Wash., Willamette River at mouth, Columbia River at St. Helens, Oreg., Columbia River at Longview, Wash., and Columbia River at mouth. Two tables of estimates are compiled for each site. One table lists estimates of "observed" flow, the flows that would be measured by a gaging station. The other table lists "adjusted" flows, the "observed" flows adjusted for storage changes in major reservoirs and for diversion at Grand Coulee Dam.

Two methods are used in making these estimates. One method involves a detailed summation of flows from all gaged and ungaged areas, allowance for precipitation on and evaporation from the channel water surface, and adjustment of flow to allow for travel time from gaging stations at the Dalles, Oreg. (Columbia River main stem), and at Salem Oreg. (Willamette River).

The other method is the same as the summation method except that flows from individual gaged and ungaged areas below The Dalles and Salem are not summed in detail. Instead, the entire drainage area below The Dalles is divided into three major inflow segments and the flow from each segment is obtained from a correlation with streams that are representative of the flow from that segment.

Estimates of monthly mean flows are considered to be accurate within 2 or 3 percent.

INTRODUCTION

The need for historical streamflow data for the lower reaches of the Columbia and Willamette Rivers is heightened by prospects for increased industrialization in those areas and by water-quality standards that are being set. Because of tidal effects in the lower reaches of these streams, no continuous records have been collected there until the last few years and then, only on the Columbia River at Vancouver, Wash. Because actual historical streamflow data are lacking, the obvious alternative is to estimate such records using the best available data. Throughout the Columbia River basin the Water Management Subcommittee of the Columbia Basin Inter-Agency Committee has used the period July 1928 to June 1958 for planning purposes as this period includes the critical low-water periods as well as high-water years such as 1948 and 1956. The estimates presented in this report include that period.

PURPOSE AND SCOPE

This report presents two tables of discharge estimates for each of five ungaged sites in the lower Columbia River basin for the period 1928–65 (see tables 3–12 at end of this report). One table lists "observed" monthly mean discharge; that is, the flows that would have been measured at a gaging station at the site. The other table lists "adjusted" monthly streamflow, which is the "observed" flow adjusted for storage changes in major upstream reservoirs and for diversions at Grand Coulee Dam. The "adjusted" flows represent a "no-reservoir" condition. Because these runoff figures more nearly represent natural flow conditions, they are convenient for studies involving different sets of reservoirs or operations.

The report also describes methods used to estimate these monthly and annual streamflows at the four sites on the Columbia River below Bonneville Dam and for Willamette River at mouth. The four Columbia River sites are at Vancouver, Wash., below Lewis River at St. Helens, Oreg., below Cowlitz River at Longview, Wash., and at mouth. No attempt has been made to estimate daily flows.

DESCRIPTION OF THE STUDY AREA

The lower Columbia River basin as used in this report includes that part of the basin

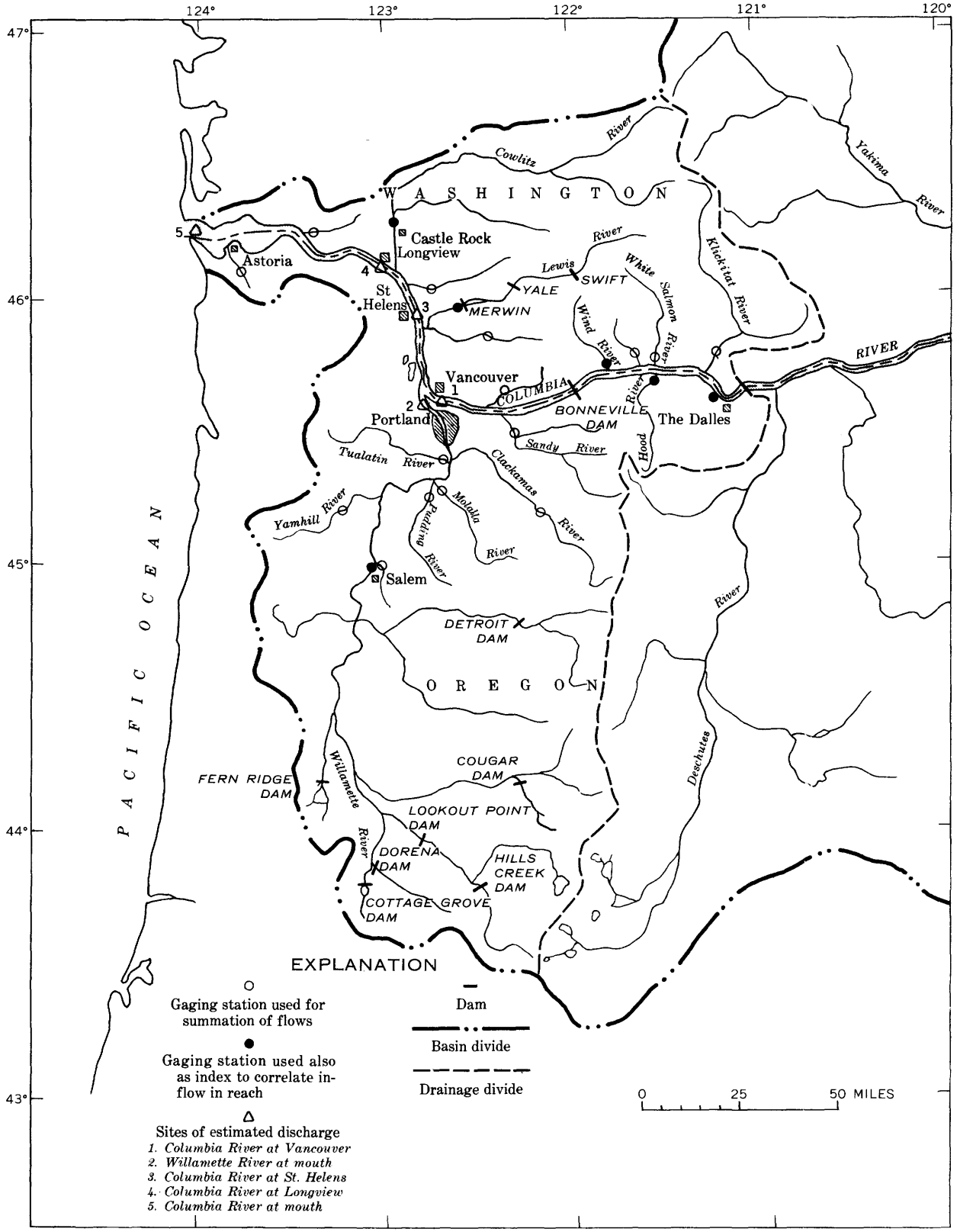

Figure 1.—Map of lower Columbia River basin.

downstream from the gaging stations on Columbia River at the Dalles, Oreg., and on Willamette River at Salem, Oreg. (see fig. 1). The drainage area at the Dalles is about 237,000 square miles and the drainage area at the mouth of the Columbia River is about 258,000 square miles. The incremental area between these points is, therefore, 21,000 square miles, lying almost entirely west of the Cascade Range. Only about 4,600 square miles of the area below the Dalles and Salem is ungaged, and about 400 square miles of that is river channel water surface or low sand islands which lie largely in the extreme lower reaches where the river becomes several miles wide. However, the water from the 21,000 square miles is an important part of the flow at the mouth of the Columbia River. Average runoff from this area is 3.62 cfs per sq mi (cubic feet per second per square mile) whereas average runoff from the area above The Dalles is only 0.824 cfs per sq mi.

Most of the study area is between 500 and 5,000 feet elevation and is heavily forested; but some lower areas, such as the Willamette River valley, are largely under cultivation with interspersed forests.

There is only one impoundment (Bonneville Dam) below The Dalles on the main stem of the Columbia River, but this is a "run-of-river" reservoir with inconsequential monthly storage changes. In determining "adjusted" monthly flows it was necessary to adjust for (1) storage changes in nine major reservoirs above The Dalles, (2) pumpage (diversions) at Grand Coulee Dam, and (3) storage changes in seven reservoirs above Salem in the Willamette River basin and three reservoirs in the Lewis River basin.

ACKNOWLEDGMENTS

The author is indebted to Vail Schermerhorn of the U.S. Weather Bureau, David M. Rockwood and Carlton Jencks of the Corps of Engineers, and William Haushild of the U.S. Geological Survey for information on time of travel used in routing flows. Basic data for gaged areas are from the Oregon and Washington district Offices of the U.S. Geological Survey.

ESTIMATION OF DISCHARGE

Two methods were used for estimating monthly mean flows at the five ungaged sites. The first and basic method involved summation of flows for all gaged areas with estimates of flow for all ungaged areas (Orem, 1961). The second was a shortcut method that involved dividing the area between the Dalles, Oreg., and the mouth of the river into three major segments and estimating the flow for each segment by correlation procedures. The second method was used for some of the early years before many of the gages were installed on intervening areas between The Dalles and the mouth of the river.

SUMMATION METHOD

The summation method consisted of starting with gaged flows of the Columbia River at the Dalles, Oreg., and adding tributary flows as they entered the river. Table 1, which illustrates the method, is for the 15-year period covering water years 1943–57. The table was prepared about 1960 when average flow for that standard period was needed for Columbia River at Vancouver, Wash., and Columbia River at mouth. That table is shown in this report in preference to using a specific month as an example because (1) average values for ungaged areas were estimated in this table, and (2) the tabulation is for a 15-year period and, therefore, the computation is not complicated with travel-time adjustments. To estimate flows for individual months, travel-time adjustments are used when flow at the end of the month is materially different from flow at the beginning of the month. These adjustments will be explained in more detail later in the report.

Gaged areas

For most of the 1928–65 period streamflow records are available for all but about 1.6 percent of the Columbia River drainage area. This small ungaged area accounts for 4.6 percent of the flow at the mouth of the Columbia River. The gaged areas are listed in table 1. The "Remarks" column in the table indicates that even in the period 1943–57 there were a few months or years of missing record for several of the gaged areas and that flow data

for these short periods were estimated by correlation with records of a nearby stream.

Ungaged areas

Estimates of ungaged average inflow to the Columbia River for five areas are given in table 1. Because the ungaged areas and flows are small compared to the flow of the Columbia River, estimates of monthly flow at the ungaged main-stem sites cannot be materially in error because of erroneous estimates of ungaged inflow. Nevertheless, considerable care and effort went into these estimates. Average runoff rates for the areas were determined in terms of the average runoff rate for a nearby gaged area based on a runoff map developed by Hulsing and Kallio (1964) of the Geological Survey. Their map of isopleths of runoff was developed from a study of all records of discharge in Washington and Oregon and an isohyetal map (lines of equal precipitation) prepared by the Portland District, Corps of Engineers.

Precipitation and evaporation

Downstream from the gaging stations in Oregon at The Dalles and at Salem there are 400 square miles of river channel and islands. Increments of flow were included for precipitation directly on this surface and decrements were included for evaporation from the surface. Because these components are relatively small and tend to cancel each other, they were included in the estimates of monthly flow for only the two lower ungaged sites. About half the 400 square miles is upstream from the ungaged main-stem site below the Cowlitz River. Therefore, precipitation on and evaporation from the 400 square miles of water surface were taken into account for flow of Columbia River at mouth and from 200 square miles for Columbia River below Cowlitz River. Monthly flow increments were obtained by averaging the amount of precipitation recorded at Weather Bureau stations in Oregon at Bonneville, Salem, Portland, and Astoria and converting that average to equivalent cubic feet per second. Monthly flow decrements for evaporation were obtained using average monthly values derived from U.S. Weather Bureau Technical Papers 13 and 37 (U.S. Weather Bureau, 1950, 1959). Paper 13 shows that annual evaporation averages 24 inches for the area downstream from The Dalles and Salem. Paper 37 indicates a distribution by months of this 24 inches on the basis of records for Seattle, Wash., the most representative point for which year-round records are available.

Time of travel

When flow changed materially during the month, the estimates for the five ungaged sites required adjustment for time of travel of the water. Adjustments were made only for time of travel from The Dalles, Oreg., to Vancouver, Wash.; from The Dalles to mouth of the Columbia River; and from Salem, Oreg., to mouth of the Willamette River. Travel times and changes of flow for other tributaries were neglected.

Stream and reach	*Range of flow at lower end of reach (thousands of cfs)*	*Travel time (days)*
Columbia River (The Dalles to Vancouver)	Below 200	1½
Do	200–500	1
Do	Above 500	½
Columbia River (The Dalles to mouth)	Below 250	3
Do	250–400	2½
Do	400–600	2
Do	Above 600	1½
Willamette River (Salem to mouth)	Below 25	3
Do	25–50	2½
Do	50–75	2
Do	75–100	1½
Do	Above 100	1

Travel times were based on data and advice from Weather Bureau, Corps of Engineers, and Geological Survey personnel, plus some observations of velocities at Hood River, Vancouver, and a few other points.

Although the flows at the lower end of the reach were the basis for the assignment of travel time through the reach, the flows at the upper end of the reach were the basis for the change in discharge used in adjusting the "observed" flows at the ungaged site for travel time. For example, in May 1948 the "observed" monthly mean flow at Vancouver was 493,500 cfs (cubic feet per second). From the above schedule the travel time from The Dalles to Vancouver was, therefore, taken as 1 day. The daily mean flow at The Dalles was 249,000 cfs on April 30, 1948, and 999,000 cfs on May 31, 1948. The change in flow at The Dalles dur-

ing May was, therefore, +750,000 cfs and the needed adjustment to monthly mean flow at Vancouver was negative, computed as follows:

$$\frac{750{,}000 \text{ cfs} \times 1 \text{ day}}{31 \text{ days}} = 24{,}200 \text{ cfs.}$$

The "observed" mean flow of 493,500 cfs at Vancouver was adjusted to 469,300 cfs. If the travel time had been 2 days, then 2 days rather than 1 day would have been used in the numerator of the above equation.

The adjustment of -24,200 cfs shown above is about the maximum needed both in amount and in percentage of flow and is about 5 percent of the "observed" flow at Vancouver. For simplicity, the assumed travel times to Vancouver were used also for the ungaged sites below Lewis River and below Cowlitz River, even though it is obvious that somewhat longer travel times to those sites should be used.,

A good verification of the applicability and validity of the assumed travel time from The Dalles to Vancouver was possible because the Geological Survey measured flows at Vancouver during the 1964, 1965, and 1966 water years. Table 2 shows a comparison of estimated "observed" flows and measured flows at Vancouver for those three years. In 28 of the 36 months of record the adjustment for time of travel improved the agreement of the estimated "observed" flows with the measured flows.

The increase in discharge during the spring rise in certain years was so large that application of the time-of-travel adjustment resulted in larger flows at Longview than at the mouth, but the difference never exceeded about 2 percent and it is probable that the greater upstream flows could actually occur under certain conditions.

CORRELATION METHOD

The correlation, or shortcut, method for estimating flows at the ungaged sites was developed for two reasons, (1) many of the gaging-station records used in the detailed summation method were not available for many of the early years, and (2) for the past 6 or 7 years the Geological Survey Northwest Data Center at Portland, Oreg., has needed a method for computing current monthly flows at Vancouver, Wash., and at the mouth of the Columbia River, and many of the gaging-station records used in the summation method have not been available on a current basis.

Major Inflow Segments

In the correlation method the area between The Dalles, Oreg., and the mouth of the river was broken into three major segments and separate correlations were used to estimate the inflow from each segment. These segments are Columbia River from The Dalles to Vancouver, Wash., Willamette River from Salem, Oreg., to mouth (including Multnomah Channel), and Columbia River from Vancouver to mouth.

Good estimates of the inflow between The Dalles and Vancouver were obtained by correlating monthly inflow figures for 1943–65 (obtained by the summation method) with the sum of flows in Hood and Wind Rivers. Separate correlations were made for each month of the year to adjust for seasonal variations in the relationship. Figure 2 shows the correlation developed for January.

Similarly, the flows of Willamette River at the mouth correlated well with flows of Willamette River at Salem after both were adjusted for storage changes upstream. Figure 3 shows the correlation for the month of October. Correlations for each month were used to obtain "adjusted" monthly mean flows at the mouth of the Willamette for the early years, and the adjustments were then subtracted to obtain the "observed" monthly mean flows.

The "adjusted" inflow to Columbia River below Vancouver also correlated well with the sum of flows in Cowlitz and Lewis Rivers adjusted for upstream storage in Lewis River reservoirs. Figure 4 shows the correlation for the month of January. Here, too, the adjusted inflow obtained through correlation was converted to "observed" inflow.

Discharges obtained by correlation for these three major segments of inflow were then used directly to obtain estimated flows at three of the five ungaged sites; however, estimated flows for the other two ungaged sites required further manipulation of data. Estimated flows for Columbia River below Lewis River were obtained by adding to the flow at Vancouver,

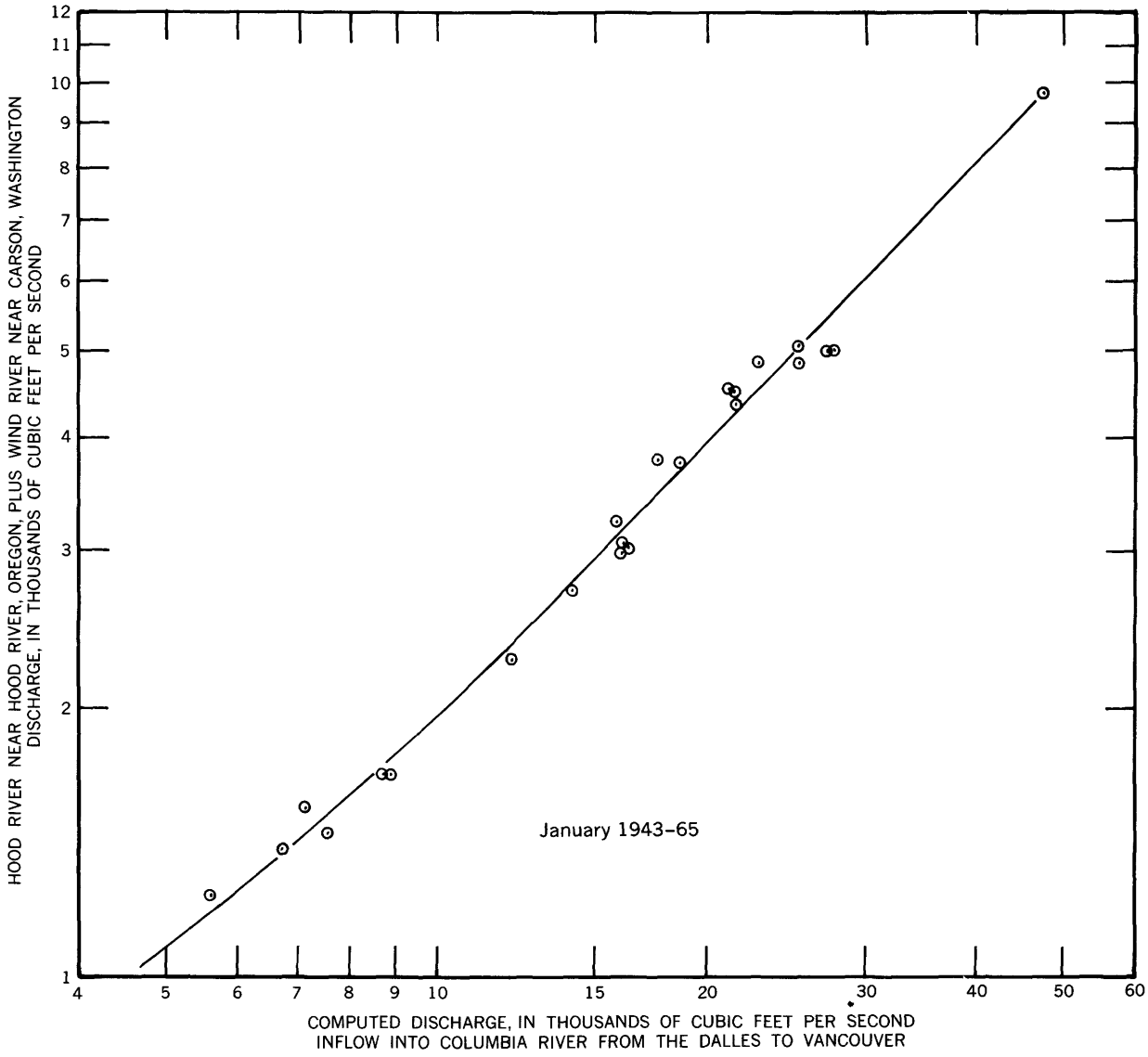

Figure 2.—Correlation for inflow between The Dalles, Oreg., and Vancouver, Wash.

the flows of Willamette River at mouth, Lewis River, East Fork Lewis River, and an increment for ungaged area prorated among the months based on East Fork Lewis River.

Estimated flows for Columbia River below Cowlitz River were obtained by a further addition of flows for Cowlitz and Kalama Rivers and another increment for ungaged area distributed according to Kalama River monthly flows.

Precipitation, Evaporation, and Time of Travel

The procedure outlined above did not result in "observed" monthly mean flows comparable to those obtained by the summation method shown in table 1. Adjustments for precipitation on and evaporation from the 400 square miles of water surface and for time of travel because of changing discharge also had to be made. This was done in the same way as for the summation method, with the following exception; the evaporation correction applicable to flows at the mouth of the Columbia River was made an integral part of the correlation developed for the inflow segment from Van-

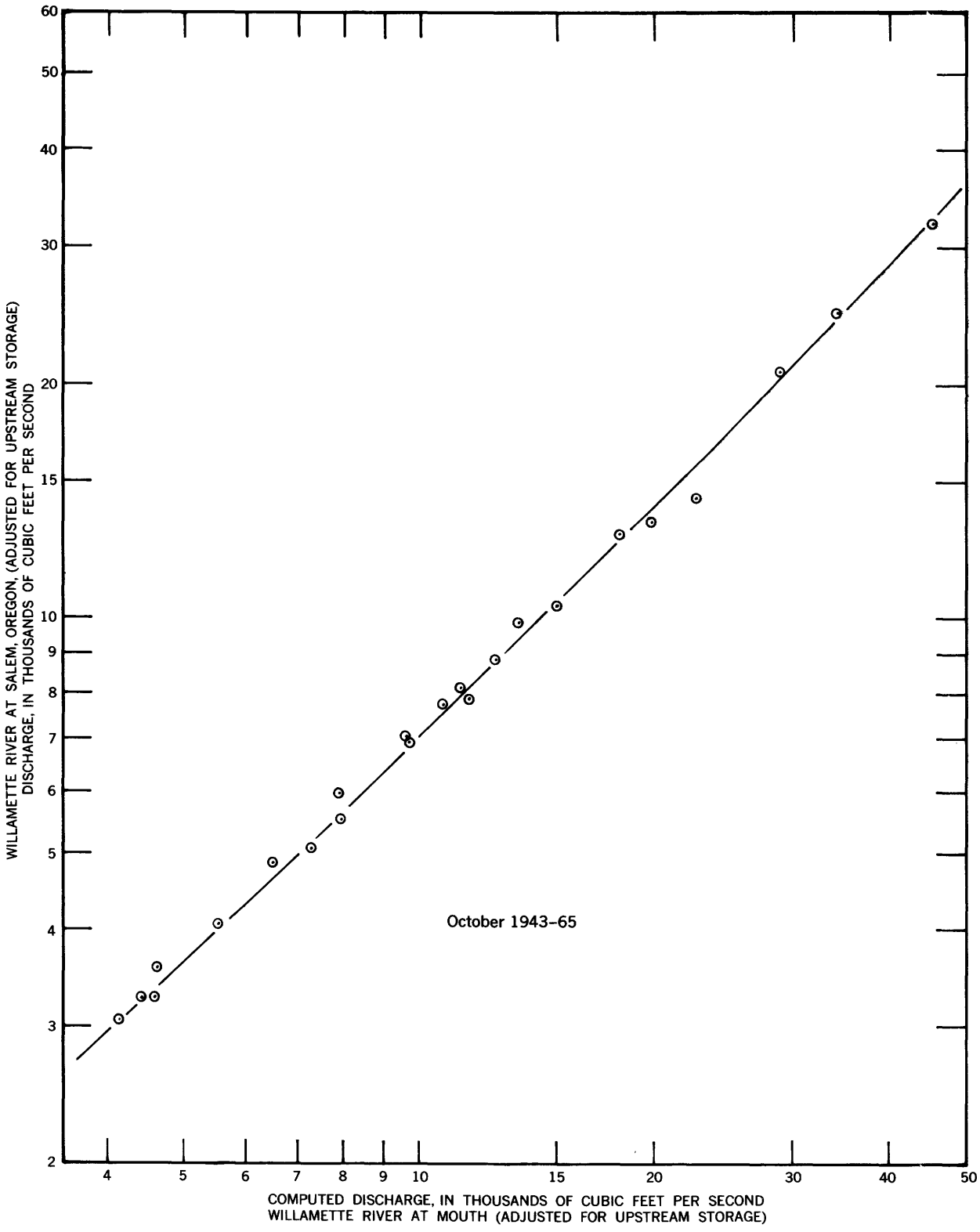

Figure 3.—Correlation for Willamette River at mouth.

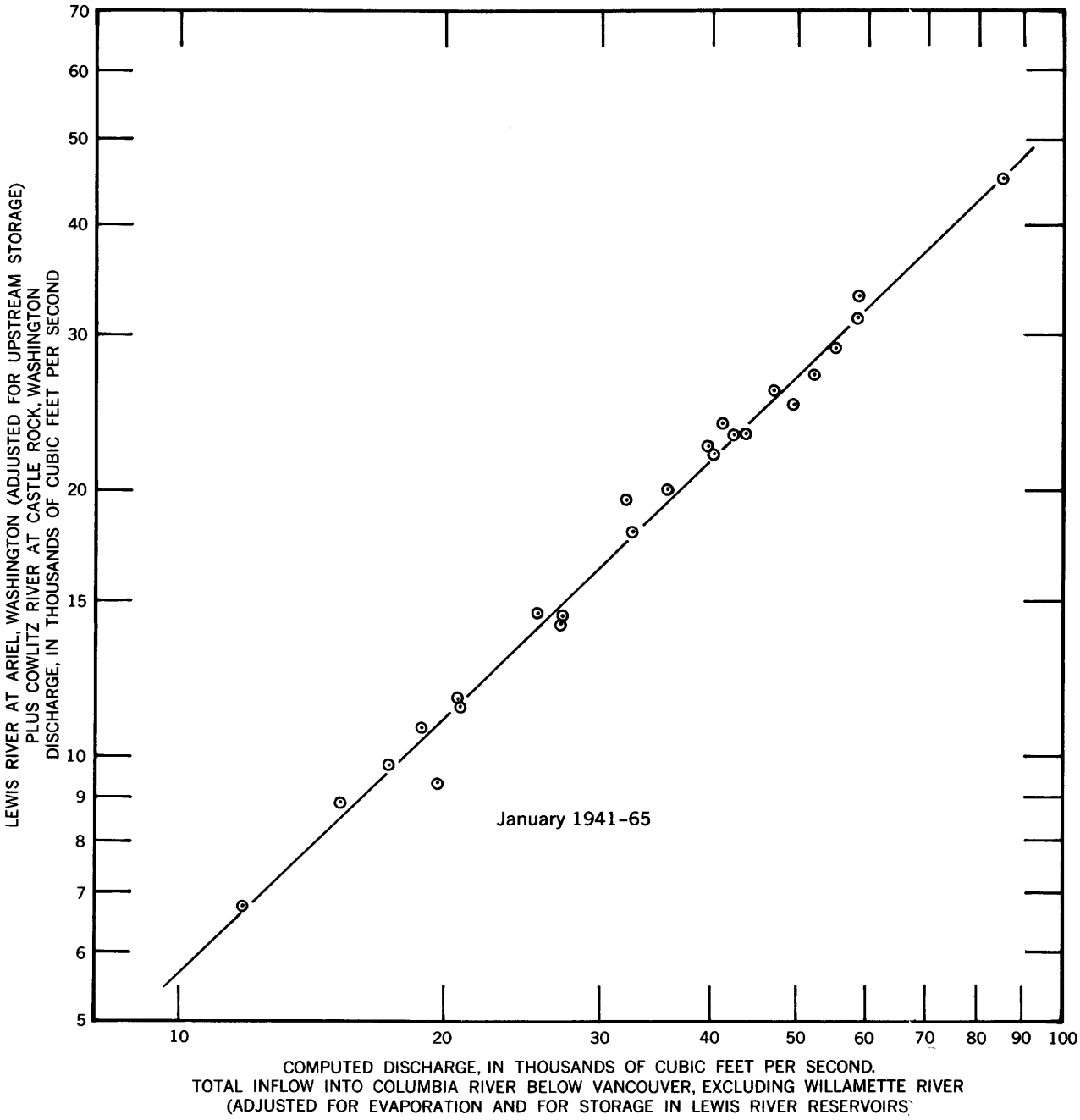

Figure 4.—Correlation for inflow below Vancouver, Wash.

couver, Wash., to the mouth. This procedure was used because the same annual evaporation of 24 inches and the same monthly distribution of that 24 inches were used each year. Precipitation corrections were not made in the same manner because the actual amount of precipitation by months and years is known.

ADJUSTED MONTHLY MEAN FLOWS

The tables of "observed" monthly mean flow for water years 1928–65 for each of the five ungaged sites were developed using both the

summation and correlation methods. Tables of "adjusted" monthly mean flows were then compiled by adjusting the "observed" flows for upstream storage changes.

The reservoirs for which adjustments were made are:

1. Nine major reservoirs in the Columbia River basin; namely, Kootenay Lake, Hungry Horse Reservoir, Flathead Lake, Noxon Rapids Reservoir, Pend Oreille Lake, Coeur d'Alene Lake, Franklin D. Roosevelt Lake, Chelan Lake, and Brownlee Reservoir.
2. Willamette River basin reservoirs of Hills Creek, Lookout Point, Cottage Grove, Dorena, Fern Ridge, Cougar, and Detroit.
3. Lewis River reservoirs of Swift, Yale, and Merwin.

Adjustments for upstream storage were computed using the system of adjusting that has been standard with the Water Management Subcommittee of the Columbia Basin Inter-Agency Committee. In that system, adjustments are made strictly on a calendar-month basis with no allowance for travel time. In other words, in any given month the adjusted flow for Columbia River at the mouth may include an adjustment for a storage change that occurred largely during the last day or two of a month and the effect would not be felt at the mouth until the following month. However, such events should not lead to consistently large errors. At times during the final days of the month one reservoir may store while another releases, and the resultant differences in flow would tend to cancel each other.

ACCURACY OF ESTIMATES

Because of the many approximations involved, it is difficult to place accuracy limits on the estimates of flow. The ungaged area between the mouth of the Columbia River and The Dalles, Oreg., is only 1.6 percent of the total Columbia River drainage area, and the ungaged flow is estimated to be less than 5 per cent of the total flow. Therefore, fairly large errors in estimates of ungaged flows would not greatly affect estimates of total flow. However, in some months, the approximations used could easily result in errors of a few percent if errors in the several estimates were in the same direction. It is more likely that the errors would be compensating.

Comparison of Estimated and Measured Flows

The only real check of the accuracy of estimates lies in a comparison of estimated flow for Columbia River at Vancouver, Wash., for water years 1964–66 with measured flows for those years (table 2). The estimates for 1964 and 1965 were by the detailed summation method whereas those for 1966 were by the correlation method. The mean deviation of the three estimated annual mean flows from the measured flows is 0.24 percent and maximum deviation is only 0.42 percent. Corresponding figures for the 36 monthly mean flows are 2.3 and 5.7 percent, respectively. However, this does not mean that the estimated flows are in error by this much, as the measured flows in this tide-affected reach of the river may be a few percent in error. The comparison does show that the estimates are reasonably close to the measured flow. It is the author's opinion that in general the estimates are accurate to within 2 or 3 percent.

Comparison of Estimates by Correlation and Summation Methods

The correlation, or shortcut, method has been used to estimate flows of the Columbia River at mouth for current data releases. Comparison of the 60 monthly estimates thus computed for water years 1961–65 with those computed by the summation method and shown in table 11 (p. 23) indicates that the average difference is 1.7 percent and the maximum difference is 4.6 percent. Average difference for annual mean flows was 0.6 percent. Some of this difference is undoubtedly caused by the fact that provisional figures of discharge for index streams were necessarily used in the shortcut method but final published figures were used in the summation method to obtain the flows for 1961–65 shown in table 11.

The shortcut method was used to estimate monthly discharge for 1928–40 but for those years it was possible to use published discharge for all index stations, thereby eliminating provisional data as a source of error.

Known Deficiencies in Methods

Known deficiencies in the results presented herein are as follows:

1. The 80,000 acre-feet of water supply for Portland, Oreg., diverted from the Sandy River basin as of 1955 had grown to about 110,000 acre-feet per year in 1965. Between one-half and two-thirds of this amount, or an average of about 100 cfs, was returned to the lower Willamette River in recent years, but no provision for this was made in the computation.
2. The increment for precipitation on and decrement for evaporation from the 400 square miles of river surface was included in the tables only for Columbia River at mouth. Fifty percent of this correction was applied below the Cowlitz River. Actually, about 40 percent of the water surface is above St. Helens, Oreg., but these factors were not included in tables for the three upstream sites.
3. Although the compilations used to estimate flows for this report take into account all known surface runoff, they do not include ground-water inflow directly into the rivers below the gaging stations. This may be important particularly for the Willamette River below Salem, Oreg., where inflow is from extensive areas of permeable alluvium. The extent of the inflow cannot be evaluated until a gaging station has been installed at Portland.
4. Adjustments for changing discharge through use of travel times are only approximate and are used only for flows passing the gaging stations on Columbia River at The Dalles, Oreg., and Willamette River at Salem; they are neglected for tributary streams.
5. Adjustments for changes in reservoir storage, used to convert "observed" flows to "adjusted" flows, are made strictly on a calendar-month basis with no allowance for travel time. This could result in occasional small errors.

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TABLES 1–12

Table 1.--Outline of summation method for estimating flow of Columbia River at mouth

Station	Period of record	Drainage area sq mi	Mean Annual Discharge 1943-57 cfs[1]	cfsm[2]	Remarks
Columbia River at The Dalles Dam	1878-1959	237,000	195,300	0.824	
Klickitat River near Pitt	1928-59	1,290	1,752	1.36	
Hood River and conduit nr Hood River	1913-59	329	1,216	3.70	
White Salmon River nr Underwood	1935-59	390	1,219	3.13	
Little White Salmon R. above Lapham Creek near Willard	Dec.1944-59	117	428	3.66	26 mo.correl.with Underwood.
Wind River near Carson	1934-59	225	1,256	5.58	
Ungaged area-The Dalles Dam to Bonneville Dam		945	(1,390)	(1.47)	Add 1.1 times Wind River.
Columbia River at Bonneville Dam-subtotal		240,296	202,561	0.843	
Washougal River nr Washougal	Sept.1944-59	108	878	8.13	24 mo.correl.with Wind River.
Sandy River below Bull Run River nr Bull Run	1929-59	440	2,528	5.75	About 80,000 A.F. diverted to Portland in 1955.
Ungaged area-Bonneville Dam to Vancouver		394	(1,703)	(4.32)	Add 2.2 times Washougal River.
Columbia River at Vancouver-subtotal		241,238	207,670	0.861	
Willamette River at Salem	1927-59	7,280	26,560	3.65	
Mill Creek at Salem	1940-59	110	146	1.33	Partly diverted.
South Yamhill River near Whiteson	1940-59	502	1,839	3.66	
Ungaged area-Salem to Wilsonville		508	(1,103)	(2.17)	Add 60% of Whiteson.
Mollalla River near Canby	1928-59	323	1,290	3.99	
Pudding River at Aurora	1928-59	479	1,358	2.84	
Tualatin River near Willamette	1928-59	710	1,589	2.24	
Clackamas River near Cazadero	1908-59	657	2,998	4.56	
Johnson Creek at Sycamore	1940-57	28.2	57	2.02	
Ungaged area above mouth of Willamette River		557	(1,098)	(1.95)	Add 80% of Pudding River.
Willamette River at mouth		11,154	38,038	3.41	
Columbia River below Willamette River-subtotal		252,392	245,708	0.974	
Lewis River at Ariel	1923-59	731	5,094	6.97	
*East Fork Lewis River near Heisson	1929-59	125	782	6.26	
*Kalama River below Italian Creek, near Kalama	1947-59	201	1,211	6.02	1943-46 correl.with Toutle R.
Cowlitz River at Castle Rock	1926-59	2,238	9,647	4.31	
*Elochoman River near Cathlamet	1940-59	66	385	5.84	
*Youngs River near Astoria	1927-58	40.1	190	4.74	
Precipitation on water surface		400	1,790	4.46	Avg.precip.for 4 stations.
Evaporation from water surface			- 710	1.78	Avg.figures used for months.
Ungaged area-below Willamette River		1,776	(7,246)	(4.08)	2.76 x sum of 4 starred rivers.
Columbia River at mouth-uncorrected		257,969	271,343	1.052	
Sum of change during period-Columbia + Willamette					
Correction for time of travel to mouth			0		
Columbia River at mouth-"observed"			271,343		
Adjustment for storage change in reservoirs			+1,182		
Columbia River at mouth-"adjusted"		257,969	272,525	1.056	

[1] Cubic feet per second.

[2] Cubic feet per second per square mile.

Table 2.--Comparison of estimated and measured flows - Columbia River at Vancouver, Wash.

[Thousands of cubic feet per second]

Water year		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
1964	Summation of upstream observed flows	95.74	106.76	106.32	118.22	121.60	119.39	151.63	300.90	588.94	360.38	166.55	109.18	195.40
	Correction for time of travel	- .51	+ .86	- .17	- .20	- .70	- .19	- 2.20	- 8.48	- 2.23	+12.0	+ 2.8	+ .3	- .09
	Estimated "observed" discharge	95.23	107.62	106.15	118.00	120.90	119.20	149.43	292.42	586.71	372.38	169.35	109.48	195.31
	Measured discharge	97.5	101.8	105.3	115.7	120.8	119.4	143.3	291.1	585.5	379.3	174.1	114.3	195.6
	Difference	- 2.27	+ 5.82	+ .85	+ 2.30	+ .1	- .2	+ 6.13	+ 1.32	+ 1.21	- 6.92	- 4.75	- 4.82	- .29
	Percent deviation of estimate	- 2.3	+ 5.7	+ 0.8	+ 2.0	+ 0.1	- 0.2	+ 4.3	+ 0.5	+ 0.2	- 1.8	- 2.7	- 4.2	- 0.15
	Avg. dev. = 24.8/12 = 2.1%													
1965	Summation of upstream observed flows	125.16	118.84	205.15	199.30	254.54	195.78	259.73	413.52	492.73	296.55	171.12	118.53	237.36
	Correction for time of travel	+ .24	- .25	- 1.97	- 4.36	+ 3.86	+ 2.95	- 7.51	- 3.04	+ 1.83	+ 7.35	+ 1.35	+ 2.45	+ .06
	Estimated "observed" discharge	125.40	118.59	203.18	194.94	258.40	198.73	252.22	410.48	494.56	303.90	172.47	120.98	237.42
	Measured discharge	125.0	113.5	195.4	187.7	255.7	196.7	247.4	409.2	504.4	313.8	182.6	125.1	237.8
	Difference	+ .4	+ 5.09	+ 7.78	+ 7.24	+ 2.70	+ 2.03	+ 4.82	+ 1.28	- 9.84	- 9.90	- 9.13	- 4.12	- .38
	Percent deviation of estimate	+ 0.3	+ 4.5	+ 4.0	+ 3.9	+ 1.1	+ 1.0	+ 1.9	+ 0.3	- 2.0	- 3.2	- 5.0	- 3.3	- 0.16
	Avg. dev. = 30.5/12 = 2.5%													
1966	Summation of upstream observed flows 1/	111.7	114.7	121.4	132.5	133.0	150.9	171.2	276.7	349.2	266.6	140.0	102.2	172.6
	Correction for time of travel	+ .48	- 1.76	- 2.45	+ 1.82	- .80	- 2.19	+ 2.16	- 4.88	+ 2.10	+ 2.44	+ 4.57	+ .24	- .03
	Estimated "observed" discharge	112.18	112.94	118.95	134.32	132.20	148.71	173.36	271.82	351.30	269.04	144.57	102.44	172.57
	Measured discharge	114.1	113.7	117.6	134.2	129.1	146.9	167.5	266.8	349.1	277.9	152.4	107.3	173.3
	Difference	- 1.92	- .76	+ 1.35	+ .12	+ 3.10	+ 1.81	+ 5.86	+ 5.02	+ 2.20	- 8.86	- 7.83	- 4.86	- .73
	Percent deviation of estimate	- 1.7	- .7	+ 1.1	+ 0.1	+ 2.4	+ 1.2	+ 3.5	+ 1.9	+ 0.6	- 3.1	- 5.1	- 4.5	- .42
	Avg. dev. = 25.9/12 = 2.2%													

1/ Preliminary figures.

Table 3.--Estimated "observed" flows - Columbia River at Vancouver, Wash.

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	165	223	207	165	133	183	224	503	518	323	182	109	244
1929	91.6	87.0	73.6	66.4	62.3	98.8	115	224	392	230	142	98.4	140
1930	72.9	65.0	73.8	55.0	107	85.5	151	255	302	237	155	105	138
1931	80.9	70.2	65.8	64.2	64.4	92.1	152	250	279	204	132	103	130
1932	76.6	77.1	68.5	79.7	68.5	186	253	452	488	321	172	118	197
1933	83.4	113	112	111	80.8	111	160	325	638	440	220	140	212
1934	113	158	238	257	174	172	301	430	389	224	154	108	227
1935	82.6	119	117	102	121	112	153	295	450	321	198	117	182
1936	81.3	69.7	64.3	90.9	64.0	108	207	444	430	221	143	103	169
1937	73.3	60.9	63.7	47.1	60.8	87.2	139	254	365	257	149	102	138
1938	78.3	114	127	119	100	153	244	401	524	325	149	107	204
1939	96.6	85.7	82.5	81.8	82.3	117	193	350	316	240	149	103	158
1940	79.6	90.8	96.4	82.3	112	152	222	279	324	213	133	111	158
1941	96.4	106	91.5	93.4	91.7	112	153	244	253	148	125	130	137
1942	128	133	187	121	131	112	204	273	399	290	169	111	188
1943	85.8	110	127	127	137	137	357	367	499	409	197	106	222
1944	93.4	97.1	86.1	84.7	86.0	88.3	107	176	295	179	128	95.2	126
1945	90.2	89.3	79.0	98.1	109	103	130	300	435	257	134	98.9	160
1946	79.0	102	107	136	104	154	246	464	508	310	165	120	209
1947	100	110	177	119	141	149	203	456	466	279	159	107	206
1948	139	152	126	143	132	124	185	469	854	335	187	130	248
1949	106	106	109	88.3	131	172	237	506	430	202	134	99.5	193
1950	92.4	98.7	117	111	148	191	235	345	606	507	203	127	232
1951	119	157	168	185	220	182	268	474	472	355	189	115	242
1952	136	125	135	127	154	157	268	473	421	275	149	100	210
1953	88.6	87.6	88.6	157	165	150	162	263	521	330	163	124	192
1954	105	115	133	130	148	148	175	379	517	534	224	159	223
1955	116	123	116	114	120	128	159	214	454	420	192	119	190
1956	116	151	183	183	140	185	356	548	658	320	168	121	261
1957	118	120	134	118	129	177	206	523	497	211	132	99.7	205
1958	103	103	120	121	172	166	228	395	470	211	126	99.6	193
1959	104	132	149	169	160	175	222	358	519	372	176	157	224
1960	189	174	158	124	148	144	284	312	397	295	162	105	208
1961	102	129	108	118	205	191	190	338	602	242	128	98.3	204
1962	97.8	104	110	123	141	124	230	315	407	247	163	102	180
1963	115	132	154	136	181	142	183	267	401	260	144	104	185
*1964	95.2	108	106	118	121	119	149	292	587	372	169	110	195
*1965	125	119	203	195	258	199	252	410	495	304	172	121	237

*See also measured (published) flows shown in table 2.

Table 4.--Estimated "adjusted" flows - Columbia River at Vancouver, Wash.

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	166	227	196	163	129	195	237	582	475	298	160	99.6	244
1929	91.0	83.1	69.3	61.5	59.6	103	125	270	392	202	129	90.0	140
1930	68.2	59.8	74.4	50.5	113	87.7	190	265	304	217	141	98.3	139
1931	77.7	67.8	61.3	63.9	65.2	96.2	163	286	270	185	121	98.2	130
1932	73.1	77.8	67.8	75.9	74.4	196	278	490	485	282	157	109	198
1933	80.6	119	110	108	76.2	113	190	361	666	388	198	132	212
1934	120	156	257	242	162	184	356	433	355	202	141	100	226
1935	82.6	126	113	103	117	111	172	342	443	294	177	107	182
1936	76.4	66.9	61.5	89.4	60.4	110	258	471	403	199	132	96.2	169
1937	68.5	56.8	63.2	43.9	60.4	88.1	153	298	369	230	136	96.4	139
1938	78.8	115	123	116	96.0	158	282	441	514	292	136	100	205
1939	92.7	82.2	79.6	78.6	75.8	122	219	379	303	226	144	97.2	159
1940	77.0	856.	94.4	76.2	110	160	235	346	308	192	129	107	160
1941	98.5	101	88.9	87.3	84.2	111	174	275	291	183	122	129	146
1942	130	128	178	104	118	101	234	332	422	279	164	107	192
1943	79.6	107	120	114	128	147	409	381	509	389	186	102	222
1944	88.6	84.6	75.9	61.1	70.0	74.7	128	239	300	170	123	95.1	126
1945	83.2	83.2	63.6	89.1	102	99.3	138	363	438	237	128	95.1	160
1946	76.5	103	104	128	94.0	151	277	506	496	289	156	116	209
1947	99.8	112	175	107	132	143	232	495	455	260	151	107	206
1948	146	147	120	130	116	113	223	550	819	306	180	129	249
1949	102	101	94.9	67.0	122	177	273	556	406	187	134	98.5	192
1950	86.6	101	112	88.3	133	193	248	384	655	466	196	121	232
1951	123	155	169	167	213	161	293	530	467	338	182	116	243
1952	142	118	119	91.4	129	127	353	521	448	272	151	93.6	214
1953	76.2	62.9	65.9	156	149	115	161	366	581	330	166	110	195
1954	87.6	101	120	103	134	130	204	457	542	551	219	159	226
1955	110	118	101	85.4	82.6	79.3	151	314	541	408	186	113	191
1956	115	151	185	167	107	171	364	633	664	314	168	112	263
1957	110	101	118	74.1	99.8	173	224	643	505	209	127	94.3	206
1958	91.2	82.8	100	97.7	162	138	244	529	477	209	136	99.1	197
1959	99.8	136	144	158	123	131	228	413	596	365	175	159	228
1960	186	165	143	89.1	122	142	291	354	463	293	161	104	209
1961	93.3	120	86.2	88.5	194	168	191	440	635	231	136	98.8	206
1962	91.5	86.5	90.2	85.0	112	109	266	368	467	250	165	104	183
1963	110	127	137	93.6	169	128	187	338	444	260	148	111	188
1964	86.5	98.0	82.7	91.5	79.1	93.2	168	361	670	365	173	114	198
1965	119	109	201	168	202	163	290	454	575	304	178	122	240

Table 5.--Estimated "observed" flows - Willamette River at mouth

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	22.0	74.4	58.0	69.5	35.7	58.1	72.8	29.6	10.2	6.18	4.87	5.01	35.7
1929	5.83	13.0	22.7	45.7	35.0	37.5	47.3	35.5	24.4	8.56	5.83	4.63	23.7
1930	4.50	4.51	48.7	21.7	85.7	29.0	19.0	22.2	15.1	6,08	4.12	4.12	21.6
1931	5.40	12.5	17.1	27.6	22.0	40.4	71.3	14.7	10.9	6.29	4.10	3.65	19.6
1932	6.30	30.7	44.7	71.0	36.9	96.0	56.4	37.1	26.2	10.1	5.83	4,58	35.5
1933	6.54	32.7	46.8	75.4	53.6	58.3	42.6	45.4	50.4	16.2	6.88	7.54	36.8
1934	6.92	15.3	83.7	77.7	26.9	28.1	32.5	14.3	8.29	5.35	4.34	4.02	25.7
1935	11.6	50.7	75.3	66.7	49.7	47.5	43.6	30.6	16.9	8.44	5.01	4.61	34.1
1936	6.03	12.0	18.9	116	45.0	44.3	39.9	35.2	19.8	8.62	5.25	5.02	29.8
1937	4.42	4.30	14.5	16.2	63.4	59.7	91.2	45.4	38.1	14.2	6.46	5.65	30.0
1938	9.29	63.5	70.1	89.7	73.0	86.8	54.4	34.2	15.0	7.04	4.89	4.68	42.5
1939	5.04	23.0	35.9	37.6	64.0	60.2	30.0	17.9	13.5	7.25	4.43	4.53	25.0
1940	5.80	5.88	29.9	33.4	79.4	66.8	34.5	17.8	7.09	4.43	3.66	3.92	24.1
1941	5.76	22.1	42.0	51.2	25.2	16.4	15.0	20.9	13.2	6.76	4.46	8.13	19.2
1942	9.11	35.3	86.4	42.9	55.2	25.7	17.9	25.0	22.5	10.4	5.37	4.45	28.2
1943	4.39	63.0	115	103	84.0	29.7	66.4	28.5	27.2	12.8	7.15	6.08	45.5
1944	14.1	26.4	26.6	30.5	37.0	28.0	34.4	21.3	12.8	6.50	4.27	4.37	20.4
1945	4.58	11.6	12.9	44.1	76.0	59.0	51.8	49.3	18.2	6.83	4.67	5.73	28.4
1946	5.75	43.6	77.1	103	57.1	68.6	33.1	26.0	18.6	10.2	5.61	5.49	37.9
1947	12.5	51.2	98.4	43.0	62.4	42.0	45.3	15.7	17.5	10.2	6.83	5.78	34.2
1948	44.1	72.1	41.2	93.2	63.1	54.5	48.1	44.1	24.9	10.5	7.01	6.89	42.4
1949	12.9	33.5	90.7	27.9	104	55.4	38.5	51.3	18.6	8.89	5.82	6.07	37.3
1950	10.2	17.2	43.9	87.7	94.2	88.6	51.4	38.6	34.7	14.2	7.01	6.19	40.9
1951	23.0	105	82.8	109	84.7	57.1	35.6	30.4	13.0	7.33	5.60	5.67	46.8
1952	28.7	37.0	89.7	54.3	83.9	48.4	44.7	31.8	18.0	17.1	6.74	6.23	38.8
1953	5.62	5.46	22.4	136	102	49.2	33.3	42.7	33.9	12.3	7.54	7.40	37.8
1954	11.7	47.7	115	88.8	98.8	40.1	44.3	19.2	22.7	12.3	8.34	10.4	43.0
1955	14.3	24.2	30.4	55.1	34.7	39.7	66.5	36.9	31.8	14.8	8.11	9.07	30.5
1956	25.0	75.1	155	140	50.3	69.2	49.9	37.4	26.0	11.6	7.73	8.43	54.8
1957	12.2	33.2	57.5	28.5	43.7	96.8	44.2	25.7	14.8	7.80	6.99	7.71	31.7
1958	11.7	17.5	77.5	82.0	109	41.2	46.4	22.7	17.0	9.24	7.02	8.47	36.9
1959	10.5	56.1	44.8	94.0	69.8	35.8	37.6	31.6	16.4	8.28	6.56	11.6	35.0
1960	24.2	22.3	22.8	27.7	71.0	61.9	63.7	50.9	23.7	8.27	7.25	8.03	32.4
1961	11.0	65.6	53.1	43.3	134	97.0	34.6	34.4	15.4	8.13	7.02	8.13	41.8
1962	12.8	31.5	78.2	42.3	34.3	52.7	48.2	39.8	18.6	8.47	7.81	7.95	31.9
1963	23.3	49.8	57.4	19.7	62.7	30.8	70.6	53.6	13.4	10.2	7.44	8.36	33.7
1964	13.4	56.2	35.0	105	48.1	41.7	27.9	26.4	26.7	11.1	8.35	8.79	33.8
1965	10.9	24.3	158	130	74.3	22.5	21.8	18.7	11.1	7.08	6.88	7.43	41.2

Table 6.--Estimated "adjusted" flows - Willamette River at mouth

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	22.0	74.4	58.0	69.5	35.7	58.1	72.8	29.6	10.2	6.18	4.87	5.01	35.7
1929	5.83	13.0	22.7	45.7	35.0	37.5	47.3	35.5	24.4	8.56	5.83	4.63	23.7
1930	4.50	4.51	48.7	21.7	85.7	29.0	19.0	22.2	15.1	6.08	4.12	4.12	21.6
1931	5.40	12.5	17.1	27.6	22.0	40.4	71.3	14.7	10.9	6.29	4.10	3.65	19.6
1932	6.30	30.7	44.7	71.0	36.9	96.0	56.4	37.1	26.2	10.1	5.83	4.58	35.5
1933	6.54	32.7	46.8	75.4	53.6	58.3	42.6	45.4	50.4	16.2	6.88	7.54	36.8
1934	6.92	15.3	83.7	77.7	26.9	28.1	32.5	14.3	8.29	5.35	4.34	4.02	25.7
1935	11.6	50.7	75.3	66.7	49.7	47.5	43.6	30.6	16.9	8.44	5.01	4.61	34.1
1936	6.03	12.0	18.9	116	45.0	44.3	39.9	35.2	19.8	8.62	5.25	5.02	29.8
1937	4.42	4.30	14.5	16.2	63.4	59.7	91.2	45.4	38.1	14.2	6.46	5.65	30.0
1938	9.29	63.5	70.1	89.7	73.0	86.8	54.4	34.2	15.0	7.04	4.89	4.68	42.5
1939	5.04	23.0	35.9	37.6	64.0	60.2	30.0	17.9	13.5	7.25	4.43	4.53	25.0
1940	5.80	5.88	29.9	33.4	79.4	66.8	34.5	17.8	7.09	4.43	3.66	3.92	24.2
1941	5.76	22.1	42.0	51.2	25.2	16.4	15.0	20.9	13.2	6.76	4.46	8.13	19.2
1942	9.11	35.3	87.3	42.2	55.6	26.0	18.1	25.2	22.6	10.3	5.04	3.89	28.2
1943	4.30	64.1	116	102	83.8	30.3	67.0	28.4	27.2	12.6	7.07	5.85	45.6
1944	13.7	25.0	26.6	30.5	37.3	28.6	34.8	21.5	12.8	6.46	4.21	4.10	20.4
1945	3.99	11.2	12.9	44.1	76.7	59.7	52.2	49.4	18.2	6.75	4.58	5.23	28.4
1946	4.55	43.8	77.6	102	57.8	69.3	33.5	26.1	18.5	10.2	5.50	4.72	37.8
1947	11.6	51.3	98.3	43.0	63.1	42.9	45.6	15.8	17.6	10.1	6.76	5.67	34.3
1948	42.7	71.6	41.2	93.2	63.9	55.1	48.8	44.1	24.9	10.4	6.92	6.45	42.4
1949	11.5	33.5	90.7	27.9	105	55.6	38.8	51.7	18.6	8.79	5.70	5.09	37.2
1950	9.50	17.3	43.9	88.6	94.3	89.7	52.2	38.8	34.7	14.0	6.80	5.14	41.0
1951	23.2	103	82.6	109	85.1	58.1	36.1	30.9	12.9	7.12	4.88	4.81	46.7
1952	27.9	36.9	89.6	54.4	84.8	48.5	45.4	32.1	18.0	17.0	5.98	5.17	38.8
1953	4.72	5.38	22.5	139	102	51.6	35.3	44.6	33.9	12.1	6.86	5.92	38.3
1954	9.66	48.6	114	90.6	98.9	42.6	48.0	21.2	23.9	11.8	6.72	7.46	43.3
1955	11.3	21.8	31.8	54.3	37.4	43.1	67.8	42.3	32.2	14.4	6.14	5.85	30.7
1956	21.1	74.6	160	132	53.6	72.5	54.0	39.7	26.3	11.3	6.35	5.11	54.8
1957	9.76	28.5	57.5	27.2	52.9	97.8	46.7	27.0	15.0	6.93	5.23	4.14	31.6
1958	8.05	14.4	82.0	80.1	111	43.4	50.1	24.6	17.4	8.33	5.04	4.96	36.9
1959	6.43	53.6	44.8	96.9	70.9	40.7	40.9	32.3	16.4	7.17	4.41	8.90	35.0
1960	19.6	19.7	22.6	28.7	74.9	67.2	65.9	51.6	24.2	7.29	5.32	5.21	32.4
1961	6.65	66.7	48.9	43.9	139	101	38.1	35.7	15.1	6.71	4.47	5.69	41.0
1962	9.62	31.5	78.4	41.3	37.8	58.3	54.6	40.4	18.8	7.59	5.86	5.19	32.4
1963	17.8	48.5	53.8	19.8	71.9	34.6	73.6	54.9	13.5	9.42	5.20	5.44	33.7
1964	7.79	52.6	34.8	107	49.9	47.1	32.9	28.3	28.5	10.4	6.07	4.63	34.0
1965	5.56	21.2	170	125	70.8	25.3	27.7	21.6	11.8	6.24	4.84	3.53	41.2

Table 7.--Estimated "observed" flows - Columbia River at St. Helens, Oreg.

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	193	314	273	244	174	254	308	542	532	332	188	115	287
1929	100	105	102	117	99.8	143	170	268	422	240	150	104	169
1930	78.3	70.4	129	80.7	208	121	176	282	320	244	160	110	164
1931	87.5	85.5	86.1	99.1	92.5	142	234	267	291	211	136	108	153
1932	85.9	116	120	160	114	300	321	497	520	334	179	125	240
1933	92.5	158	170	198	140	180	211	382	700	461	229	150	256
1934	127	180	358	356	206	209	339	448	399	231	160	114	261
1935	97.2	185	204	178	179	166	203	332	472	331	205	124	223
1936	90.4	84.4	87.6	220	115	160	254	487	456	232	151	110	204
1937	80.6	66.4	83.3	67.2	130	154	244	308	413	274	158	110	174
1938	90.7	191	212	220	179	249	309	442	543	334	156	114	253
1939	104	113	125	129	155	185	229	373	333	250	155	109	189
1940	88.2	99.6	134	122	206	230	263	302	333	218	138	116	187
1941	105	133	141	152	121	132	171	269	268	156	131	142	160
1942	141	174	289	169	193	143	226	304	427	302	176	117	222
1943	92.0	186	254	236	231	175	436	402	532	425	206	114	274
1944	110	128	118	120	129	121	147	202	311	186	133	101	150
1945	97.1	105	96.1	152	195	170	189	360	457	265	140	106	194
1946	86.7	155	196	251	170	232	286	498	533	324	173	127	253
1947	116	173	295	170	214	198	256	475	487	291	167	114	247
1948	192	235	175	247	203	186	241	523	885	348	196	139	298
1949	122	148	210	120	244	237	285	569	453	213	140	107	236
1950	105	126	171	210	256	294	298	393	649	526	212	134	281
1951	149	276	266	307	319	246	311	512	489	364	196	122	296
1952	174	170	236	186	248	213	319	513	433	294	156	108	255
1953	95.0	94.1	113	317	282	207	202	311	561	346	172	134	236
1954	121	170	264	230	258	197	228	405	547	551	234	171	273
1955	135	154	155	177	163	172	234	257	495	439	202	131	226
1956	150	243	355	337	198	264	415	595	692	336	178	132	325
1957	135	161	202	153	179	286	260	555	515	220	140	108	243
1958	118	127	208	215	295	215	284	424	491	221	134	109	236
1959	117	198	200	276	238	218	267	397	541	383	184	173	266
1960	222	206	190	159	229	214	357	372	426	305	170	118	247
1961	116	204	170	171	360	301	232	381	622	252	137	109	253
1962	114	143	200	176	183	185	284	361	429	257	172	112	218
1963	142	196	222	165	250	179	263	327	416	272	153	114	224
1964	112	176	151	237	180	171	183	323	618	387	180	120	236
1965	140	152	379	340	342	227	279	434	509	312	181	130	285

Table 8.--Estimated "adjusted" flows - Columbia River at St. Helens, Oreg.

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	193	317	262	242	170	265	321	622	489	306	166	106	287
1929	99.8	101	98.1	112	97.1	147	180	314	422	212	136	95.6	168
1930	73.6	65.2	130	76.2	214	123	214	292	322	225	146	103	164
1931	84.3	83.0	81.6	98.8	93.3	147	245	305	283	193	126	103	153
1932	82.7	117	120	156	120	309	347	535	517	295	164	115	240
1933	89.2	166	168	195	135	181	241	417	729	409	207	143	257
1934	134	179	376	340	194	221	394	451	365	208	147	105	260
1935	99.6	192	200	179	174	166	222	379	464	305	184	113	223
1936	83.8	81.6	85.3	221	111	162	304	514	428	210	139	102	204
1937	74.0	62.1	85.8	62.4	129	157	258	352	417	247	143	103	174
1938	90.0	194	209	217	175	254	347	482	533	301	142	106	254
1939	99.4	111	124	126	148	190	256	402	320	235	149	103	189
1940	84.3	93.4	136	115	204	238	276	370	317	198	134	112	190
1941	106	129	138	146	114	131	192	300	306	191	128	141	169
1942	144	169	280	151	181	132	257	362	450	291	171	112	225
1943	85.2	185	248	223	222	177	488	416	542	404	195	110	274
1944	105	113	108	96.9	113	108	169	265	316	178	129	100	150
1945	88.5	98.5	80.8	144	190	167	198	423	459	245	133	102	194
1946	82.5	157	193	242	160	229	318	540	521	303	163	122	253
1947	115	175	293	159	205	193	285	515	476	272	159	114	247
1948	198	230	169	234	188	175	280	604	849	319	189	137	298
1949	117	143	196	97.5	237	242	320	619	430	198	141	105	236
1950	98.8	128	165	187	241	298	311	433	699	484	205	128	281
1951	153	273	267	289	312	225	337	568	484	347	188	122	297
1952	179	162	220	150	225	181	407	561	460	291	158	99.8	259
1953	81.8	69.2	93.0	320	263	174	203	419	621	346	174	117	240
1954	99.7	159	250	205	246	180	262	486	573	567	227	168	277
1955	124	148	141	147	128	127	227	364	582	428	194	121	228
1956	146	243	362	312	166	255	428	683	698	329	176	118	327
1957	124	136	188	105	161	283	281	677	524	218	133	99.4	244
1958	101	102	195	190	287	187	305	560	497	219	142	105	240
1959	108	205	200	270	201	186	278	453	619	374	181	172	270
1960	214	194	173	123	208	218	368	415	493	302	168	111	248
1961	103	199	142	144	354	282	237	484	654	239	142	106	256
1962	104	124	182	135	157	174	330	416	490	260	172	110	221
1963	132	190	200	119	250	168	271	400	460	271	154	117	227
1964	96.6	163	125	214	136	148	208	396	706	379	182	121	239
1965	127	138	387	307	283	193	326	482	590	311	184	127	288

Table 9.--Estimated "observed" flows - Columbia River at Longview, Wash.

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	205	341	289	266	182	273	326	558	539	336	190	117	300
1929	105	112	112	125	106	155	184	284	436	245	152	106	177
1930	80.3	72.3	140	88.0	234	132	188	293	327	247	161	112	172
1931	90.3	90.5	91.9	114	104	158	254	276	297	214	138	110	161
1932	91.7	129	136	178	129	328	341	513	534	341	182	126	253
1933	96.9	188	194	223	150	197	224	398	722	471	234	156	271
1934	140	194	426	394	219	227	351	456	404	233	162	116	277
1935	108	213	228	201	195	179	213	344	482	337	208	127	236
1936	93.4	88.8	95.4	246	128	176	268	506	471	237	153	112	215
1937	82.6	68.2	96.5	73.5	142	169	267	325	432	280	160	113	184
1938	94.4	217	239	242	191	265	326	457	552	337	158	116	266
1939	108	123	141	148	174	199	241	385	342	254	157	111	199
1940	91.2	104	153	132	231	249	276	314	337	220	139	118	197
1941	109	141	154	164	129	138	177	277	273	158	133	147	167
1942	149	186	315	178	205	151	235	313	438	308	178	119	231
1943	94.7	210	277	250	250	188	457	413	543	431	209	116	286
1944	115	134	130	131	140	130	157	211	318	189	135	104	158
1945	99.8	112	104	168	214	184	202	379	465	269	142	110	204
1946	89.9	172	217	275	188	249	300	515	548	333	176	129	267
1947	124	192	330	187	234	210	270	485	495	295	169	117	259
1948	209	258	192	267	221	198	254	544	901	354	199	142	312
1949	128	164	232	126	265	254	300	591	465	219	144	110	249
1950	110	142	191	230	283	321	316	409	668	536	216	137	296
1951	160	301	295	331	347	260	325	526	497	368	198	125	311
1952	188	185	256	196	266	224	334	527	442	299	159	109	266
1953	96.7	96.2	121	356	306	218	212	326	573	353	176	137	247
1954	126	183	297	253	285	210	244	419	563	562	239	175	288
1955	141	168	169	191	179	183	250	271	514	450	206	134	238
1956	165	274	391	363	210	285	434	615	708	345	182	135	342
1957	144	172	224	161	194	308	275	569	523	224	142	110	254
1958	121	134	228	235	318	225	300	437	500	224	136	111	247
1959	121	224	223	306	252	231	282	411	554	388	187	180	280
1960	236	226	208	169	249	228	375	390	438	310	173	120	260
1961	121	232	183	191	397	325	248	397	634	256	139	112	268
1962	119	152	222	192	195	196	300	373	439	262	176	114	228
1963	150	219	240	175	270	190	280	339	423	276	156	116	236
1964	117	193	164	266	193	185	195	336	636	396	185	124	249
1965	145	165	414	367	364	237	291	445	518	316	183	132	298

Table 10.--Estimated "adjusted" flows - Columbia River at Longview, Wash.

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	206	345	277	264	177	285	340	637	496	311	169	108	300
1929	104	108	108	120	103	160	194	330	436	217	138	97.2	177
1930	75.6	67.1	141	83.5	239	134	226	302	328	228	148	105	172
1931	87.1	88.0	87.4	114	105	163	265	315	290	196	127	105	162
1932	88.5	130	135	174	135	338	366	551	530	302	167	116	253
1933	93.6	195	191	219	146	199	253	433	751	420	212	148	272
1934	147	193	445	379	208	239	406	459	369	211	148	107	276
1935	110	220	224	202	190	179	233	391	475	310	187	116	236
1936	86.8	86.0	93.1	247	124	179	318	533	444	215	141	104	215
1937	76.0	63.9	99.0	68.8	142	172	281	369	436	253	146	106	184
1938	93.8	220	236	240	187	270	364	497	542	304	144	108	267
1939	113	120	140	144	167	205	268	414	329	240	152	105	199
1940	87.3	97.4	154	126	229	257	290	382	321	200	135	114	199
1941	110	137	151	158	121	137	198	309	311	193	130	146	175
1942	152	181	306	160	193	140	265	372	461	296	173	113	234
1943	87.9	209	271	237	241	190	509	428	553	410	198	112	287
1944	110	119	120	108	124	117	135	274	323	181	130	103	157
1945	91.2	106	89.0	161	208	181	211	442	468	249	135	106	204
1946	85.7	174	214	266	179	246	331	557	536	312	166	124	267
1947	122	194	328	175	225	205	299	524	483	276	161	117	260
1948	215	253	186	254	206	188	293	625	866	324	192	140	312
1949	123	159	218	104	259	259	335	641	442	204	144	108	249
1950	104	144	185	208	268	324	330	449	717	494	209	130	296
1951	164	298	296	313	340	239	352	582	492	351	191	125	312
1952	193	177	240	160	243	192	422	576	469	296	161	102	270
1953	83.4	71.3	101	359	287	185	214	434	633	353	178	120	251
1954	105	172	283	227	273	193	277	500	589	577	232	172	292
1955	129	161	155	160	144	137	244	378	601	438	198	124	239
1956	161	274	397	338	177	276	447	703	714	338	181	122	345
1957	133	146	211	113	176	305	295	691	532	221	136	101	255
1958	104	110	216	211	310	197	322	573	506	222	144	107	251
1959	113	231	223	300	214	199	293	467	632	380	184	178	284
1960	228	215	191	133	229	232	386	434	505	306	171	114	261
1961	108	226	156	164	391	306	253	501	666	244	144	108	271
1962	109	133	203	152	168	185	346	428	500	264	176	113	232
1963	139	214	218	129	270	179	288	412	466	275	157	120	238
1964	101	180	149	243	150	161	221	410	725	388	186	125	252
1965	132	151	422	334	305	203	337	492	598	315	187	129	300

Table 11.--Estimated "observed" flows - Columbia River at mouth

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	213	352	304	282	189	282	333	545	558	343	195	119	307
1929	108	119	120	132	108	163	187	280	437	256	153	107	181
1930	82.5	73.8	148	93.0	246	138	188	294	328	252	165	114	176
1931	92.9	94.3	97.0	123	112	166	264	273	300	218	141	112	166
1932	95.3	138	144	188	134	345	345	512	534	354	185	129	259
1933	100	203	205	239	155	205	221	396	720	481	242	161	278
1934	147	203	452	424	232	236	346	459	410	240	165	118	286
1935	115	226	241	215	206	187	212	337	486	342	215	129	243
1936	96.3	92.9	101	263	132	187	260	508	478	245	156	115	220
1937	83.8	69.5	104	77.3	147	177	274	320	434	288	164	115	187
1938	97.1	230	254	257	198	272	325	453	561	350	163	117	273
1939	110	129	149	159	182	202	245	382	348	259	161	113	203
1940	92.2	108	164	140	240	261	279	312	342	226	143	119	202
1941	111	150	160	174	132	140	178	276	278	161	133	152	171
1942	154	193	331	185	217	155	231	311	444	313	183	121	237
1943	96.8	220	290	264	263	191	460	412	545	438	217	119	293
1944	118	138	137	137	147	135	161	208	318	195	136	105	161
1945	101	119	109	180	224	193	207	373	468	278	145	113	209
1946	91.4	180	222	302	199	257	297	510	559	344	180	131	273
1947	128	201	351	197	244	214	270	479	501	303	174	119	265
1948	215	272	201	280	227	209	258	527	917	371	202	146	319
1949	132	175	249	130	278	264	295	587	478	224	146	111	255
1950	113	149	205	243	295	340	322	405	664	548	224	140	303
1951	164	319	309	350	360	268	325	519	503	375	205	127	318
1952	196	194	268	204	279	227	333	525	461	306	162	111	272
1953	97.2	97.3	130	380	320	224	212	325	577	360	181	139	253
1954	128	191	316	264	304	217	250	411	569	468	248	179	295
1955	144	176	178	201	187	189	260	271	508	459	213	137	244
1956	174	289	410	384	217	296	432	612	720	356	188	137	351
1957	150	179	237	165	195	324	279	558	535	232	146	111	259
1958	123	140	239	246	331	234	306	427	511	234	138	112	252
1959	124	238	234	320	263	238	285	412	551	402	193	180	286
1960	244	236	220	174	263	229	388	393	440	314	181	120	266
1961	125	241	192	202	416	342	255	384	640	268	141	113	276
1962	121	159	236	198	203	201	300	373	444	269	180	117	234
1963	153	230	251	182	278	194	290	335	428	285	158	117	241
1964	119	205	172	284	201	194	199	328	635	408	188	125	255
1965	147	173	433	378	380	244	284	445	520	327	185	135	304

Table 12.--Estimated "adjusted" flows - Columbia River at mouth

[Thousands of cubic feet per second]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1928	214	356	293	280	185	293	346	624	516	318	174	110	307
1929	108	115	115	128	105	167	197	326	437	228	140	98.5	180
1930	77.8	68.5	148	88.5	252	140	227	303	329	233	151	107	176
1931	89.8	91.8	92.5	123	113	170	274	311	293	201	130	107	167
1932	92.1	138	144	184	140	354	370	550	531	315	170	119	259
1933	96.7	211	203	235	150	207	250	432	748	429	220	153	278
1934	154	201	471	409	220	248	400	462	375	218	151	109	286
1935	117	234	237	216	201	186	232	384	478	316	194	118	243
1936	89.7	90.1	99.1	264	128	189	311	536	450	223	144	107	220
1937	77.2	65.2	106	72.6	147	180	288	364	438	261	150	108	188
1938	96.5	233	251	254	194	277	362	492	551	317	150	109	274
1939	105	126	148	156	175	208	271	410	336	244	155	106	204
1940	88.4	102	165	134	238	268	292	380	326	206	139	115	204
1941	113	146	158	168	125	139	198	308	316	196	130	151	179
1942	156	188	323	167	205	144	261	369	468	302	178	115	240
1943	90.0	220	284	250	254	192	512	427	555	417	206	114	293
1944	112	124	128	114	131	122	183	270	323	187	132	104	161
1945	92.7	112	93.8	172	218	190	217	436	470	258	138	108	209
1946	87.3	181	219	293	190	254	329	552	546	323	170	126	273
1947	126	203	349	186	236	210	300	519	490	284	166	119	266
1948	221	266	195	266	212	198	297	608	881	341	196	144	319
1949	127	170	235	108	271	268	331	638	454	209	147	109	255
1950	107	152	199	220	281	343	336	445	713	507	216	134	304
1951	168	316	310	332	353	247	351	575	498	358	197	128	319
1952	201	186	252	168	255	196	421	573	488	303	164	103	276
1953	84.0	72.5	110	383	302	191	214	433	637	360	182	123	257
1954	107	180	302	239	292	200	283	492	595	484	241	176	299
1955	133	169	164	170	152	144	254	378	595	448	206	127	245
1956	170	289	416	360	184	288	445	700	726	349	186	124	353
1957	139	153	224	117	176	322	300	680	544	229	139	102	260
1958	106	115	227	222	323	206	327	563	517	232	146	108	257
1959	115	245	234	314	225	206	296	468	629	394	190	178	290
1960	236	225	203	138	242	233	399	436	507	310	178	114	268
1961	112	236	164	175	410	323	260	488	673	255	146	110	279
1962	111	140	218	158	176	190	347	428	505	271	180	116	237
1963	143	224	229	136	278	184	298	409	471	284	160	121	244
1964	104	192	147	261	158	171	224	401	724	400	190	126	258
1965	134	159	441	345	321	210	330	492	601	326	189	131	306

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