In Nespelem Canyon the drop was 11 feet greater in 32 miles during the 1894 high water than during medium low water, the average slope being increased from 4 to 4.35 feet per mile. There is no material change in drop at Kettle Falls with changing stage, while the drop is greatly increased with increasing stage at Little Dalles.

The changes in water-surface elevation due to change in stage between low water and the 1894 high water are approximately as follows:

	Feet		Feet
Pasco	35	Mahkin Rapids, head	64
Vernita	41	Grand Coulee	68.5
Wenatchee	54	Elbow Bend	50
Chelan	57	Kettle Falls, head	40
Methow River	48	Little Dalles	77
Foster Creek	52	International boundary	56

The Clark Fork falls 453 feet in the 16 miles of its course in Canada, and 225 feet between the boundary and Metaline Falls, a distance of 11 miles. Above Metaline Falls the average slope is much less, being only 0.9 foot per mile to Pend Oreille Lake. This stretch is broken by Albany Falls near the Washington-Idaho line, where the low-water fall is about 7 feet. Above the lake the slope of Clark Fork increases with distance from the lake, from 4.7 feet per mile to 6.7 feet per mile at a distance of 300 miles from the lake. That is, the profile is concave, although the increase in slope is not uniform but broken by Thompson Falls and other less important changes in slope.

In the 65-mile stretch above its mouth, the Flathead has a slope of about 2.5 feet per mile. From the end of that stretch to Flathead Lake, the slope is at the rate of 22.5 feet per mile.

3. ARABLE LANDS

123. As previously stated, the total drainage area of the Columbia River above the mouth of Snake River is 103,000 square miles, of which about 64,000 square miles are in the United States, and 39,000 square miles are in Canada.

124. That portion of this area within the United States may be roughly classified as follows:

	Percent	Square miles
1. Forests	35	22,500
2. Cut over and burned over	35	22,500
3. Native grass, dry farmed and nonirrigated	12	7,600
4. Irrigated	2	1,200
5. Swamps	1	600
6. Rocky or otherwise nonproductive	15	9,600

125. The location and extent of the irrigated and irrigable lands in the United States in the Columbia Basin above the mouth of Snake River are shown on plate no. 3. Their combined area is estimated to be about 5,600 square miles divided between the States as shown in table no. 3.

TABLE No. 3.—*Irrigated and irrigable lands*

	Washington		Idaho		Montana		Total	
	Square miles	Acres	Square miles	Acres	Square miles	Acres	Square miles	Acres
Irrigated	703	450,000	13	8,000	427	273,000	1,143	731,000
Irrigable	3,686	2,359,000	62	40,000	692	443,000	4,440	2,842,000
Total	4,389	2,809,000	75	48,000	1,119	716,000	5,583	3,573,000

126. The soil of these lands is mainly a fine-textured, silt loam, locally known as volcanic ash, of good depth and very fertile. The crop possibilities cover a wide range and include every variety of product indigenous to the Temperate Zone. On the lands under irrigation there are now being produced heavy yields of wheat, alfalfa, and other cereals and forage crops, fine-quality apples, peaches, pears, cherries, apricots, prunes, and the principal small fruits. Also there are heavy yields of watermelon, cantaloupes, potatoes, asparagus, tomatoes, and practically all hardy vegetables. The range of crop possibilities also includes sugar beets, grapes, peanuts and sweetpotatoes.

127. The dry-farmed areas are almost exclusively used for wheat growing, the success of which varies with the precipitation. In areas having an annual precipitation of 20 inches or more, irrigation, although in many instances desirable, is not considered necessary for the successful growing of crops. Areas having an annual precipitation of less than 15 inches may be classed as arid and irrigation is therefore necessary for successful farming. In areas between these limits, the climate merges from subhumid to semiarid; and the successful production of crops depends in part upon the timeliness of the precipitation.

128. In a general way it may be stated that those areas in which the precipitation exceeds 20 inches have a forest cover in their natural state, the density of which varies directly with the amount of precipitation until the higher altitudes are reached. Where the forest cover is not found, an insufficient precipitation is indicated, and dry farming or irrigation will be practiced if other conditions such as soil and topography are suitable.

129. It is probable that dry farming in the Columbia River Basin will not expand much beyond its present proportion. On the other hand, considering that dry-farmed lands as an agricultural asset have a low value in comparison with irrigated lands, it is reasonable to expect that considerable areas now dry-farmed will be converted in the future into irrigated farms.

(D) CLIMATE

1. GENERAL

130. The physical facts which form the foundation for the widespread interest in the utilization of the waters of the Columbia River and its tributaries are based, primarily, upon the unusual climatic conditions of the Pacific Northwest. The heavy precipitation in the Cascade Mountains and in the upper reaches of the Columbia River and its tributaries provides an ample supply of water for the irrigation of all available lands within the basin in the semiarid areas of eastern Washington and Oregon, and in the valleys of Idaho, Montana, and Wyoming. After all irrigation requirements are met, there

is enough water remaining in the Columbia River Basin and in western Washington and Oregon to supply a total amount of electrical energy estimated to be equal to one sixth of the water-power possibilities of the Nation. The heavy stand of timber in the rugged, glaciated country between the Cascades and the Pacific, due directly to the ample precipitation, represents 50 percent of the remaining saw timber in the United States,[1] even after 50 years of active timber operations in the territory. In addition to the influence of climate upon the supply of raw material in timber, and on the possibilities of production through irrigation and power development, the cool and bracing atmosphere of the coast country provides conditions favorable to maximum human health and efficiency. It is apparent, therefore, that a study of climatic conditions is particularly pertinent to the purposes of this report. (See plate no. 4.[2])

2. PRECIPITATION

131. The climate of the Pacific Northwest is characterized by wet and dry seasons. Rains gradually increase during the fall, reaching a maximum in December, gradually declining during the spring months, with a minimum of rainfall in July and August.

132. There are various forces which combine to influence the seasonal distribution of precipitation. The change in seasons is aided by two facts: First, that land changes temperature more quickly than the water, and second, that warm air has a greater moisture-holding capacity than cool air. The moisture borne by the warm winds coming from the Pacific is condensed when cooled by crossing the land surface during the winter months when the land is colder than the ocean. During the summer months, these same air currents coming off the ocean encounter land which is warmer than the water, and are, therefore, able to absorb moisture rather than lose it. The fact that the ocean is comparatively warm in winter and the land comparatively cold creates conditions favorable to low-barometer or low-pressure areas in the North Pacific during the winter months. The low-pressure storms which result move inland and are the primary cause of the heavy winter rains. The influence of these storms coincides with the period when the natural tendency is toward precipitation, due to the direct effect of the cooling influence of the land on the moisture-holding capacity of the westerly winds. During the summer months, the low-pressure zone moves northward with the sun, and it is only occasionally that showers occur. During this period a general low-pressure area, centering in Arizona, due to the intense heat of the desert country, extends northward and may eventually be the cause of local showers in the Pacific Northwest.

133. The Olympic and Cascade Mountains tend to accentuate the influence on precipitation due to changes in temperature, and largely control the geographical distribution of the rainfall. The air currents moving in from the Pacific are raised to elevations of 5,000 or 6,000 feet by the Olympic Range, where the temperatures are lower. This causes a heavy precipitation in the counties on the western slope, where the annual precipitation is uniformly high and exceeds 100 inches in the wettest localities. As these air currents move down the eastern slope of the Olympics, they encounter warmer conditions, with

[1] Bulletin No. 1241, U.S. Department of Agriculture. [2] Not printed.

the result that the moisture-holding capacity of the air is increased, and the rainfall diminished. At Port Townsend, at the eastern foot of the Olympics, the rainfall averages 20 inches, and in the Puget Sound section the rainfall varies from 20 to 55 inches. The air currents are again raised by the Cascade Mountains, causing heavy precipitation, exceeding 100 inches in places on the western slopes. Again, as these air currents flow down the eastern slope of the Cascades, the moisture-holding capacity is increased, with the result that the precipitation diminishes. At Yakima, the mean annual rainfall is about 7 inches, and at Hanford the annual mean is but 6 inches.

134. To the east of this semiarid belt, the elevations increase, so that on the plateau country of eastern Washington the rainfall during the wintertime is sufficient to permit successful dry farming. In the higher elevations of the mountainous country of northern Idaho and Montana, heavy precipitation again occurs.

135. The influence of the mountain ranges has caused well defined precipitation belts, which are shown on plate no. 5.[2] This map has been constructed by drawing isohyetal lines, or lines of equal rainfall, at 10-, 15-, 20-, 30-, 40-, 50-, and 75-inch precipitation contours. These isohyetal lines in eastern Washington correspond in a general fashion to the horseshoe-shaped topographic contour lines which are characteristic of the upper Columbia Basin.

TABLE No. 4.—*Normal precipitation for various stations in Washington, Idaho, and Montana, from records of the U.S. Weather Bureau*

	Elevation	Inches													Length of record
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	
Washington:	*Feet*														*Years*
Bellingham	107	4.75	2.82	2.88	2.63	1.85	1.57	0.71	1.54	2.06	3.91	4.41	5.30	34.43	39
Seattle	125	4.94	3.89	3.05	2.38	.87	1.33	.63	.70	1.77	2.84	5.03	5.60	34.03	34
Tacoma	194	6.14	4.69	3.48	3.68	2.12	1.46	.60	.74	2.09	3.33	6.26	6.71	40.40	47
Ellensburg	1,510	1.46	1.01	.49	.44	.65	.56	.32	.24	.59	.59	1.57	1.45	9.37	47
Ephrata	1,275	.97	.84	.40	.43	.67	.77	.30	.49	.58	.76	1.16	1.04	8.41	28
Farmington	2,900	1.44	1.50	1.57	1.33	1.90	.96	.13	.02	.75	.85	3.39	1.13	14.97	1
Hanford	385	.86	.68	.21	.41	.40	.44	.08	.21	.35	.57	1.08	.78	6.07	19
Lind	1,475	1.17	1.10	.68	.75	.88	.78	.27	.40	.64	.76	1.58	1.19	10.20	34
Quincy	1,300	.36	1.19	.17	.15	.22	.83	.10	.10	.52	.10	.60	.22	4.56	1
Ritzville	1,825	1.31	1.31	.74	.71	.84	.66	.22	.45	.72	.69	1.61	1.60	10.86	32
Spokane	1,929	2.16	1.77	1.20	1.13	1.42	1.28	.69	.62	.90	1.17	2.09	2.19	16.62	40
Wahluke	416	.96	.64	.43	.32	.41	.43	.20	.34	.39	.59	1.01	.89	6.61	26
Walla Walla	991	1.96	1.76	1.61	1.51	1.61	1.12	.39	.49	.95	1.53	2.02	2.06	17.01	34
Wenatchee [a]	700	1.45	1.03	.35	.29	.75	.50	.37	.30	.42	.86	1.39	1.87	9.58	31
Yakima	1,071	1.29	.99	.38	.47	.63	.59	.32	.17	.51	.61	.85	1.34	8.15	21
Idaho:															
Avery	2,500	4.25	3.09	4.19	2.60	2.81	1.80	1.62	1.22	1.89	2.56	3.49	4.10	33.62	17
Bonners Ferry	1,850	2.81	1.35	.96	.95	2.02	1.92	1.42	1.12	1.64	1.65	3.37	1.91	21.12	23
Burke	4,082	6.17	5.30	4.78	2.50	3.09	2.84	1.68	1.03	2.62	3.27	5.48	5.48	44.24	23
Clarks Fork	2,084	3.75	2.74	3.51	2.03	2.35	2.68	1.54	1.32	2.54	2.84	4.83	3.05	33.18	18
Coeur d'Alene	2,157	3.59	2.39	2.38	1.83	1.91	1.45	.71	.57	1.35	1.68	3.36	3.48	24.70	49
Kellogg	2,305	3.80	2.82	2.99	2.01	3.15	2.15	1.16	1.01	1.93	2.61	3.81	3.08	30.52	25
Lakeview	2,250	3.41	2.73	2.42	1.74	2.62	2.05	1.16	.99	1.79	2.36	4.65	3.20	29.12	33
Montana:															
Butte	5,716	.84	.78	1.09	1.13	2.09	2.23	1.26	.85	1.18	.97	.81	.82	14.05	36
Columbia Falls	3,100	2.05	1.67	1.25	1.21	2.67	2.94	1.56	1.51	2.05	1.43	2.07	1.96	22.37	37
Deer Lodge	4,509	.70	.48	.66	.82	1.65	2.22	.90	.81	1.26	.74	.67	.62	11.53	61
Fortine	2,975	1.66	1.23	1.37	1.02	1.81	2.43	1.52	1.51	1.56	1.10	1.62	1.27	18.10	24
Hamilton	3,583	.87	.67	.72	.97	1.68	1.66	.68	.64	1.11	.92	.88	.49	11.29	35
Kalispell	2,973	1.34	1.05	1.06	.82	1.71	1.98	1.15	1.01	1.47	.94	1.54	1.14	15.21	34
Libby	2,075	2.61	1.70	1.68	1.09	1.53	1.64	1.17	.94	1.56	1.61	3.40	2.34	21.27	35
Missoula	3,225	1.35	.86	1.02	1.03	2.12	2.15	1.02	.86	1.34	1.20	1.18	1.43	15.56	37
Snowshoe	4,500	9.20	5.70	6.24	4.21	4.06	3.24	1.95	1.99	3.65	6.44	14.07	5.87	66.62	5

[a] Records taken in the city of Wenatchee.

[2] Not printed.

136. The popular conception of the excessive rainfall in the Pacific Northwest territory is not altogether correct. The records of the United States Weather Bureau show the following mean annual precipitation records in the principal cities of the Puget Sound-Willamette Valley strip:

Station	Length of record	Average rainfall to 1930
	Years	*Inches*
Bellingham, Wash. (bulb farm)	39	33.45
Seattle, Wash	50	[1] 34.05
Tacoma, Wash	47	39.53
Portland, Oreg	50	[1] 41.62
Salem, Oreg		37.31

[1] To 1927 inclusive (50 years normal).

137. The New York district has 44 inches, Washington, D.C., 43d the major portion of Florida over 50, and an extensive portion of the Gulf States over 60 inches. Outdoor activities are generally carrie, on throughout the year, as hard rains are rare. The greater part of the precipitation during the rainy season falls during the period between sunset and sunrise, so that even in the wet season there are many days on which rain does not fall during the hours of daylight, and many days where there are intervals of several hours of fair weather. Snow does not occur every year west of the Cascades except at higher elevations, and when snow does fall in the valley areas it remains only a relatively short period as a rule. The average January snowfall is 6 inches at Bellingham, 5.2 at Seattle, 6.2 at Tacoma, 6.2 at Portland, and 3 inches at Salem.

3. HUMIDITY

138. The annual relative humidity at Seattle at 5 a.m. is 87 percent, with a range from 85 percent in June to 91 percent in October; the average at 5 p.m. is 66 percent, with a range from 52 percent in July to 82 percent in December, while at Spokane the mean relative humidity is 77 percent at 5 a.m. with a range from 64 percent in July and August to 86 percent in December, and a mean relative humidity of 50 percent at 5 p.m. with a range from 25 percent in July and August to 80 percent in December. The high, and relatively uniform, humidity in the coast section is due, of course, to the marine influence, while the lower humidity and the greater variation in the interior is due to the influence of the Cascade Mountains on the prevailing winds and to the higher summer temperature.

139. Plate no. 6 [2] shows the mean monthly temperatures in Seattle and the annual range of relative humidity and precipitation in percent, largely representative of conditions in the balance of the Puget Sound section. The consistent high relative humidity, not under 55 percent for any length of time, has a very direct bearing upon certain industries, which can operate with a minimum of artificial humidification and the attendant expense, which is necessary in areas of lower humidity and greater variation.

140. Plate no. 7 [2] shows the mean monthly wet-bulb temperature at Seattle and Portland. This temperature is far more important

[2] Not printed.

than a dry-bulb or ordinary temperature, as it measures actual comfort expressing the combined effect of the temperature of the air and of the moisture contained in the air. The ordinary thermometer merely records the temperature of dry air, and registers conditions of actual health and comfort only if the variable moisture is contained in proper proportions.

141. Dry air at 80° temperature and 21 percent relative humidity and moist air at 60° temperature with 85 percent relative humidity have exactly the same wet-bulb temperature of 57°, hence the same degree of comfort. This circumstance explains the discomfort of the humid high temperature of eastern summers. The high temperature can be endured with comfort in the dry air of the semiarid belt, while high humidity accompanied by moderate temperatures, as occurs in the coast sections of Washington, and Oregon causes no discomfort.

142. The findings of Drs. Huntington and Hill [2] and the standards adopted by the American Society of Heating and Ventilating Engineers show that the zone of maximum actual comfort lies between a lower limit of 36° wet-bulb temperature in the winter and 60° in the summer, as shown by the shaded area in plate no. 7 [3]. It will be noted that at Seattle and Portland wet-bulb temperatures fall inside of this zone during the whole year, while the typical wet-bulb temperature of eastern cities, shown in the dotted lines, falls outside of the favorable area, causing discomfort during about 50 percent of the year.

143. The relation between wet-bulb temperature and the death rate has been determined by studies by Drs. Huntington and Hill [4] and by Mr. O. W. Armspach [5], covering nearly 8,000,000 deaths, with the following summarized results: The death rate is lowest at 58° wet bulb, being 10 percent below normal; it reaches normal at 65° and is 25 percent above normal at 75°.

144. For wet-bulb temperature below 58° the following relations result: The death rate increased to normal at 48° and to 25 percent above normal at 35°. The wet-bulb temperature in the Puget Sound-Willamette Valley strip indicates the death rate close to normal and consequently, relatively low. Available records indicate the correlation between this factor and the death rate. The 1929 United States Infant Mortality Statistics show that the cities of Seattle, Portland, and Tacoma have the lowest infant mortality of any cities in the United States in the same population class as shown by table no. 5.

TABLE NO. 5.—*1929 infant mortality rate per 1,000 births*

Population class	Lowest cities	Other United State cities	
		Medium range	Maximum
100,000	Tacoma, 36	65	87
300,000	Portland, 43	70	95
400,000	Seattle, 45—37	68	77

[2] Civilization and Climate, by Elsworth Huntington and Armspach and Hill, investigation published in Journal of American Society of Heating and Ventilating Engineers, May 1920.

[3] Not printed.

[4] Civilization and Climate, by Elsworth Huntington and Armspach and Hill, investigation published in Journal of American Society of Heating and Ventilating Engineers, May 1920.

[5] Armspach and Hill investigation published in Journal of American Society of Heating and Ventilating Engineers, May 1920.

4. FOGS

145. The records of the United States Weather Bureau show an annual average of 73 days of foggy weather in Seattle. Of this total, 32 days represent dense fog, where objects were obscured at a distance of 1,000 feet, and 41 days had light fogs only. In most cases the fog cleared up by noon. October is the foggiest month; the spring and summer months are comparatively clear.

146. Valley fogs occur in the area east of the Cascades, but the foggy period is of shorter duration than in western Washington.

5. SUNSHINE

147. The percentage of sunshine varies between the coastal section and the country east of the Cascades, as would be expected. In Seattle the amount of sunshine averages 43 percent, with a range from 21 percent in December to 65 percent in July. Tacoma has an average of 38 percent, varying from 13 percent in December to 60 percent in July. Spokane, representing eastern Washington, has an average of 52 percent, varying from 20 percent in December to 80 percent in July. At Walla Walla the average is 55 percent, 20 percent in December, 84 percent in July, and 85 percent in August.

148. Table no. 6 shows the hours of direct sunshine in representative parts of the globe.[6]

TABLE No. 6.—*Hours of sunshine in various parts of the globe*

Location	Number of hours of sunshine in a year	Location	Number of hours of sunshine in a year
Southern England and northwestern European coast	1,550	Willamette Valley strip	2,119
North central Europe	1,650	Mediterranean (average)	2,650
Puget Sound	2,047	Southern California and Arizona	3,200
		Sahara, Egypt, Arabia, and deserts	3,500

149. The amount of sunshine is a climatic feature which is receiving more attention on the part of climatologists than formerly. Dr. Huntington and other authorities[7] contend that northern races flourish best when the total duration of direct sunlight is less than 2,000 hours per year; that efficiency declines after 2,500 hours and that a deterioration of the race sets in at 3,000 hours. Sunshine in excess of 3,000 hours at first stimulates, then overstimulates, causing eyestrain, nervous disorders, etc., in races which are not accustomed through generations of adjustment to longer periods of sunlight. It is contended by these authorities that every succeeding generation of northern European stock weakens and finally breaks down in areas of excess sunshine.

150. A fact which has some bearing on the agricultural production is that in Seattle the period between sunrise and sunset is 1½ hours longer on June 21 than in the latitude of Los Angeles, and 1 hour and 20 minutes longer than in the latitude of San Francisco. During most of the growing period, therefore, the period of sunlight is greater in the Columbia Basin than in the territories farther south. No field studies have been made to determine the influence which this

[6] Records of United States Weather Bureau and the Ideal Climate for the Human Race, by Erwin L. Weber, 1924.

[7] Civilization and Climate, by Elsworth Huntington, research professor, Yale University.

factor may have, but laboratory studies indicate that vegetative growth for most plants responds directly to an extension of the period of sunlight, although retarded in some cases by too direct and intense rays.[8]

6. TEMPERATURE

151. The temperatures of the Pacific Northwest are affected by elevation and by the presence or absence of marine influence. In western Washington and Oregon the normal range in temperature is very slight. The periods of extremely cold weather occur usually during storms coming from the north, which only last for a few days. The extremely hot days in eastern Washington also occur occasionally when the hot winds, due to low barometer, blow from the east for periods of 2 or 3 days.

TABLE NO. 7.—*Temperatures for stations in Washington*

Temperature	Month	Seattle	Tacoma	Spokane
Mean annual:				
Mean		51.3	50.9	48.3
Maximum	July	64	63.6	69.5
Minimum	January	40	38.9	26
Mean maximum:				
Mean		58.1	58.3	58.3
Maximum	July	73.1	73.5	84
Minimum	January	44.3	43.9	32
Mean minimum:				
Mean		44.7		38.5
Maximum	August	54.8		
	July			55.5
Minimum	January	35.4		21.2

TABLE NO. 8.—*Temperatures for various stations in Washington, Idaho, and Montana, from reports of the U.S. Weather Bureau*

	Elevation, feet	Degrees Fahrenheit												
		January	February	March	April	May	June	July	August	September	October	November	December	Annual
Washington:														
Bellingham, near	107	36.5	39.4	42.5	47.6	52.7	57.9	61.2	61.3	56.1	49.6	43.2	37.8	49.7
Seattle	125	40.0	41.8	45.0	49.5	55.9	59.6	63.9	63.7	58.8	52.3	46.0	41.7	51.4
Tacoma	194	38.8	40.6	44.2	48.6	54.1	58.7	62.6	62.6	57.3	50.5	44.6	40.6	51.7
Ellensburg	1,510	25.0	31.0	40.4	48.2	55.2	61.5	67.7	66.4	57.2	47.5	36.1	27.4	47.0
Ephrata	1,275	25.9	33.6	43.1	52.6	60.8	68.5	77.1	74.5	63.8	50.1	39.9	28.9	51.6
Hanford	385	28.9	36.8	46.1	53.8	61.4	70.0	76.5	74.1	63.6	52.7	40.5	30.2	52.9
Lind, near	1,475	29.3	33.2	40.9	50.0	57.9	65.3	73.3	72.2	61.1	51.1	38.9	29.7	50.3
Quincy	1,300	14.8	34.2	46.1	54.3	57.8	63.2	74.7	73.1	61.2	45.8			
Ritzville	1,825	27.4	32.7	40.6	48.2	56.0	63.7	71.5	70.0	60.4	50.0	37.2	27.8	48.8
Spokane	1,929	27.5	31.3	39.7	48.4	55.5	62.8	69.0	68.1	59.2	48.3	38.5	30.5	48.2
Wahluke	416	30.0	36.7	46.3	54.7	64.2	69.4	77.1	74.8	65.4	54.4	42.0	32.2	53.7
Wenatchee, near	2,200	25.4	30.1	39.7	48.1	55.5	62.8	70.5	69.2	60.8	49.7	36.4	27.5	48.0
Yakima	1,071	27.4	34.5	44.2	52.5	59.0	66.4	71.4	69.5	61.1	50.2	38.9	30.7	50.5
Idaho:														
Avery	2,500	28.6	31.3	37.4	45.4	52.4	59.4	65.8	64.2	58.7	46.0	35.3	27.0	46.0
Bonners Ferry	1,850	23.0	26.8	37.2	45.7	52.4	58.4	63.8	62.8	55.0	45.3	35.2	26.1	44.3
Burke	4,082	22.0	26.4	32.3	38.6	44.8	51.4	59.9	58.2	53.2	43.2	33.0	22.4	40.4
Coeur d'Alene	2,157	28.3	32.0	37.8	46.8	54.2	61.0	67.8	68.2	58.2	48.4	36.7	31.2	47.6
Kellogg	2,305	26.2	30.7	36.5	45.3	51.5	58.6	65.8	63.4	56.0	46.0	36.2	28.8	45.4
Lakeview	2,250	27.2	30.0	36.2	45.1	51.8	58.5	64.2	63.6	55.0	45.8	36.6	30.8	45.5
Montana:														
Butte	5,716	23.6	25.0	31.4	40.5	48.0	56.6	64.0	63.0	53.0	43.6	33.0	25.1	42.2
Columbia Falls	3,100	22.2	24.4	32.8	43.0	51.4	57.8	64.4	63.2	53.8	43.2	32.2	24.7	42.8
Deer Lodge	4,509	21.6	24.0	30.1	40.6	51.3	61.1	67.7	64.1	55.4	44.0	33.1	21.0	42.8
Fortine	2,975	17.8	23.3	32.9	42.2	49.4	57.4	62.7	60.4	51.7	42.2	31.7	22.6	41.2
Hamilton	3,583	26.8	29.0	38.1	46.7	53.2	60.4	66.8	65.2	56.1	46.4	36.8	27.0	46.0
Kalispell	2,973	22.0	24.2	33.1	43.8	51.3	58.1	64.5	62.8	53.2	43.6	32.7	24.9	42.8
Libby	2,075	23.4	27.9	35.9	46.0	53.1	59.3	64.9	63.4	55.0	45.4	33.9	25.8	44.5
Missoula	3,225	21.8	25.8	35.2	44.9	52.4	59.4	66.9	65.2	55.4	44.8	33.1	24.6	44.1
Snowshoe	4,500	18.8	22.7	32.0	37.6	45.0	52.8	61.1	57.0	50.8	42.5	31.2	21.6	39.4

[8] Plant Physiology, by Duggar.

152. The range in altitudes and latitudes, the normal topographical features, and the general north-south trend of the various mountain ranges, are the potent influences in creating a variation of temperature from place to place. After the westerly winds have crossed the Cascade Range they no longer retain the marine influence, with the consequence that east of this mountain range there is a continental variation in temperature. The upper Columbia Basin is, however, slightly protected by the Rocky and Bitterroot Mountains from the severe interior continental influences, in that the extremes of temperature in eastern Washington and Oregon are not as frequent nor of as long duration as in the States further inland. Neglecting extremes in altitude, latitude has an appreciable influence on temperature.

153. The sections lying in southern Grant, western Adams and Benton Counties have the highest mean annual temperature, and also the lowest mean annual precipitation, there being a direct correlation between the temperature, precipitation, and relative humidity. With this general section as a core, the temperature contour lines tend to be parallel to the topographical features, but at the same time, tend to bend downward with increase in latitude.

7. GROWING SEASON

154. As would be expected, the frost-free period of growing season varies considerably in the general territory under consideration. The dates of the first killing frost in the fall and the last killing frost in the spring are given in table no. 9. It is apparent that so far as temperature is concerned, a wide range of crops can be grown. In the higher elevations, the crops, such as corn, requiring a comparatively long season, would not mature, but in the area covered by the Columbia Basin irrigation project any of the ordinary field crops, vegetables, and fruits would mature satisfactorily, as indicated by the fact that vegetables, including potatoes, require from 60 to 70 days to mature, while small grains require from 65 to 100 days, corn 120 days, and apples 150 days. All of these are well within the range of the growing season in the Columbia Basin irrigation project.

TABLE NO. 9.—*Dates of killing frosts and length of growing season, from records of U.S. Weather Bureau*

	Elevation	Average date of last killing frost in spring	Average date of first killing frost in autumn	Latest date of killing frost in spring	Earliest date of killing frost in autumn	Length of period
Washington:	*Feet*					*Years*
Bellingham, near	107			May 26	Sept. 20	27
Seattle	125			Mar. 17	Nov. 14	30
Tacoma	194			Feb. 28	Nov. 14	24
Ellensburg	1,510	May 13	Sept. 26	May 26	Oct. 9	27
Ephrata	1,275	Apr. 21	Oct. 12	Apr. 27	Oct. 9	8
Farmington	2,900			May 26	Sept. 1	
Hanford	385	May 2	Oct. 15	May 6	Oct. 6	9
Lind	1,475	May 13	Oct. 2	May 7	Oct. 10	10
Quincy	1,300			Apr. 17	Sept. 23	
Ritzville	1,825	May 26	Sept. 26	May 26	Oct. 9	6
Spokane	1,929	Apr. 14	Oct. 12	Apr. 10	Oct. 13	40
Wahluke	416	Apr. 14	Oct. 19	Mar. 17	Oct. 13	15
Walla Walla	991	Mar. 30	Nov. 5	Mar. 16	Oct. 30	36
Wenatchee, near	2,200	Apr. 20	Oct. 25	Apr. 4	Oct. 15	22
Yakima	1,071	Apr. 20	Oct. 17	May 7	Oct. 15	13

TABLE No. 9.—*Dates of killing frosts and length of growing season, from records of U.S. Weather Bureau*—Continued

	Elevation	Average date of last killing frost in spring	Average date of first killing frost in autumn	Latest date of killing frost in spring	Earliest date of killing frost in autumn	Length of period
Idaho:	*Feet*					*Years*
Avery	2,500	June 8	Oct. 8	July 30	Sept. 20	7
Bonners Ferry	1,850	May 4	Sept. 19	May 26	Aug. 24	9
Coeur d'Alene	2,157	May 12	Oct. 14	June 12	Aug. 31	14
Kellogg	2,305	May 17	Sept. 24	May 29	Aug. 28	16
Lakeview	2,250	May 10	Oct. 8	June 30	Sept. 8	19
Montana:						
Butte	5,716	May 29	Sept. 18	July 14	Aug. 24	28
Columbia Falls	3,100	June 11	Sept. 2	July 15	July 19	28
Deer Lodge	4,509	June 11	Sept. 6	July 7	Aug. 15	16
Fortine	2,975	June 13	Aug. 26	July 14	July 19	15
Hamilton	3,583	May 17	Sept. 23	June 10	Aug. 23	22
Kalispell	2,973	May 5	Oct. 2	May 23	Sept. 10	23
Libby	2,075	June 6	Sept. 6	July 15	July 26	27
Missoula	3,225	May 23	Sept. 18	June 20	Aug. 1	31
Snowshoe	4,500	May 25	Sept. 14	May 30	Aug. 24	5

8. EFFECT OF TEMPERATURE ON HUMAN EFFICIENCY

155. Plate no. 8[1] shows the result of Dr. Elsworth Huntington's studies of the effect of temperature on the mental and physical accomplishments of about 400 factory operatives and 1,000 university students.[9] The mean productivity is low from 0° to 20° F., and increases rapidly with the temperature to a maximum at about 38°. With further increases, the mean productivity remains fairly constant until 64° is passed. With continued increases in temperature, the productivity declines at a rapid rate. Dr. Huntington clearly shows by additional studies that the New England industries are economically handicapped by two distinct annual periods of low labor productivity, under the excessive heat of summer and during the cold of midwinter, and his final conclusions relative to the temperature are as follows: The annual temperature range for maximum health and physical and mental productivity lies between a winter minimum of about 40° and a summer maximum of 60° to 65°. (Plate no. 8[1] shows the highest mean productivity to occur between 38° and 64°.)

156. Plate no. 6[2] shows the mean monthly temperature of Seattle and Portland, the largest and climatically most representative Washington and Oregon cities in the Puget Sound-Willamette River strip. It will be noted that in these cities the annual temperature either falls within the zone of maximum comfort and accomplishment, or follows it very closely.

157. As a consequence, industries may in those cities work under favorable labor conditions, with the possibility of a high rate of production during the whole year, and the cost of the product must be competitively affected.

158. Plate no. 9[2] shows the location of the mean July and January isotherms of 64° and 38°. It will be noted that the favorable summer temperature merely touches the northern border of the United States, and the favorable winter temperature traverses the Southern States,

[2] Not printed.
[9] "Civilization and Climate," by Elsworth Huntington, Yale University.

paralleling the Gulf and the Mexican border, and there is only one limited area within the United States where both the most favorable January and July temperature limits occur—in the Puget Sound-Willamette Valley strip. In the balance of the country, the winters are too cold and the summers too hot for maximum comfort and productivity. This circumstance cannot fail to influence the future growth of the population in the "favored strip."

9. WINDS

159. The prevailing winds are from the southwest. The lower air currents may vary because of the influence of low-pressure areas in the North Pacific, or to low-pressure areas in the desert country to the east of the mountains during the summertime. As a result of these and other influences, north and northeast winds occur during portions of the year, which are oftentimes accompanied or followed by storms. The Cascade Mountains protect Seattle and the general territory immediately to the west of the mountains from the full effects of the occasional northeast winds, which winds may cause a greater drop in temperature at Portland, where the gap in the mountains caused by the Columbia River permits the air currents to pass through.

160. During the winter season, brisk to high southeast, south and southwest winds occur, so that the general westerly circulation is interrupted and displaced by the vortex storms from the North Pacific. At such times southwest gales occur along the coast. Occasional dust storms occur in eastern Washington and Oregon and in Idaho. These storms are disagreeable and sometimes cause considerable damage to newly leveled fields. After the land is irrigated the effect of these dust storms is minimized. There are no tornadoes in any of this territory. The average hourly velocity of the wind at various stations in Washington and Idaho is given in table no. 10.

TABLE NO. 10.—*Wind velocities for stations in Washington and Idaho, from records of the U.S. Weather Bureau*

	Length of record (years)	Miles per hour												
		January	February	March	April	May	June	July	August	September	October	November	December	Annual
AVERAGE WIND VELOCITIES														
Washington:														
Port Angeles	18	5.0	4.9	5.4	5.8	6.4	6.5	6.5	5.6	4.5	4.3	4.6	4.8	5.4
Seattle	29	8.2	7.9	8.5	7.7	7.4	7.1	6.3	5.7	6.5	6.7	8.2	8.2	7.4
Tacoma	25	6.5	6.2	6.9	6.3	5.8	5.0	4.7	4.6	5.2	5.3	6.1	6.0	5.9
Spokane	41	5.2	5.4	6.5	6.6	6.5	6.5	5.7	5.0	5.2	4.8	5.3	5.2	5.7
Walla Walla	35	5.8	5.8	6.6	6.6	6.2	6.1	5.8	5.3	5.1	4.9	5.6	5.5	5.8
Idaho: Lewiston	20	4.3	4.3	4.8	5.0	4.6	4.8	4.8	4.3	3.7	3.1	3.8	4.2	4.3
MAXIMUM WIND VELOCITIES														
Washington:														
Port Angeles	18	38	45	40	36	38	38	34	41	36	37	48	38	48
Seattle	29	59	54	49	55	44	47	48	42	48	58	64	64	64
Tacoma	25	40	44	43	35	40	36	40	28	34	36	42	48	48
Spokane	41	40	41	44	40	39	48	52	39	48	44	42	48	52
Walla Walla	36	45	50	45	50	40	65	52	50	38	44	46	60	65

(E) STREAM FLOW AND STORAGE

1. GENERAL

161. *a'. Unequal distribution of precipitation.*—The Columbia River drains a region of extremely diverse topographic and meteorological features. The Rocky Mountains, along the eastern boundary of the drainage basin, the Cascade Range along the western boundary, and the Selkirk, Bitterroot, and other ranges in between, cause most of the basin to be extremely rugged and precipitous. The axes of these mountain systems trend in a north and south direction, roughly parallel to the coast range and perpendicular to prevailing winds from the west and southwest, which become saturated with moisture as they cross the warm Japan current off the Pacific coast.

162. The combined effect of topography and prevailing winds produces abrupt changes in precipitation within short distances so that the precipitation ranges from less than 10 inches to over 100 inches. Upon reaching the coast, the moisture-laden air is forced upward by the coast range, thereby being cooled by expansion. In summer the cooling effect of expansion is wholly or partly offset by a higher temperature of the land areas than that of the ocean. During the winter they are augmented by a lower temperature of the land areas. As a result, a large amount of moisture content condenses during winter and falls upon the westward slopes of the range. After passing the crest of the range, the air currents settle to a lower level, being warmed by compression and by the higher temperatures prevailing at that level. Hence the tendency is for them to yield only a relatively small amount of precipitation in the winter and to actually absorb moisture from areas at low level during the summer. This process is repeated as the prevailing wind passes over the Cascade Range and other mountain systems to the eastward. Each successive range acts as a condenser and an accumulator of moisture, straining it out with varying effectiveness, depending upon the height of the range, the steepness of the western slope, and other factors of less consequence. The intervening valleys, lying in the "rain shadow" of the ranges, receive only a small part of the moisture. They are arid or semiarid, and irrigation is needed for successful agriculture. This unequal distribution of precipitation causes marked differences in run-off per unit of area. The yield of tributaries varies widely, depending upon which side of the ranges they originate and to what extent they drain the arid, or semiarid, intermontane regions. For this reason estimates of stream flow based upon drainage areas, or on precipitation data at sparsely located observation stations, are subject to considerable uncertainty.

163. *b'. Equalizing effects.*—The climate in the eastern part of the Columbia River drainage area is predominantly of the rigorous continental type, whereas in the western part it is modified by the more equable features of the oceanic type of climate. Variations in climate and a spread in latitude of about 7½ degrees are responsible for marked differences in the accumulation of snow and ice in the winter and in the rate of melting in the summer. In the southern part of the basin, melting snow begins to augment stream flow much earlier in the season than in the northern part. The later yield of the northern part, however, is decidedly advantageous, because it produces an increased run-off during the hot and dry summer months, and in

conjunction with natural lake storage, discussed in the next paragraph, extends the benefit into the fall months.

164. During several times in the past the northern part of the drainage area has been covered to a large extent by glaciers. Movement of the glaciers gouged great troughs which are occupied now by a multitude of lakes. The lakes have a combined area of at least 1,100 square miles and their capacity, below low stage and average annual crest stage, is about 9,000,000 acre-feet. The annual filling and draining of this huge natural reservoir has a marked equalizing effect. The lakes act as a shock absorber in capturing a considerable part of the spring flood flow and releasing it gradually during the summer and fall, thereby producing a well-sustained flow in the main river and on some of the tributaries.

165. *c'. Records.*—The longest record of stream flow in the Northwest is on Columbia River at The Dalles. Observations of stage were started by the Corps of Engineers at Umatilla in June 1878 and later at The Dalles and above the Cascades; also the United States Weather Bureau has obtained gage readings since February 1892. These records of stage, together with measurements of discharge made by the Corps of Engineers and the United States Geological Survey, furnished the base data used by the United States Geological Survey in computing discharge during the past 53 years.

166. Records of discharge on Columbia River above Snake River were not started until May 1913, when a gaging station was established at Trail, British Columbia. The gaging station at Vernita, Wash., was started in January 1917 and discharge computations carried back to May 1913 by making use of United States Weather Bureau observations of stage at Wenatchee. Fragmentary records of stage were kept at several points along the river prior to May 1913; but they cannot be used for determining discharge satisfactorily on account of uncertainties in datum and in rating. Discharge estimates at Kettle Falls and at Grand Coulee have been extended to May 1913 by balancing between results at Trail, British Columbia, and Vernita, Wash., and taking into account the flow of intervening tributaries.

167. The second longest record in the Northwest is on Spokane River at Spokane, where observations have been continuous since April 1891. Records were started on Yakima River in August 1896, on lower Clark Fork, Methow, and Chelan Rivers in 1903, on Wenatchee River in July 1904, on Flathead River in July 1907, and on Okanogan and Priest Rivers in 1911.

168. One of the first steps taken in planning the present investigation was to ascertain the status of existing stream-flow records. They were found to be meager and inadequate. Hence funds (see par. 26) were transferred to the United States Geological Survey for establishing and maintaining the gaging stations shown in table no. 11. Unfortunately, the results at some of the gaging stations were of too short duration to be used in the storage analyses. They were of value, however, in reflecting varying characteristics of yield. The United States Geological Survey has arranged for the continuance, after September 30, 1931, of the most important of the newly established gaging stations.

TABLE No. 11.—*Gaging stations established in connection with the present investigation*

River and location	Type of gaging station	Records started
Columbia River at Grand Coulee, Wash.	Recorder, permanent construction	June 1, 1928.
Kootenai River at Leonia, Idaho	do	March 25, 1928.
Clark Fork near Missoula, Mont.	Staff gage	March 16, 1929.
Clark Fork at St. Regis, Mont.	do	February 18, 1929.
Clark Fork near Heron, Mont.	Recorder, creosoted fir construction	September 21, 1928.
Pend Oreille Lake at Hope, Idaho	Recorder, permanent construction	October 8, 1929.
Clark Fork at Priest River, Idaho	Recorder, creosoted fir construction	September 22, 1928.
Flathead River near Columbia Falls, Mont.	Recorder, untreated wooden construction.	April 6, 1929.
Middle Fork of Flathead River at Belton, Mont.	Staff gage	February 24, 1929.
South Fork of Flathead River near Columbia Falls, Mont.	Recorder, permanent construction	August 15, 1928.
Priest River at Priest River, Idaho	do [1]	February 28, 1929.
Little Spokane River at Dartford, Wash.	Staff gage	April 22, 1929.
Okanogan River near Tonasket, Wash.	Recorder, creosoted fir construction	April 17, 1929.
Wenatchee River at Peshastin, Wash.	Staff gage	March 1, 1929.

[1] Part of cost borne from cooperative funds.

169. The maximum flow of upper Columbia River ranges from about 700,000 second-feet at Kettle Falls to about 740,000 second-feet at Vernita. The mean flow at those localities ranges from 100,000 second-feet to 121,000 second-feet, respectively, and the minimum flow from about 14,000 second-feet to about 21,000 second-feet. The extreme minimum flows are caused by a rapid formation of ice during a sudden and severe freeze which affects the flow in two ways: first, by increasing frictional resistance, thereby causing backwater and building up channel storage; and second, by deducting from stream flow the amount of water changed into ice. These influences are of short duration, seldom in effect for more than 10 days.

170. *d'. Period chosen for investigation.*—Stream-flow data for the principal tributaries are available for somewhat longer periods than at points on the main stream above Snake River. The extra length of record is of great importance in appraising feasibility of projects on the tributaries; but unfortunately it is of little use in investigating projects on the main stream. In view of the possibilities on the main stream being of much greater magnitude than on the tributaries, and also in view of the greater emphasis placed on those possibilities in this investigation, it seemed best to limit the analyses on tributaries to the period during which the flow of the river proper is known. The period chosen covers 18 years, extending from April 1913 to March 1931. The year ending March 31 seemed better suited to storage operations than the usual climatic year ending September 30, because the need for storage usually ceases at the end of March. During most Aprils a start can be made toward accumulating storage for use during the ensuing low-water fall and winter months. The term "storage year", as used in this report, refers to a year ending March 31.

171. The period chosen for investigation includes three storage years, during which the yield was exceedingly low for part of the time (1919–20, 1926–27, and 1929–30) and also three storage years containing periods of unusually high yield (1913–14, 1916–17, and 1928–29). Records at The Dalles seem to indicate that the periods of low yield, within the 18-year period, are as critical from the standpoint of both power and irrigation use, as any during the past 53

years. The flood of June 1894, however, was very much greater than any that occurred during the 18-year period chosen for the analyses.

172. In order to ascertain to what extent records during the past 18 years may afford a true picture of water supply, a comparison was made between the flow of Columbia River at points above Snake River, and of the principal tributaries, with that at The Dalles, as shown in table no. 12.

TABLE NO. 12.—*Comparative yield for periods longer and shorter than that chosen for the water-supply and storage analyses, percent of average yield for the 18 years ending Mar. 31, 1931*

Stream and location	During the last—						
	53 years	40 years	28 years	18 years	9 years	5 years	2 years
Columbia at Kettle Falls				100.0	94.3	93.0	76.6
Columbia at Grand Coulee				100.0	94.6	92.9	75.6
Columbia at Vernita			[1] 101.4	100.0	93.5	91.5	73.9
Columbia at The Dalles	107.6	106.3	101.6	100.0	93.4	84.7	74.7
Wenatchee, Chelan, and Methow, aggregate			105.2	100.0	88.1	78.7	63.7
Spokane at Spokane		107.2	100.5	100.0	92.3	88.2	55.8
Clark Fork at Newport			104.9	100.0	94.5	93.7	67.5
Kootenai at Nelson, B.C.				100.0	90.8	89.0	73.6

[1] Estimated.

NOTE.—Percentages for Columbia at The Dalles are based on measured flow plus a uniformly increasing allowance for depletion, due to irrigation, varying from zero in 1887 to about 7 percent of normal river flow in 1931. Results at the other gaging stations are affected so slightly by irrigation depletion that corrections on that account did not seem essential for the comparison.

173. The foregoing table indicates a close agreement between the flow at The Dalles and at points above Snake River, even though Snake River has characteristics quite dissimilar to those of the Columbia. The agreement is not so close in respect to the yield of tributaries. In general, yields of the Columbia and of the upper tributaries appear to be more nearly comparable than might be expected. The comparison demonstrates that the long-time records at The Dalles reflect the status of run-off in the whole basin fairly well and may be used as an index of performance in the upper part of the basin during the past 53 years. Hence, it may be assumed that mean annual run-off during the past 53 years was 7 or 8 percent greater than during the 18 years chosen for investigation. Conversely, the possibilities set forth in this report may represent only about 93 percent of the true long-time possibilities.

174. A striking feature of the comparison is the way in which the percentages progressively decrease as the number of years decreases. For example, The Dalles percentages range from 107.6, for the last 53 years, to 74.7 for the last 2 years. Apparently an explanation of this phenomenon lies in a periodic variation in run-off.

175. *e'. Periodic variation.*—Cumulative departure from mean annual run-off for Columbia River at The Dalles, after correction has been made for assumed irrigation depletion, is shown on plate no. 10.[2] The graph reflects yield in terms of that occurring during the 18 years chosen for the analyses, because the mean annual run-off during those 18 years is taken at 100 percent and constitutes the basis of computing departures. A slope upward represents an annual run-off greater

[2] Not printed.

than the average during the last 18 years, and a slope downward represents a smaller annual run-off. Except for short intervals, such as 1889 to 1893, 1905 to 1907, and 1915 to 1916, the general trend was upward from 1879 to 1923; thereafter the trend is downward. The steepest downward slope since 1878 occurred during the two storage years ending March 31, 1930 and 1931, when the yield was only 74.7 percent of the base flow. Dotted slope lines indicate relation between base flow or 18-year flow, and that recorded during longer and shorter periods. The periods and percentages are the same as given in table no. 12, for Columbia River at The Dalles.

176. A graph representing cumulative departure from average provides a good means of visualizing variations in run-off in terms of yield during any given period. A 5-year, running, weighted, graph, however, is better adapted to emphasize the ups and downs of yields and to compare periodic characteristics.

177. The 5-year, running, weighted graphs in plate no. 11[2] are also based upon percent of mean flow during the 18 years ended March 31, 1931. The graphs indicate that:

First, the flow of Columbia River is much more uniform than that of the upper tributaries; the range in the upper set of graphs is only 36 percent, whereas the range for the lower set is about 62 percent.

Second, periodic characteristics of the main stream, at different points along its course, are quite similar. Those of the upper tributaries vary widely. It will be noted that the Cascade drainage, as represented by "sum of Wenatchee, Chelan, and Methow", had a relatively higher yield than Clark Fork and Spokane River from 1905 to 1910, and a decidedly lower relative yield from 1926 to 1929.

Third, fluctuation in the flow of Columbia River was much greater prior to 1906 than after that year; during the last 18 years the fluctuation was just a little over half that occurring from 1891 to 1895.

Fourth, except for being more erratic, Clark Fork and Spokane Rivers have about the same characteristics as the main stream.

178. *f'. Storage possibilities.*— The flow of the Columbia River and principal tributaries above the Snake River is fairly well sustained by melting snow and glaciers and by the natural stabilizing effect of a large number of lakes. Even so, conditions are so favorable for creating storage at relatively low cost that any comprehensive plan of development must of necessity take into consideration the probable influence of prospective storage operations. The mountainous regions contain numerous lakes of glacial origin that could be controlled advantageously, but only the larger and the more outstanding storage possibilities, as shown in table no. 13, have been given consideration in this investigation. The location of the reservoirs considered and the usable storage within assumed limiting elevations are given in this same table.

[2] Not printed.

TABLE No. 13.—*Reservoir sites given consideration in the present investigation*

Reservoir and stream	Regulations between elevations	Storage assumed to be available
	Feet	*Acre-feet*
Hungry Horse: South Fork of Flathead River, in Montana	3,435.0 and 3,312.0	1,100,000
Flathead Lake: Flathead River, Mont.[1]	2,893.0 and 2,880.0	1,540,000
Pend Oreille Lake: Clark Fork, in Idaho	2,066.8 and 2,049.0	1,620,000
Priest Lake: Priest River, in Idaho	2,459.0 and 2,436.7	569,000
Kootenai Lake: Kootenai River in British Columbia	1,746.0 and 1,740.2	715,000
Coeur d'Alene Lake: Spokane River, in Idaho [2]	2,129.1 and 2,117.7	430,000
Columbia: Columbia River above Grand Coulee Dam, in Washington:		
High dam	1,287.6 and 1,207.6	5,028,000
Low dam	1,157.6 and 1,127.6	776,000
Grand Coulee: Former bed, Columbia River, in Washington	1,570.0 and 1,554.8	329,000
Chelan Lake: Chelan River, in Washington [3]	1,100.0 and 1,079.4	665,000
Chiwawa: Chiwawa River, tributary to Wenatchee River, in Washington	2,550.0 and 2,409.4	482,000
Wenatchee Lake: Wenatchee River, in Washington (power only)	1,980.0 and 1,901.0	1,000,000
For irrigation of Quincy unit	(2,009.0 and 1,875.0)	(1,660,000)
Keechelus Lake: Yakima River, in Washington	2,515.0 and 2,425.0	152,000
Kachess Lake; Kachess River, tributary to Yakima River, in Washington	2,258.0 and 2,192.8	221,000
Cle Elum Lake: Cle Elum River, tributary to Yakima River, in Washington	2,252.0 and 2,105.0	501,000
Bumping Lake: Bumping River, tributary to Yakima River, in Washington	3,426.0 and 3,389.0	34,000
Tieton: Tieton River, tributary to Yakima River, in Washington	2,926.0 and 2,766.0	198,000
Total, if Columbia River at Grand Coulee is developed by means of the high dam		14,584,000
Total, if Columbia River at Grand Coulee is developed by means of the low dam		10,332,000

[1] Assumed ultimate development, the present plan of development of the Rocky Mountain Power Co., contemplates the use of only 1,100,000 acre-feet.
[2] Includes 155,000 acre-feet now used by the Washington Water Power Co.
[3] The Chelan Electric Co., has regulated storage in Chelan Lake within these limits since Aug. 1927.

179. The interests of flood control, irrigation, and power are often conflicting in their demands for the release of storage from reservoirs. For instance, flood control requires a reservoir to be kept as nearly empty as possible, whereas power and navigation require it to be kept as nearly full as possible. This conflict of interests becomes in certain cases so acute that the joint use of the reservoir for the purposes mentioned becomes impracticable.

180. The use of auxiliary steam power to supplement the output of hydroelectric plants is less economical in the northwest than in many other parts of the country. Storage reservoirs, however, can be utilized to a large extent as a substitute for auxiliary steam power so that power plants on streams capable of regulation by storage will be provided with excess capacity to accommodate load fluctuations while power plants on uncontrollable streams are carrying as much of the base load as possible. Storage possibilities will probably be held at a premium in the future and costs per acre-foot, deemed excessive now, may soon be justified.

181. *a''. Hungry Horse Reservoir.*—The Hungry Horse Reservoir site is located in the Flathead National Forest in the State of Montana, about 35 miles by river northeast of Flathead Lake. The Hungry Horse Dam site is located about 8 miles east of Columbia Falls, Mont., on the South Fork of Flathead River, about 4 miles above its mouth. Most of the drainage area has an excellent forest cover.

182. A dam 480 feet high and about 2,240 feet long on top would impound about 3,300,000 acre-feet of water, or enough to equalize the

flow during a period of 10 years. The storage could be used jointly for flood-control, power, and irrigation with little or no conflict. Whether or not the provision of so much storage would be economically feasible, would depend upon the cost of the dam, an adequate spillway, and regulating works balanced against the relative benefits obtainable by the three usages.

183. Pardee [10] reports that the foundations and other physical features appear to be favorable for building a dam any height up to 500 feet.

184. The analyses made in this office have been based on obtaining 1,550,000 acre-feet of gross storage and 1,100,000 acre-feet of effective storage, which would require a dam 365 feet high with a maximum reservoir elevation of 3,435 feet and a drawdown of 123 feet to elevation 3,312 feet.

185. The effective storage of 1,100,000 acre-feet is the same as was used in previous studies by other agencies and has served as a basis for the regulation of the Hungry Horse Reservoir for the 18-year period ending March 31, 1931. It resulted in a minimum regulated flow of 708 second-feet, as against a minimum natural flow of 309 second-feet, representing an increase of 399 second-feet, or 129 percent. The area-capacity curves used by this office are shown on plate no. 12.[2]

186. A later paragraph gives the results of studies made by this office to determine the effect of the regulation of the Hungry Horse Reservoir between elevation 3,435 feet and elevation 3,455 feet for flood control exclusively, on the levels of Flathead Lake and Pend Oreille Lake.

187. *b''. Flathead Lake.*—Flathead Lake is the second largest body of fresh water entirely within the United States, and is located in the northern portion of the State of Montana. The area of Flathead Lake, at elevation 2,881 feet, is approximately 107,000 acres, or approximately 167 square miles. The shores are fairly steep, except at the upper end where the Flathead River has built up a large delta.

188. The analyses made in this office have been based on controlling the lake level below elevation 2,893 feet. The assumed ultimate development would involve lowering the lake outlet about 3.6 feet in order to provide sufficient outlet capacity, when the lake was at elevation 2,880 feet, to pass a minimum regulated flow of 7,100 second-feet. This lower limit of draft is the lowest mentioned in the Cavanaugh report,[11] which assumed 1,600,000 acre-feet to be available. The difference between the figure of 1,600,000 acre-feet used in that report, and the corresponding figure of 1,540,000 acre-feet used in this present analysis, is due to a revision in the capacity curve. (See plate no. 13 [2] for the area-capacity curves as used by this office.)

189. In view of the fact that the lake would be controlled within a range in stage that occurs under natural conditions, no misgivings need be entertained as the probable watertightness of the reservoir. An excellent dam site is available at the Newell tunnel site, about 5 miles downstream from the outlet of the lake, at a point where the Rocky Mountain Power Co. is now building a dam as mentioned in a later paragraph in the power section under "Tributary Effects."

[2] Not printed.
[10] Unpublished report of the U.S. Geological Survey, 1928; by J. T. Pardee on the geology of the Hungry Horse Dam site.
[11] Report to the Federal Power Commission on the Uses of the Upper Columbia River, 1925.

190. A Federal Power Commission license (project no. 5) was granted in May 1930 to the Rocky Mountain Power Co., which permits initial regulation of Flathead Lake between elevation 2,893.0 feet and elevation 2,883.0 feet, as referred to a certain United States Geological Survey bench mark at Somers, Mont. The Rocky Mountain Power Co. began construction in July 1930 and has so far constructed the diversion tunnel.

191. *c''. Priest Lake.*—Priest Lake is located in northern Idaho near the international boundary. It forms an enlargement of Priest River and has an area of about 23,500 acres at low water. The banks are mostly steep and the area subject to flooding by a rise of the water surface is not large.

192. The limiting lake elevation used in this report (2,436.7 feet to 2,459.0 feet, U. S. C. & G. S. datum) vary from those mentioned in the Cavanaugh report, which assumed that Priest Lake would be regulated between elevations 2,457.0 feet and 2,434.0 feet. The effective storage capacity for a drawdown of 23 feet was given in the Cavanaugh report as 600,000 acre-feet, but this capacity is greater than that obtained from plate no. 14,[2] which shows the area-capacity curves for the lake as used by this office.

193. Several dam sites have been investigated, but the one that seems most promising is located about 2 miles below the outlet.

194. The Gault report (Senate Committee print, 69th Cong., 2d sess., p. 107, Columbia Basin project) indicates that 612,000 acre-feet of storage would be obtainable by regulation between elevation 2,438.5 feet and 2,462.5 feet, United States Geological Survey datum (see Bull. 567), which is equivalent to 2,435.6 feet and 2,459.6 feet, United States Coast and Geodetic Survey datum as used in this report, and that the cost would be $538,497, or 88 cents an acre-foot; a very low cost of storage considering its utility not only on Priest River, but also on Clark Fork and Columbia River. The 1925 Board of Engineers report to the Bureau of Reclamation on the Columbia Basin Irrigation project took into account the possibility of using either Priest Lake or Coeur d'Alene Lake to supplement storage available in Pend Oreille Lake in supplying a maximum project of 1,883,000 acres. Thereafter the Idaho Legislature passed a law placing limitations on the use of either Priest or Coeur d'Alene Lakes for storage.

195. A license for power development on Priest River, 2 miles below the outlet of the lake, was granted in August 1930 by the Federal Power Commission (project no. 885) to the city of Sandpoint, Idaho, which city is thereby allowed to regulate Priest Lake between elevations 2,436.1 feet and 2,440.2 feet, United States Coast and Geodetic Survey datum. Between these limitations, corresponding to a drawdown of only 4.1 feet, there would be 97,600 acre-feet of effective storage. More detailed information on this power development of the city of Sandpoint will be found in a later paragraph in the power section under "Tributary Effects". The proposed operation contemplates the release of some water to facilitate log driving but no allowance has been made for that use in the present investigation.

196. *d''. Pend Oreille Reservoir.*—Pend Oreille Lake is an enlargement of Clark Fork that embraces an area of about 80,000 acres, or 125 square miles, lying wholly within the northern panhandle of Idaho. Priest River joins Clark Fork between the lake outlet and Albany

[2] Not printed.

Falls where a control dam could be located; consequently, it is tributary to the Pend Oreille Reservoir site.

197. The elevation (2,066.8 feet U. S. C. & G. S. datum), below which regulation of Pend Oreille Lake was assumed to be practicable, together with the estimated cost of overflow damages, was determined after careful field investigations and inspection of the areas involved. During the field investigation attention was directed to those areas which would be submerged by the proposed regulation; areas that, while not submerged, might be damaged by the regulation; damages to railroads, highways, and adjacent towns with their questions of flood control, waterworks, sewers, and other improvements.

198. Estimates of damage to property subject to overflow by the proposed regulation were based upon data secured from inspection and upon studies of county records and data collected for the purpose of considering problems relating to the allocation of water among the Northwestern States. The damages estimated [12] and included in this report are ample to recompense all injured parties, including the various political units of the State depending upon State or county taxation.

199. Pend Oreille Lake in its unregulated condition has reached or exceeded elevation 2,066.8 feet 6 years out of 29 years of record, or about 1 year out of 5. The maximum known stage, 2,076.08 feet, occurred during the 1894 flood. Elevation 2,066.8 feet, as used in this report, is equivalent to elevation 2,070 feet mentioned in the Cavanaugh report,[13] the discrepancy of 3.2 feet being due to a difference between United States Coast and Geodetic Survey datum and United States Geological Survey datum.

200. The proposed plan of creating storage in Pend Oreille Lake provides for constructing a dam across three channels of the river at Albany Falls, 27½ miles by river below Sandpoint, Idaho, which is at the lower end of the lake. At Albany Falls the river crosses a dike of hard rock which affords a satisfactory foundation for a controlling dam. The elevation of the water surface at the dam site, during medium low stage, is about 13 feet lower than the corresponding uncontrolled lake level and about 31 feet lower than the proposed maximum controlled elevation. A dam providing 12 feet of freeboard would have a maximum height of about 82 feet at the deepest part of the main channel.

201. The area and capacity curves shown on plate no. 15 [2] were based upon topographic maps, scale 1:31,680, which were prepared from surveys by the United States Geological Survey in 1926.

202. *e''. Coeur d'Alene Lake.*—Coeur d'Alene Lake is a large body of water located in the western part of Idaho, 25 miles east of Spokane. The area is approximately 52,100 acres, or 81 square miles, at elevation 2,127.0 feet, United States Coast and Geodetic Survey datum.[14]

203. The Washington Water Power Co. has regulated Coeur d'Alene Lake below elevation 2,123.6 feet since July 1906 and controls flowage rights up to elevation 2,125.1 feet. The average annual crest elevation (about 2,128.5 feet) is nearly 5 feet higher than the present upper limit of control, and lakes can usually be regulated

[2] Not printed.
[12] See Estimates Plan No. 2, Feature No. 1, irrigation section.
[13] Report to the Federal Power Commission on the uses of the upper Columbia River, revised edition 1924.
[14] For a discussion of differences in datum see U.S. Geological Survey water-supply paper 632, p. 100.

economically up to a greater elevation than the annual average crest elevation. The advantage of utilizing additional storage appeared to be so great that a reconnaissance was made to determine possibilities and to estimate the cost of controlling the lake within reasonable and economical limits. As a result of field investigations and studies of data relating to possible damage to railroads and other improvements adjoining the lake, and along the lower courses of the three principal tributaries, it was concluded that the lake could be regulated below elevation 2,129.1 feet, without unduly disturbing property rights or other equities. The estimated cost of regulation below that elevation is included in the irrigation section [15] of the report. The recorded annual crest elevations of the lake have exceeded 2,129.1 feet during 14 of the past 40 years, or about once in every 3 years.

204. In 1927 the Idaho State Legislature passed a law placing limitations upon the use of Coeur d'Alene Lake for storage purposes.

205. The area and capacity curves, shown on plate no. 16 [2] are based on information furnished by The Washington Water Power Co.

206. *f''. Kootenai Lake.*—Kootenai Lake is located in British Columbia, a few miles north of the international boundary. The storage analyses include regulation within a part of the natural range in stage because the West Kootenay Power & Light Co. has an application pending before the International Joint Commission on Waterways, which proposes regulation of Kootenai Lake below an elevation corresponding to a reading of 6 feet on the Nelson gage; equivalent to elevation 1,745.8 feet, Geodetic Survey of Canada datum, and elevation 1,746.0 feet, United States Coast and Geodetic Survey datum. The plan of development includes excavation in the outlet channel at Grohman Narrows for the purpose of reducing crest stages in the lake and for permitting the lake to be drawn down to a lower level, for a given discharge, than would be possible under natural conditions.

207. The Dominion Water Power and Hydrometric Bureau of Canada furnished the monthly discharge of Kootenai River at Nelson, B.C., and the lake elevations for the last day of each month upon which the storage analyses were based. It also furnished most of the information used in defining the area and capacity curves shown in plate no. 17.[2] Areas submerged in Idaho under natural conditions and during different stages of dike construction were furnished by the United States Geological Survey.

208. *g''. Columbia River reservoir.*—The artificial lake, or reservoir, that would be formed by a dam across Columbia River at the Grand Coulee power site has been designated the "Columbia River reservoir."

209. The proposed high dam, backing water up to elevation 1,287.6 feet, would create a reservoir 150 miles long, with an area of about 76,800 acres, or 120 square miles. It would extend up the Columbia as far as the international boundary, and up the Spokane about 32 miles, almost to the tailrace of the present power plant at Little Falls. The Kettle Falls power site on the Columbia and the two lower power sites on the Spokane (Fish Hawk and Narrows) would be drowned out.

210. The proposed low dam, backing water up to elevation 1,157.6 feet, would create a reservoir extending up the Columbia about 110

[2] Not printed.

[15] See estimate, Plan No. 2-A, Feature No. S-V-1.

miles, to the tailrace of Kettle Falls power site, and up the Spokane about 11 miles. Most of the head at the Narrows power site on lower Spokane River would be drowned out. The flowage area would be about 29,300 acres, or nearly 46 square miles.

211. Release of storage from behind the proposed Grand Coulee dam would decrease head at the Grand Coulee power site to the extent that the reservoir level was lowered. Therefore, storage regulation would not be practicable unless the increase in flow more than offset the decrease in head. A study was made of the relation between storage draft, resulting flow, and resulting power, which indicated that the economic limit of draft behind the high dam during the critical period of low flow in the winter of 1929–30 was about 60 feet, if only the power possibilities at the Grand Coulee power site were taken into consideration. If utility of the storage at all Columbia River sites below Grand Coulee down to and including Priest Rapids were taken into consideration, the economic storage draft would exceed 80 feet, but the maximum was fixed at that amount because a greater draft would hamper navigation past Kettle Falls. Storage operations for periods of extremely low yield were based on a draft of 80 feet; for other periods on a draft of 70 feet.

212. In like manner the economic limit of draft behind the low dam, when used in connection with the gravity plan (no. 2-A) of development, was found to be about 20 feet, if governed by needs at the Grand Coulee power site alone, and about 50 feet if governed by aggregate needs of all Columbia River power sites down to Priest Rapids. With the pumping plan (no. 4) in operation the limits of drawdown would be less on account of pumping head being increased by the amount of drawdown. Use of the same drawdown for analyses of both projects seemed desirable, in order to simplify comparison of the gravity and pumping plans of development and to avoid undue complexity. Accordingly a maximum drawdown of 30 feet was chosen and used in connection with assumed storage operations for the period of critically low flow, during the storage year 1929–30. Assumed storage operations for the remaining years were based on a draft of 25 feet.

213. The high dam would submerge the city of Marcus and about 15 miles of the Great Northern Railway Co.'s branch lines, as well as the power sites mentioned in the foregoing. The flowage area would include isolated tracts of cultivated land closely adjacent to the river and the principal tributaries and also some higher areas that could be irrigated economically by pumping. Otherwise, damage to agricultural interests would be slight.

214. Area and capacity curves for the Columbia River reservoir are shown on plate no. 18.[2]

215. *h''. Grand Coulee reservoir.*—The original plan of developing the Columbia Basin irrigation project by pumping, as outlined by engineers of the State of Washington,[16] contemplated the construction of two dams across Grand Coulee. One of the proposed dams was located near the northern end of the coulee and the other near Coulee City. The purpose of the dams was not to create a reservoir, but to provide a conduit, through which water could be delivered with a minimum loss of head. Water-supply analyses for the Gault[17]

[2] Not printed.
[16] Columbia Basin Project; Columbia Basin Survey Commission ,State of Washington, 1920.
[17] Columbia Basin Project; Gault Report, March 1924; Senate Committee print, 69th Congress, 2d session.

investigation were based on a storage draft of 5 feet in the Grand Coulee Reservoir, which was assumed to provide 108,000 acre-feet for use in meeting part of the irrigation requirement during an occasional April, whenever the flow of the Columbia was considerably below normal for that month. Such use of storgae would materially decrease the power needed for pumping during April and thereby permit most of the pumping requirements to be met from secondary power.

216. The use of storage from Grand Coulee Reservoir to meet part of the irrigation requirement during some Aprils, and to offset assumed seepage losses during short intervals of some winters, appeared to be so advantageous that analyses for the present report were based on a maximum draft of 15.2 feet, representing 329,000 acre-feet of storage.

217. The proposed dams at either end of the reservoir would be about 18 feet higher than contemplated in previous investigations. The one at the northern end would be at practically the same location, but the one at the southern end would be located farther north than the site chosen originally, in order that a monoclinal fold, crossing the coulee about 4 miles north of Coulee City, would be excluded from the submerged area. The length of the reservoir would be about 23 miles, the width would vary from one half a mile to 3 miles, and the flowage area at maximum stage, elevation 1,570 feet, would be about 23,200 acres.

218. The bed of the coulee is composed of water-lain material and wind-blown loess, overlying an irregular basalt foundation. The side walls consist of nearly vertical cliffs of basalt, projecting above talus slopes of disintegrating basalt. At Dry Falls, about 5½ miles below the southern dam site, a sheer drop of about 400 feet occurs in the floor of the coulee; and at a point about 1½ miles from the northern dam site, Columbia River flows at an elevation about 600 feet below the floor of the coulee. This proximity of drainage outlets and the possibility of seepage through the basalt and along the contact planes of successive layers of the basalt, were a source of grave concern as to the feasibility of the reservoir site. Whether excessive leakage would occur or not was given, perhaps, more careful consideration in the present investigation than any other single feature of the pumping plan of developing the Columbia Basin irrigation project. Even though the engineers and geologists connected with previous investigations had concluded that the reservoir would be fairly tight,[18] additional investigations and reports were made by three highly competent geologists (see appendix no. 3, page 1178). An engineer [19] of wide experience also inspected the reservoir site and gave the seepage problem special attention. The findings of these specialists, together with information obtained by drilling, by digging test pits, and by a field examination of ground water levels and drainage conditions, led to fixing an allowance for leakage that appeared to be conservatively high by all parties consulted. A more complete discussion is included in the irrigation section of this report. The allowance chosen for leakage and evaporation, 1,000 second-feet, represents a loss of over an inch a day, or 31.2 feet a year, over the area to be submerged.

[18] The Gault investigation took into account an assumed seepage loss of 100 second-feet.
[19] A. J. Wiley, Consulting Engineer, Boise, Idaho.

219. A large part of the area within the reservoir site is suitable for winter grazing. From 3,000 to 4,000 acres have been cultivated in accordance with dry-farming methods, but the precipitation is so low and erratic that production is rather uncertain. Irrigation of 1,200 to 1,500 acres by pumping from lakes may prove practicable. The utility of land within the reservoir site for agricultural or for other purposes is of small consequence in comparison with its value as a reservoir site.

220. Area and capacity curves for the Grand Coulee Reservoir are shown in plate no. 19.[2]

221. *i''. Lake Chelan.*—Lake Chelan has been described in paragraph 62, and stream flow and other data are given in tables 38 and 62 and paragraph 843. The Federal Power Commission has granted a license (Project No. 637) to the Chelan Electric Co., a subsidiary of the Washington Water Power Co., to regulate Lake Chelan between elevations 1,079 feet and 1,100 feet, subject to certain restrictions which are not burdensome. Regulation began in August 1927. The total storage capacity is about 665,000 acre-feet. Area-capacity curves for the lake are shown on plate no. 20.[2]

222. *j''. Reservoirs on Wenatchee River.*—Wenatchee Lake and River have been briefly described in paragraph 63. Stream-flow data are given in the tables at the end of this section. A further discussion of Wenatchee Lake and Chiwawa Reservoir appears in a later section entitled "Tributary Effects." The possibility of using Wenatchee Lake as a storage reservoir and as a source of supply for irrigating water for the large area of land lying east and south of Quincy and Ephrata has been discussed for a number of years. Several preliminary reports have been made by various agencies covering such development, and some years ago the Quincy Valley Irrigation District was formed for the purpose of constructing the necessary works. Financial difficulties prevented the execution of these plans, although legislation was secured reserving a portion of the water of Wenatchee Lake for the use of the Quincy area.

223. The site selected for a dam to create usable storage in Wenatchee Lake is located about 9 miles below the lake outlet at natural low-water elevation 1,798 feet. No subsurface explorations were made at the dam site. A geological report covering this site will be found in Appendix 3, page 1178. Chiwawa River enters the main stream above the dam site.

224. About 1,660,000 acre-feet of usable storage would be provided in Wenatchee Lake Reservoir between elevations 2,009 feet and 1,875 feet, and about 1,000,000 acre-feet between elevations 1,980 feet and 1,901 feet, the former being the amount used in the study of plan no. 6-A of irrigating the Columbia Basin Irrigation Project; the latter being the amount used in the study of plans nos. 2-A and 4 of irrigating the same project.

225. The area-capacity curves for Wenatchee Lake Reservoir are shown on plate no. 21 [2] and the topography at the dam site is shown on plate no. 22.[2] It is understood that about half of the lake's shore lands are State-owned and that the State has agreed to sell these lands to the Wenatchee Reclamation District for $3,137.75. The lake and the dam site lie within the Wenatchee National Forest.

[2] Not printed.

226. Under date of August 10, 1927, Cascade Power Co., a subsidiary of the Puget Sound Power & Light Co., applied to the Federal Power Commission (Project No. 839) for a preliminary permit for power development on Wenatchee River. In that application it was "proposed to construct an earth and rock-filled dam about 3 miles below the outlet of Wenatchee Lake, of such height as will raise the present waters of Wenatchee Lake to the elevation of 1,910 feet (U.S.G.S. datum), thus making a storage reservoir of Wenatchee Lake. * * * It is further proposed to build a concrete masonry dam at a point * * * about 2 miles west of the town of Leavenworth, Wash., and to form an auxiliary reservoir * * * backing the waters of the Wenatchee River upstream a distance of approximately 6 miles. * * * At the base of this dam would be erected a power house of proper capacity, wherein will be installed water wheels and electric generators of modern type, developing a head of approximately 400 feet." No action has as yet been taken by the Commission on this application.

227. Chiwawa River, for about 14 miles upstream from Grouse Creek, has a flat gradient and occupies a wide U-shaped valley. Below Grouse Creek the river flows through a deeply incised canyon and passes several dam sites which appear suitable for creating a reservoir. The site selected is about 12 miles upstream from the confluence of the Chiwawa and Wenatchee Rivers. The topography at this site is shown on plate no. 23.[2] The geological report on the site as given in Appendix 3, page 1178, says "There is no reason why this bedrock at this dam site should not be regarded as an excellent foundation for a dam." A usable storage of 482,000 acre-feet between elevations 2,550 and 2,409 feet could be secured. See area-capacity curves on plate no. 24.[2] The reservoir area and the dam site are in the Wenatchee National Forest.

228. *k''. Reservoirs on Yakima River.*—Of the five reservoirs (as listed in table no. 13) on the Yakima River or its tributaries, all are now in actual operation by the Bureau of Reclamation except the one at Cle Elum Lake. A call for bids for the dam and control works for this reservoir has been issued by that Bureau but, due to some legal questions, the contract has not, as yet, been let. These reservoirs are an integral part of the Bureau of Reclamation plan for the irrigation of lands in the Yakima Valley.

229. *g'. Storage analyses—a''. Plan of regulation.*—Storage analyses always involve the choice from numerous possibilities of one or more plans of regulation. One plan of regulation that is used frequently for preliminary studies is based on maintaining a given flow and releasing no more storage than needed for that purpose. Operation, according to this plan, results in a surplus of storage being carried over frequently from one year to another, and full use of available storage being realized only during critical periods. During years of high yield, and perhaps even during years of normal yield, little or no storage would be used. The storage is assumed to be held as a reserve to insure a predetermined specified flow. The plan is well adapted to investigation of a single power site where firm power is of vital concern, or of an irrigation project, which cannot sustain an occasional shortage. It yields conservative results but it seldom reflects the highest practicable utilization of available storage.

[2] Not printed.

230. Another plan of regulation is predicated upon making the best possible use of available storage. It is easy to determine what that best possible use would have been over a series of years during which records of flow were available. It is difficult to lay out and to execute a plan of operation, which will insure a high utilization of storage in the future, with an unknown performance of streams. The "best use" plan, however, serves the excellent purpose of pointing toward an ideal schedule, which though not attainable, can frequently be approximated. Some conditions, favorable to a high utilization of storage sites in the upper Columbia River Basin, are discussed in the following paragraphs 231 to 233.

231. *a''*. *Seasonal regularity.*—The high flow occurs almost invariably during May, June, and July, and the low flow during the late fall and winter. For obvious reasons, the use of storage could not be planned effectively if both high flows and low flows were apt to occur during any month of the year.

232. *b'''*. *Value of snow surveys.*—The Washington Water Power Co. has demonstrated that water content in snow at the headwaters of Spokane and Chelan Rivers, as determined about the middle of March each year, can be correlated satisfactorily with subsequent run-off. The company's experience seems to indicate that snow surveys, supplemented by other meteorological data, can be depended upon to furnish advance information as to when floods are imminent, as to the volume of water that will be available for regulation, and approximately how storage should be released to meet anticipated needs.

233. *c'''*. *Availability of auxiliary fuel power in interconnected systems.*—Most of the power plants in the Northwest are interconnected now, and the tendency is toward taking even greater advantage of interconnection in the future. At different places within the region auxiliary fuel power will be needed for emergency and stand-by uses. As a result of interconnection, it can be used also for supplementing storage in carrying regional loads during periods of extremely low flow. At such times it will probably be more economical to make nearly full use of storage before loading auxiliary steam plants to capacity, because the carrying charge for storage will be practically the same whether the storage is used or not, whereas the use of auxiliary power at or near capacity would involve an extra outlay for fuel, if, by so doing, an excess of storage remains on hand at the end of critical periods. The economy of utilizing storage as fully as possible may warrant placing considerable dependence upon auxiliary fuel power for meeting firm power requirements during periods of unusually low yield of streams. If so, the reservoirs that can be filled every year will probably be emptied during most of the years, and carry-over storage will be limited to those reservoirs which are of sufficient capacity to regulate the entire input over a series of years. Even though the second plan of regulation reflects storage benefits which can only be approximated under favorable conditions, it was adopted because the storage analyses were designed to determine maximum future possibilities for comparison with the minimum present possibilities which are governed by natural flow. The lack of conservatism introduced by use of the second plan is probably offset by diversity in run-off within the Columbia River drainage, and in that adjoining it on the west side of the Cascade Range.

234. *b''*. *Procedure.*—The comprehensive plan of development, described in this report, embraces an extensive territory. It takes

into account the use of water at a multitude of power and irrigation sites, and gives consideration to a number of alternative plans. The purpose of the report is to present a picture of possibilities, and to outline how those possibilities should be coordinated in the interest of highest practicable utilization. The refinement usually attained in investigating a single site, or a small group of sites, was not warranted. A simple procedure was desirable. The main features of the one chosen are discussed in the following paragraphs 235 to 243.

235. *a'''. Monthly units.*—In view of the diminution of run-off during recent years and the need of making comparisons on a duration basis, it seemed essential that the storage studies be extended over as many years as possible. Hence, the period chosen for investigation covers 18 years ending March 31, 1931, as limited by the availability of records on the main stream above Snake River. The average flow for each calendar month of the period was used as the basis of all computations and all durations. Regulated flow, as determined from monthly units, is always higher than actually obtainable, on account of not taking into consideration daily fluctuations in flow. The lack of conservatism introduced by using monthly flow as a basis, rather than the flow during shorter intervals, is probably more than offset by the flow during the 18-year period, being perhaps 7 or 8 percent below normal.

236. *b'''. Correction for natural storage.*—Most of the storage reservoirs under consideration are to be formed by controlling lakes, and most of the stream-flow records upon which storage analyses must be based were obtained below the lakes. The lakes are large, and the equalizing effect of natural storage is too great to disregard, hence it was necessary to derive monthly inflow from measured outflow by taking into account change in lake contents between the last days of each month. Whenever observed lake stages were not available for this purpose, they were derived from the outflow on the last day of each month, by means of curves representing relation between lake stage and lake outflow.

237. *c'''. Criterion of regulation.*—All storage was assumed to be regulated for the direct benefit of the power site, or sites, immediately downstream from the reservoirs. The low flow at different sites extends over periods varying considerably in length. In general the periods of low flow are longer on the tributaries than on the main stream. Therefore, under the criterion adopted, a large amount of storage would be released at times when no storage is needed on the main stream. However, regulation for the direct benefit of power sites on the main stream would probably be infeasible because of uncertainty in timing release, and because that method of regulation would greatly reduce power possibilities at sites on the tributaries. It is conceivable, however, that better results might be obtained if release of storage were balanced between needs on the main stream and those on the tributaries.

238. *d'''. Storage for irrigation.*—In the Northwestern States, court decisions and legislative acts recognize that the use of water for irrigation is of greater public concern than its use for power, therefore ample allowance was made for prospective irrigation. The Columbia Basin irrigation project will require substantial amounts of storage for both the gravity and the pumping plans of development. Analyses for the gravity plan provide for control of Pend Oreille and Coeur

d'Alene Reservoirs jointly for the irrigation project and for power. The amount of storage assumed to be available in these reservoirs is somewhat greater than that needed for the irrigation project. Analyses for the pumping project also involved regulation of Columbia River Reservoir and Grand Coulee Reservoir, jointly in the interest of power and irrigation. Allowances for all other prospective irrigation were small in comparison with natural flow. It was convenient, therefore, to deduct sufficient water from natural flow to accommodate the assumed irrigable acreage and thereafter regulate the remaining flow for power storage. If storage had been manipulated for the joint benefit of both usages, practically the same result would have been obtained, but the computations would have been more complicated.

239. *e'''. Characteristics of regulated flow.*—Seasonal variation in irrigation needs is too great to be disregarded in storage analyses. Fluctuations in power load, however, are much smaller, and the trend is toward more uniform power loads on account of increasing diversity and interconnection. The opportunity of smoothing out power requirements through interconnection is clearly shown in table no. 14. This trend toward more uniform requirements does not necessarily indicate the desirability of utilizing storage to produce as uniform a flow as possible during both filling and releasing periods. In fact, interconnection is apt to bring about a marked lack of uniformity in regulated flow, on account of the tendency to apportion as much of the base load as possible to power plants located on uncontrollable streams, and carrying a large part of the load fluctuations by power plants on controllable streams. When all streams in the region are above normal most of the load can be met by use of nonstorable flow, thereby permitting the reservoirs to fill quickly and remain full until nonstorable flow can no longer produce the energy needed, whereupon storage release can conform to the requirements of interconnected systems rather than those of communities or even regions. The advantage of diversity in use and in stream flow can be realized, and the regulation can be balanced between needs on the main stream and those on the tributaries somewhat as suggested at the end of paragraph 237.

TABLE NO. 14.—*Variation in power requirements in Washington and Montana, in percent of annual average, 1920–26, inclusive, combined water power and fuel plant production*

Month	Puget Sound region (1)	The Washington Water Power Co. (2)	Average, columns 1 and 2 [1] (3)	Washington and Montana, aggregate (4)
	Percent	*Percent*	*Percent*	*Percent*
January	106.8	95.5	101.2	100.7
February	104.4	94.8	99.6	101.6
March	99.3	91.1	95.2	100.3
April	96.5	89.1	92.8	98.5
May	93.9	91.9	92.9	97.5
June	94.0	92.5	93.2	97.9
July	91.1	102.6	96.8	97.1
August	92.9	112.3	102.6	99.0
September	95.1	109.3	102.2	97.7
October	101.3	105.2	103.2	99.3
November	107.6	110.5	109.0	103.8
December	117.6	105.9	111.8	107.3
Annual average	100.0	100.0	100.0	100.0
Range in percentages	26.5	23.2	19.0	10.2

[1] Arithmetical average of percentages in columns 1 and 2. The true percentages, as determined on the basis of combined loads of the 2 regions, would probably vary slightly from those shown in column 3.

240. The complexities involved in regulating storage to take advantage of diversity in use of energy, and also diversity in stream flow, are altogether too great for an investigation of this kind, particularly when a simple method will give more conservative results. With minor exceptions, the analyses were based upon regulating reservoirs to produce as uniform a flow as possible, during both filling and releasing periods.

241. *f'''. Varying storage from lakes.*—The relation between lake stage and outflow governs the amount of storage that can be utilized, because it fixes the lowest stage to which a lake can be drawn. At Flathead Lake the available storage during a critical year varied from that available during a high year by as much as 159,000 acre-feet; at Pend Oreille Lake the same variation amounted to 242,000 acre-feet. It seemed desirable, therefore, to adjust the storage utilized each year from Flathead, Pend Oreille, Kootenai, and Coeur d'Alene Lakes in accordance with the elevation at which the resulting regulated discharge could be accommodated by the natural or proposed outlet capacity of each lake. Usually the lakes were assumed to be drawn down to a stage about 0.2 foot above the limiting stage.

242. *g'''. Loss of power head due to storage draft.*—At some of the power sites release of storage to produce a uniform outflow would result in decreasing power heads (with consequent decrease of power output) on account of head varying with the amount of drawdown. On the other hand, regulation to produce a constant power output at the site immediately below the reservoir would result in a variable output at power sites farther downstream. Determination of a proper adjustment between release and power outputs was not deemed warranted, except in connection with analyses for power sites between Grand Coulee and Snake River. The computations for a number of the low-water years (varying from 7 years to 9 years, depending upon the plan) were based upon releasing storage from Columbia River Reservoir to produce constant power at all sites on the main stream between the reservoir and Snake River. Storage release for the remaining years was based on maintaining as uniform a flow as possible below Grand Coulee power site. As a result the power durations from about 82 percent of the time to 100 percent of the time, were determined on the basis of releasing storage to produce constant power. Durations within these limits are the most critical in determining value of sites and in making comparisons.

243. *h'''. Evaporation disregarded.*—All except five of the reservoir sites are lakes. Gaging stations located below these lakes measure the flow after evaporation from the natural lake areas has already occurred. At most of the lakes the regulated areas will be only slightly greater than natural areas, so that differences in evaporation would be negligible. Regulated area of the proposed Wenatchee Lake Reservoir would be considerably greater than natural area. An estimate of evaporation from the increased area indicated that consequent loss in run-off did not amount to 1 percent of regulated flow. Lakes do not exist within Hungry Horse, Grand Coulee, Chiwawa, Ticton, and Columbia River Reservoir sites. When they are developed, therefore, the total area of water surface exposed will be a factor in causing evaporation loss. Evaporation loss of Hungry Horse and Chiwawa sites may be as much as 3 percent of the minimum regulated yield. Taking it into account was not warranted, because

the flow, assumed to be available for regulation at those sites during a considerable part of the 18-year period, was estimated from meager information. The estimates were made conservatively and are apt to be enough less than the true flow to more than offset evaporation. The volume of water that will pass through the Columbia River Reservoir is so great that evaporation losses could be no more than 1 percent of the minimum regulated yield. Uncertainties introduced by disregarding evaporation losses appeared to be too small to warrant consideration.

244. *c''. Set-up.*—A tabular form of analysis was devised, which indicated practically all of the steps taken. It permitted a check of operations as the work progressed, and preserved results in a convenient form for ready reference. Values for each of the 216 months of the period chosen for investigation were listed in columns. Each column was provided with a heading indicating what the monthly values represented and a number which served to identify it. Occasionally a repetition of columns was necessary. In that event the original column heading and number were retained. The analyses required use of seven sets of tables with an aggregate of 270 columns. In some cases storage diagrams were used to facilitate determination of the best method of regulation, but the results were incorporated in the tables in order that the set-up might be complete, and in order to avoid confusion in carrying effects downstream.

245. The storage operations were started at the farthest reservoir upstream (Hungry Horse), where the regulated monthly flow was derived, and compared with the estimated natural flow to determine monthly plus and minus effect to be carried downstream. Regulated elevations of the reservoir were also determined for the end of each month.

246. The next step was to compute the change in contents of Flathead Lake between the last days of each month, by means of lake stages and a lake-capacity table. If the contents increased during the month, a plus correction was applied to natural outflow to obtain natural inflow; if the contents decreased, the correction was minus.

247. Having determined natural Flathead inflow, the assumed effect of future irrigation and the downstream effect of Hungry Horse regulation were combined algebraically with it to obtain the modified Flathead inflow available for regulation. Then this modified inflow was regulated for the direct benefit of power sites immediately below Flathead Lake, and the resulting elevation of Flathead Lake at the end of each month was determined. This reregulated flow from Flathead Lake was compared with the natural measured flow to determine the net plus and minus effect of regulation in Hungry Horse and Flathead Reservoirs and of making allowance for assumed future irrigation diversion from the lake or its tributaries. This net effect was carried forward and similar steps taken to derive new net effects below each reservoir.

248. Most of the operations were simple, but those needed to regulate Pend Oreille and Coeur d'Alene Lakes for both gravity irrigation of Columbia Basin Irrigation Project and for power on Clark Fork and Spokane Rivers became quite involved, mainly on account of flow adjustments designed to compensate the Washington Water Power Co. for the use of water and property rights.

249. The storage analyses at the Grand Coulee power site were also quite complicated and tedious, due to some of the steps requiring cut-and-try methods.

250. *h'. Effect of irrigation—a''. Present effect.*—About 835,000 acres of land are irrigated in the part of Columbia River Drainage Basin that is located above Snake River. Of this amount, about 380,000 acres, or over 45 percent, are located in the Yakima Valley and along the Columbia between Priest Rapids power site and the Snake. As the Priest Rapids power site is the lowest one given consideration in this report, the effect on the natural flow of Columbia River of irrigating the 380,000 acres need not be taken into account here. The remaining acreage, 455,000, is fairly well distributed over an extensive area. Moreover, the resulting depletion is quite small in comparison to flow of the main river and principal tributaries. Therefore, its effect on natural flow is of little consequence. Most of this acreage has been irrigated throughout the 18-year period under investigation, so that the stream-flow records indicate water supply available for future use after present irrigation has been served with water, hence no corrections have been made on account of present irrigation.

251. *b''. Future effect—a'''. Irrigable acreage.*—The abundant water supply of the upper Columbia and tributaries can serve all of the irrigable acreage within practicable economic reach, with only slight detriment to water-power resources. One reason is that a large part of the irrigation demand comes during a period when the natural flow is well sustained. Another reason is that irrigation builds up ground-water storage which is gradually returned to the streams during the latter part of the irrigating season, and on into the low-water period after irrigation diversion ceases. Only the water consumed by plant growth and that dissipated by evaporation is lost to the river system. Even this loss is offset, to some extent, by accretion from ground storage. It is quite fitting, therefore, that ample allowance be made for all prospective irrigation.

252. Estimates of irrigable acreage are subject to considerable uncertainty, due to the lack of definite information as to feasibility. They need not be conservative, however, when they involve a relatively small use of water compared with that remaining for power and navigation uses. The purpose of the estimates shown in table no. 15 was to furnish a basis for setting aside an irrigation reserve which may not be fully needed in the future.

TABLE NO. 15.—*Assumed irrigable acreage above Snake River*

Location	Acres
Above Flathead Lake	125,000
Between Flathead Lake and Montana-Idaho boundary	225,000
Between Montana-Idaho boundary and Newport, exclusive of Priest River	65,000
From Priest Lake	20,000
Between Newport and Kettle Falls, exclusive of British Columbia	15,000
In British Columbia	125,000
Between Kettle Falls and Grand Coulee [1]	50,000
Columbia Basin irrigation project, pumping with supplemental pumping plan no. 4	1,199,000
Between Grand Coulee and Chelan River	60,000
From Lake Chelan	12,000
Between Chelan and Wenatchee Rivers	15,000
Between Wenatchee River and Priest Rapids	30,000
Between Priest Rapids and Snake River, exclusive of Yakima Valley	35,000
Yakima Valley	250,000
Total, based on plan no. 4, pumping	2,226,000
Additional included in Columbia Basin irrigation project plan no. 2-A, gravity with supplemental pumping	321,000
Total, based on plan no. 2-A, gravity	2,547,000

[1] Includes 20,000 acres assumed to be supplied from Coeur d'Alene Lake.

253. *b'''. Above Newport.*—The effect at Newport of future irrigation was assumed to be about the same as that previously used in connection with the Cavanaugh report [20] but the distribution among the several localities is different. The aggregate monthly effect at Newport was assumed to be the same year after year, whereas the Cavanaugh report assumed that it would be less during years of low yield than during years of high yield. The aggregate monthly effect at Newport was derived by averaging that assumed in the Cavanaugh report.

254. The allowances, assumed to be applicable above Newport, take into account storage of water during the winter for irrigation use during the ensuing summer. In this case assumed depletion on account of irrigation would decrease natural flow during the low-water winter season. All other allowances, except those in Yakima Valley, are assumed to augment winter flow on account of seepage return.

255. *c'''. Columbia Basin irrigation project.*—The assumed effect of future irrigation of all areas, except those included in the Columbia Basin irrigation project, was determined by making allowance for net algebraic difference between diversion and return flow. The diversion and return flow effects of the Columbia Basin irrigation project, however, were segregated because very little of the return flow would reach Columbia River above the mouth of Crab Creek at Beverly, whereas the diversion would be at Albany Falls for the gravity project and at Grand Coulee for the pumping project.

256. Table no. 16 indicates diversion requirements of the three alternative plans of development that were included in the storage analyses. It also shows from what streams the water was assumed to be diverted. The basis of determining requirements, after taking into account rediversion of seepage return flow, is set forth fully in the irrigation section.

257. Plan no. 4 was the only pumping plan, for which a water-supply study was made. It would require the maximum assumed withdrawal of water at Grand Coulee dam site and the maximum power for pumping. Consequently, the remaining power at Grand Coulee, available for commercial use, would be less for plan no. 4 than for any of the other pumping plans given consideration. The same would be true but to a less extent, at all other Columbia River power sites down to Priest Rapids.

258. Likewise, plan no. 2-A is the maximum gravity project given consideration, and its effect, in decreasing commercial power possibilities, would be greater than for the other gravity projects. This decrease in commercial power possibilities would be due primarily to use of storage in Pend Oreille and Coeur d'Alene Lakes for irrigation, which otherwise would be available for power use. Plan no. 6-A was included in connection with investigating the feasibility of irrigating the Quincy unit by diversion from Wenatchee River.

[20] Uses of the Upper Columbia River; Federal Power Commission (revised edition); appendix E, pp. 103–114.

TABLE NO. 16.—*Assumed diversion for the Columbia Basin irrigation project*

[Units of 1,000 acre-feet]

Month	Plan no. 4. Pumping and repumping 1,199,430 acres			Plan no. 2-A. Gravity with repumping 1,519,890 acres			Plan no. 6-A. Gravity with repumping 1,449,390 acres			
	Irrigation demand	Assumed losses in Grand Coulee Reservoir	Total from Columbia [1]	From Clark Fork	From Spokane	Total	From Clark Fork	From Spokane	From Wenatchee	Total
1	2	3	4	5	6	7	8	9	10	11
April	383	60	443	494		494	369		111	480
May	655	61	716	722	111	833	498	117	194	809
June	615	60	675	699	87	786	483	94	185	762
July	687	61	748	722	154	876	499	141	209	849
August	657	61	718	722	115	837	499	115	198	812
September	430	60	490	553		553	405		131	536
October	187	61	248	247		247	181		59	240
November		60	60							
December		61	61							
January		61	61							
February		56	56							
March		61	61							
Total	3,614	723	4,337	4,159	467	4,626	2,934	467	1,087	4,488

[1] In order to conserve commercial power possibilities at the Grand Coulee power site, during periods of low flow within the 18-year period, these requirements for irrigation and for seepage were assumed to be met partly from storage in Grand Coulee Reservoir. Hence, the monthly amounts, assumed to be pumped from Columbia River, did not always coincide with these requirements.

259. Of course, amount of return flow and its distribution throughout the year are quite uncertain. Therefore, separate return flows for each of the three plans of development, included in the storage analyses, did not seem justifiable. The return flow shown in table no. 17 was estimated for an acreage of 1,360,000 acres, which represents the average between the area of plan no. 2-A, gravity, and plan no. 4, pumping. The return flow was assumed to be 0.862 feet on the area, or 28 percent of the amount diverted. Distribution throughout the year was based on percentages that were estimated during the Gault [21] investigation (column 5).

TABLE NO. 17.—*Estimated seepage return from the Columbia Basin irrigation project*

Month	Rate (percent)				Amount (acre-feet)			Net, approximate (second-feet)
	Fast 55 percent of area	Slow 35 percent of area	Very slow, 10 percent of area	Composite	Gross	Rediverted	Net	
1	2	3	4	5	6	7	8	9
April	2	5	7	3	35,000	7,000	28,000	500
May	7	9	7	8	95,000	24,000	71,000	1,200
June	14	10	8	12	140,000	35,000	105,000	1,800
July	15	11	9	13	152,000	49,000	103,000	1,700
August	16	12	10	14	165,000	42,000	123,000	2,000
September	16	11	10	13	152,000	32,000	120,000	2,000
October	14	10	9	12	140,000	21,000	119,000	1,900
November	10	9	9	10	117,000		117,000	2,000
December	4	7	9	6	71,000		71,000	1,200
January	2	6	8	4	47,000		47,000	800
February		5	7	3	35,000		35,000	600
March		5	7	2	23,000		23,000	400
Total	100	100	100	100	1,172,000	210,000	962,000	

[21] Senate Committee Print, 69th Congress, 2d session, Columbia Basin Project.

260. The amount assumed to be available for rediversion, see paragraph 259, from seepage return flow, column 7, is also the average of those assumed for plans no. 2-A and no. 4. About two thirds of the net return flow, column 8, has been assumed to be tributary to Columbia River, principally through Crab Creek drainage, and the remainder tributary to Snake River.

261. *d'''. Yakima Valley.*—About 350,000 acres are irrigated in Yakima Valley now, and the United States Bureau of Reclamation has made plans for irrigating 600,000 acres eventually. Storage in five reservoirs, aggregating 1,106,000 acre-feet, will be necessary for supplemental natural flow.

262. An accurate determination of the effect of irrigating 600,000 acres in Yakima Valley would involve a tremendous amount of work. The effect would reach Columbia River below the lowest power site, Priest Rapids, given consideration in this report. The next power site downstream, at Umatilla Rapids, is below Snake River, and the effect of irrigation in the Snake River Valley is much greater than that in the Yakima Valley. Moreover, the Yakima effect will be very small in comparison with the flow of Columbia River at Umatilla Rapids. Under these circumstances the Yakima effect can be roughly approximated without introducing much uncertainty in the future regulated flow at Umatilla Rapids. Therefore, the effect of irrigating 600,000 acres in Yakima Basin has been derived as shown in table no. 18 and based upon assumptions as follows:

First, that the approximate effect, as determined for an average year, is applicable year after year.

Second, that the estimated natural flow of Yakima River at Union Gap [22] represents the natural yield of Yakima Basin, column 2, table no. 18.

Third, diversion and return flow for 600,000 acres, according to estimates furnished in 1923, by J. L. Lytel, formerly project manager. Yakima project, United States Bureau of Reclamation, columns 5 and 6, table no. 18.

Fourth, all water diverted at Union Gap. The actual plan of development calls for diversion at points above and below Union Gap.

Fifth, that the average yield available for storage each month, from November of one year to June of the following year, is represented by averaging storable yields at the reservoirs for those months, and that this storage is released during the remaining months, July to October, for the purpose of meeting aggregate irrigation requirements, column 3, table no. 18.

[22] Water Power of the Cascade Range, Part III; U.S. Geological Survey Water Supply Paper 369, pp. 50-59; and Summary of Hydrometric Data in Washington; U.S. Geological Survey Water Supply Paper 492, pp. 215-251.

TABLE NO. 18.—*Roughly approximate effect of irrigation in Yakima Valley* [1]

Month	Estimated natural yield [2]	Stored (−)[3] released (+)	Regulated yield (2)+(3)	Diversion	Return	Modified flow (4)+(5)+(6)	Downstream effect (7) minus (2)	
1	2	3	4	5	6	7	8	9
	Acre-feet	*Acre-feet*	*Acre-feet*	*Acre-feet*	*Acre-feet*	*Acre-feet*	*Acre-feet*	*Sec.-ft.*
April	497,000	−150,000	347,000	−299,000	+62,000	110,000	−387,000	−6,500
May	713,000	−278,000	435,000	−429,000	+78,000	84,000	−629,000	−10,200
June	607,000	−128,000	479,000	−474,000	+170,000	175,000	−432,000	−7,300
July	284,000	+204,000	488,000	−488,000	+248,000	248,000	−36,000	−600
August	111,000	+369,000	480,000	−480,000	+264,000	264,000	+153,000	+2,500
September	81,000	+280,000	361,000	−361,000	+280,000	280,000	+199,000	+3,300
October	99,000	+122,000	221,000	−221,000	+170,000	170,000	+71,000	+1,100
November	232,000	−77,000	155,000	----------	+78,000	233,000	+1,000	--------
December	242,000	−120,000	122,000	----------	+62,000	184,000	−58,000	−900
January	229,000	−87,000	142,000	----------	+62,000	204,000	−25,000	−400
February	178,000	−62,000	116,000	----------	+47,000	163,000	−15,000	−300
March	299,000	−73,000	226,000	----------	+31,000	257,000	−42,000	−700
Total	3,572,000	−975,000 +975,000	3,572,000	−2,752,000	+1,552,000	2,372,000	−1,624,000 +424,000	--------

[1] It should be noted that the effect shown in table no. 18 is due to both present and future irrigation, whereas the effect discussed in other parts of this section refer only to future irrigation.
[2] Average, August 1896 to September 1919.
[3] Average storable yield, based on records below each reservoir from October 1914 to June 1919 and on permitting at least 25 second-feet to pass through each reservoir.

263. *e'''. Other areas below Newport.*—Allowances for all other areas below Newport, except for 12,000 acres assumed to be supplied from Lake Chelan, have been based upon the application of 3 feet of water on the land and a return of 1.4 feet. The basis chosen for diversion and return are shown in table no. 19.

TABLE NO. 19.—*Assumed diversion and return from 1 acre of land*

Month	Diversion	Return [1]	Net effect decrease(−) increase(+)
	Acre-feet	*Acre-feet*	*Acre-feet*
April	−0.360	+0.028	−0.332
May	−.474	+.098	−.376
June	−.534	+.196	−.338
July	−.552	+.210	−.342
August	−.510	+.224	−.286
September	−.360	+.224	−.136
October	−.210	+.196	−.014
November	----------	+.140	−.140
December	----------	+.056	−.056
January	----------	+.028	−.028
February	----------	----------	----------
March	----------	----------	----------
Total	−3.000	+1.400	−1.600

[1] Rate of return same as that used for so-called "fast" area of Columbia Basin irrigation project, column 2, table no. 17.

264. *f'''. Summary.*—The allowances made for the effect of future irrigation upon the flow within stretches of the river system, and the total effect at the mouth of Snake River, are summarized in table no. 20. The total does not include the effect of any irrigation within the Snake River Basin, except for the part of Columbia Basin irrigation project that lies within the Snake River drainage. It does include about one third of the seepage return flow from Columbia Basin irrigation project, which presumably would drain into Snake River.

TABLE No. 20.—*Summary of estimated effect of future irrigation*

Month	Above Flathead Lake, 125,000 acres	Between Flathead Lake and Newport, 310,000 acres	Between Newport and Grand Coulee, 190,000 acres	Columbia Basin irrigation project, plan no. 4, 1,199,000 acres	Between Grand Coulee and Priest Rapids, 117,000 acres	Between Priest Rapids and Snake River, 285,000 acres [1]	Total	
1	2	3	4	5	6	7	8	9
	Acre-feet	*Acre-feet*	*Acre-feet*	*Acre-feet*	*Acre-feet*	*Acre-feet*	*Acre-feet*	*Second-feet*
April	−5,000	−17,000	−63,000	−415,000	−36,000	−399,000	−935,000	−15,700
May	−13,000	−68,000	−71,000	−645,000	−44,000	−644,000	−1,485,000	−24,100
June	−31,000	−154,000	−65,000	−570,000	−40,000	−444,000	−1,304,000	−21,900
July	−50,000	−130,000	−65,000	−645,000	−41,000	−48,000	−979,000	−15,900
August	−25,000	−79,000	−55,000	−595,000	−34,000	+147,000	−641,000	−10,400
September	−6,000	−35,000	−26,000	−370,000	−16,000	+193,000	−260,000	−4,400
October	−5,000	−5,000	−2,000	−129,000	−2,000	+71,000	−72,000	−1,200
November	−5,000	−5,000	+27,000	+57,000	+15,000	+7,000	+96,000	+1,600
December	−5,000	−5,000	+11,000	+10,000	+6,000	−58,000	−41,000	−700
January	−5,000	−5,000	+6,000	−14,000	+3,000	−22,000	−37,000	−600
February	−5,000	−5,000	----------	−21,000	----------	−15,000	−46,000	−800
March	−5,000	−9,000	----------	−38,000	----------	−42,000	−94,000	−1,500
Total	−160,000	−517,000	−303,000	−3,375,000	−189,000	−1,254,000	−5,798,000	----------

[1] Also includes effect of present irrigation in Yakima Valley.

2. TABLES

265. *a. General statement.*—The monthly stream-flow data upon which the water-supply and storage analyses are based and the regulated flows at power sites are presented in order that the findings of the present investigation may be checked and extended at some time in the future when additional information has been accumulated.

266. Records at some of the key gaging stations are fragmentary, especially in the upper Clark Fork Basin, where the effect of prospective storage operations upon the behavior of the main stream will be great. It seemed essential that the gaps be filled, so that complete working data would be available for all of the 18-year period chosen for investigation. Even though some uncertainty was introduced by filling gaps, a more dependable and a more representative picture of possibilities, particularly on the main stream, has been obtained than would have been possible if only recorded flow had been utilized.

267. From time to time during the past 10 years the United States Geological Survey has reviewed, revised, and extended stream-flow data in parts of the basin. Some of the results have been published, but considerable information was available only in district office files, or in manuscript reports. All information of this kind was assembled, studied, and scrutinized carefully. In some cases the unpublished data were revised, usually downward to be more conservative, but always in accord with some reasonable basis. Estimates were made to fill quite a number of gaps that had not been given consideration by the United States Geological Survey. Frequently the missing flows, or lake heights, were estimated in accordance with several different methods. In that event the most conservative estimates were chosen for filling gaps.

268. *b. Natural flow.*—The basic stream-flow data used in the water-supply and storage analyses, together with an abstract of other data relating to each of the key gaging stations, are included in tables nos. 21 to 41.

269. Most of the information given in the tables has been abstracted from published and unpublished information accumulated by

the United States Geological Survey. Records were started at some of the gaging stations prior to the beginning of the 18-year period. Results prior to April 1913 have not been included in the tables given herewith, however, because they were not used in the present investigation, and because they are already published in Water-Supply Papers of the United States Geological Survey.

270. When this report was completed, the published data of the United States Geological Survey were complete only to September 30, 1926. Results from that date to March 31, 1931, a period of 4½ years, were obtained from unpublished data, furnished by the district offices of the United States Geological Survey at Tacoma, Wash., at Helena, Mont., and at Boise, Idaho. Such data are subject to revision. Hence, the discharges given in the tables for the last 4½ years may not agree with those yet to be published by the United States Geological Survey.

271. As mentioned in paragraph 267, conservative estimates of monthly flow were made to fill gaps in the records. The estimated flows have been printed in italics.

COLUMBIA RIVER AT TRAIL, BRITISH COLUMBIA

Gaging station located 15 miles above the mouth of Clark Fork. Drainage area, 34,000 square miles. Records available, April 18, 1913, to March 31, 1931. Maximum discharge during period of record, 312,000 second-feet June 14–15, 1913; minimum discharge, 9,600 second-feet March 28, 1917.

TABLE No. 21.—*Monthly discharge, in units of 1,000 second-feet, of Columbia River at Trail, British Columbia*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	*18.0*	86.4	262	181	125	83.5	46.9	32.2	22.6	20.7	16.8	17.8	76.3
1914–15	43.9	125	190	200	112	65.7	49.3	45.9	30.5	19.9	16.4	17.3	76.7
1915–16	45.5	110	123	140	132	76.6	38.2	35.0	25.4	16.3	13.7	23.0	65.1
1916–17	45.0	99.4	192	262	136	86.7	42.3	29.1	19.6	14.1	12.4	10.6	79.5
1917–18	17.3	79.2	198	205	115	68.6	53.5	29.6	27.1	27.9	20.8	18.4	72.
1918–19	41.5	113	200	186	113	75.9	53.6	34.5	25.8	19.9	21.1	16.2	75.3
1919–20	34.4	107	195	179	119	72.5	34.7	21.8	15.7	15.2	13.3	11.7	68.4
1920–21	15.4	74.1	146	240	144	71.3	70.9	40.7	28.7	22.4	21.4	22.7	75.3
1921–22	36.6	117	245	190	127	61.2	42.5	46.9	29.2	20.8	16.7	14.6	79.3
1922–23	20.7	79.4	221	168	113	82.2	46.7	31.2	18.8	19.4	15.8	13.4	69.4
1923–24	29.0	109	220	188	115	80.3	38.9	23.2	17.7	13.9	16.9	17.7	72.6
1924–25	19.3	115	158	134	103	74.4	40.6	37.0	28.1	25.3	25.2	25.0	65.7
1925–26	63.9	164	215	181	114	60.9	34.1	20.6	17.4	14.0	12.6	13.4	76.3
1926–27	37.4	102	103	121	83.0	65.4	47.0	44.2	29.3	19.7	15.3	15.4	57.2
1927–28	23.0	87.1	217	199	127	101	76.7	60.6	37.6	26.7	22.2	22.5	83.5
1928–29	40.7	152	223	187	112	60.7	37.8	26.5	19.0	14.5	11.0	11.8	75.0
1929–30	16.7	65.3	190	128	94.4	58.9	31.1	20.2	15.1	13.9	12.7	14.5	55.2
1930–31	38.6	103	164	157	107	63.4	32.4	20.9	16.0	13.4	13.4	14.1	62.2
Highest	63.9	164	262	262	144	101	76.7	60.6	37.6	27.9	25.2	25.0	83.5
Average	32.6	105	192	180	116	72.7	45.4	33.3	23.5	18.8	16.5	16.7	71.4
Lowest	15.4	65.3	103	121	83.0	58.9	31.1	20.2	15.1	13.4	11.0	10.6	55.2

NOTE.—Estimated discharge is shown in italics.

COLUMBIA RIVER AT KETTLE FALLS, WASH.

Gaging station located 4½ miles below Kettle River and 1½ miles above Colville River. Drainage area, 64,500 square miles. Records available April 1, 1916, to March 31, 1931. Results prior to April 1916 and for several intervals thereafter obtained by adjustment between discharge at Trail, British Columbia, and Vernita, Wash., taking into account the yield of intervening tributaries. (See Geological Survey Water-Supply Paper 572, p. 67.) Maximum discharge during period of record, 458,000 second-feet June 30 and July 5, 1916. Flood discharge during June 1894 as estimated, 700,000 second-feet; during night of

June 14–15, 1913, 468,000 second-feet. Minimum discharge during period of record, about 14,000 second-feet in the latter part of January 1930 when stage-discharge relation was affected by ice.

TABLE No. 22.—*Monthly discharge, in units of 1,000 second-feet, of Columbia River at Kettle Falls, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	*42.5*	*160*	*412*	*272*	*153*	*97.3*	*58.2*	*47.0*	*34.7*	*31.5*	*27.2*	*34.9*	*115*
1914–15	*79.2*	*201*	*285*	*249*	*129*	*74.4*	*59.8*	*61.7*	*45.1*	*29.8*	*25.7*	*29.5*	*106*
1915–16	*72.3*	*164*	*181*	*180*	*153*	*88.5*	*47.9*	*46.0*	*36.0*	*24.6*	*24.6*	*44.8*	*88.8*
1916–17	86.4	175	298	402	185	107	57.5	42.9	*29.0*	*22.9*	*22.1*	*20.2*	*121*
1917–18	36.6	146	337	304	145	77.6	57.8	37.2	*35.2*	*57.8*	*41.1*	35.7	*110*
1918–19	72.0	190	297	253	133	88.1	*62.3*	*44.7*	*33.2*	*29.2*	*35.3*	31.2	*106*
1919–20	63.3	181	283	222	135	77.9	43.6	27.4	*20.2*	*20.4*	*21.7*	21.6	*93.3*
1920–21	30.3	121	227	311	174	88.3	83.2	59.3	*40.4*	*35.9*	*34.1*	43.7	*105*
1921–22	70.2	195	376	246	135	67.6	48.5	50.5	39.4	30.5	24.6	22.0	109
1922–23	37.2	132	339	215	124	86.1	52.2	36.6	23.3	29.4	22.2	22.1	93.5
1923–24	53.2	166	324	247	130	86.3	44.3	29.5	24.6	19.6	28.0	29.7	98.6
1924–25	32.9	173	220	163	112	78.7	44.5	42.7	34.4	35.9	43.9	41.7	85.5
1925–26	115	261	319	240	133	72.5	43.4	29.6	25.8	22.5	22.2	24.6	109
1926–27	56.7	159	136	138	86.9	68.0	57.1	56.1	47.4	33.8	28.7	30.2	75.2
1927–28	47.6	161	351	291	156	121	99.9	91.4	71.1	47.9	41.3	44.0	127
1928–29	74.3	259	341	252	136	72.0	46.2	35.1	26.9	21.2	18.0	21.1	109
1929–30	29.1	105	264	164	105	64.0	36.5	25.1	20.8	15.9	18.6	21.7	72.7
1930–31	60.0	155	217	189	119	71.7	41.5	29.4	23.4	19.2	20.0	23.3	81.1
Highest	115	261	412	402	185	121	99.9	91.4	71.1	57.8	43.9	44.8	127
Average	58.8	172	289	241	136	82.6	54.7	44.0	33.9	29.3	27.7	30.1	100
Lowest	29.1	105	136	138	86.9	64.0	36.5	25.1	20.2	15.9	18.0	20.2	72.7

NOTE.—Estimated discharge shown in italics.

COLUMBIA RIVER AT GRAND COULEE, WASH.

Gaging station located opposite upper end of Grand Coulee, 14 miles above Nespelem River. Drainage area, 74,100 square miles. Records available June 17 to December 31, 1923, and June 1, 1928, to March 31, 1931. Water-stage recorder after February 15, 1931. Monthly discharge for remainder of 18 years ending March 31, 1931, adjusted between results at Kettle Falls and Vernita gaging stations, taking into account the yield of intervening tributaries. Maximum discharge during period of record, 490,000 second-feet, June 1, 1928; minimum discharge, about 17,000 second-feet during the middle of January 1930, when stage-discharge relation was affected by ice. Flood discharge during June 1894 and June 1913, about 725,000 second-feet and 492,000 second-feet, respectively.

TABLE No. 23.—*Monthly discharge, in units of 1,000 second-feet, of Columbia River at Grand Coulee, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	*67.7*	*190*	*436*	*279*	*156*	*100*	*61.8*	*51.7*	*38.5*	*36.2*	*34.7*	*48.3*	*125*
1914–15	*99.6*	*220*	*293*	*252*	*132*	*76.9*	*62.5*	*65.7*	*48.3*	*32.7*	*28.9*	*36.7*	*113*
1915–16	*86.6*	*175*	*188*	*184*	*156*	*91.2*	*50.8*	*49.0*	*39.6*	*28.4*	*31.6*	*62.8*	*95.5*
1916–17	*113*	*201*	*320*	*419*	*189*	*110*	*60.6*	*46.2*	*32.3*	*26.2*	*26.0*	*25.4*	*131*
1917–18	*55.9*	*183*	*368*	*313*	*149*	*80.9*	*61.0*	*40.3*	*41.8*	*63.8*	*52.1*	*45.6*	*123*
1918–19	*92.6*	*209*	*307*	*256*	*136*	*90.4*	*64.8*	*47.6*	*37.8*	*35.5*	*43.4*	*42.6*	*114*
1919–20	*88.3*	*204*	*294*	*226*	*138*	*80.7*	*46.4*	*30.3*	*23.2*	*23.4*	*25.4*	*29.2*	*101*
1920–21	*43.9*	*140*	*237*	*315*	*177*	*90.7*	*86.8*	*64.3*	*46.1*	*47.3*	*46.4*	*62.3*	*114*
1921–22	*92.6*	*222*	*390*	*250*	*138*	*70.1*	*51.2*	*53.5*	*46.9*	*34.2*	*27.3*	*27.2*	*117*
1922–23	*53.6*	*157*	*354*	*218*	*127*	*88.5*	*54.7*	*39.2*	*26.3*	*38.3*	*26.3*	*28.3*	*101*
1923–24	*74.3*	*189*	*342*	257	136	92.5	48.2	32.8	28.3	*23.2*	*40.2*	*38.6*	*109*
1924–25	*44.5*	*191*	*225*	*166*	*115*	*81.2*	*47.0*	*46.0*	*40.6*	*41.9*	*62.7*	*55.1*	*93.2*
1925–26	*143*	*285*	*330*	*244*	*136*	*75.3*	*46.2*	*32.3*	*28.7*	*26.9*	*30.6*	*34.2*	*118*
1926–27	*70.7*	*169*	*140*	*141*	*89.4*	*70.4*	*60.3*	*61.7*	*59.4*	*40.9*	*39.4*	*42.8*	*82.4*
1927–28	*64.5*	*190*	*372*	*296*	*159*	*124*	*107*	*107*	*89.7*	*59.8*	*50.6*	*59.7*	*140*
1928–29	*94.9*	*286*	355	260	144	78.6	52.0	41.3	32.1	25.2	21.3	25.6	*119*
1929–30	38.8	116	270	168	111	69.5	41.1	29.2	23.7	18.8	23.0	28.5	78.3
1930–31	71.0	160	222	195	124	77.0	45.1	32.6	26.8	22.6	24.3	32.1	86.4
Highest	143	286	436	419	189	124	107	107	89.7	83.8	62.7	62.8	140
Average	77.5	194	302	247	140	86.0	58.2	48.4	39.5	35.8	35.2	40.3	109
Lowest	38.8	116	140	141	89.4	69.5	41.1	29.2	23.2	18.8	21.3	25.4	78.3

NOTE.—Estimated monthly discharge shown in italics.

COLUMBIA RIVER ABOVE CHELAN RIVER, WASH.

No gaging station. Monthly discharge derived by adjustment between flow at Grand Coulee and Vernita gaging stations, taking into account the yield of intervening tributaries. Drainage area, 85,500 square miles. Flood discharge during June 1894, about 735,000 second-feet.

TABLE No. 24.—*Derived monthly discharge, in units of 1,000 second-feet, of Columbia River above Chelan River, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar	Mean for year
1913-14	*70.5*	*198*	*455*	*298*	*164*	*108*	*65.9*	*55.7*	*42.5*	*38.5*	*37.1*	*50.5*	*132*
1914-15	*104*	*234*	*312*	*266*	*139*	*82.1*	*66.0*	*67.5*	*52.0*	*34.2*	*30.9*	*38.6*	*119*
1915-16	*90.4*	*182*	*196*	*190*	*164*	*97.7*	*53.5*	*51.7*	*42.7*	*30.3*	*33.8*	*65.0*	*100*
1916-17	*122*	*221*	*340*	*436*	*202*	*118*	*64.2*	*47.3*	*34.8*	*27.8*	*28.1*	*26.8*	*140*
1917-18	*55.0*	*186*	*388*	*331*	*157*	*87.8*	*66.4*	*43.0*	*43.8*	*88.3*	*55.9*	*47.4*	*130*
1918-19	*96.4*	*221*	*320*	*269*	*144*	*94.4*	*68.4*	*50.2*	*40.1*	*37.4*	*46.5*	*43.9*	*120*
1919-20	*91.1*	*212*	*314*	*240*	*145*	*85.9*	*48.0*	*32.9*	*25.1*	*24.6*	*27.6*	*29.8*	*106*
1920-21	*43.2*	*142*	*246*	*325*	*184*	*94.0*	*90.9*	*64.5*	*49.1*	*49.4*	*48.1*	*64.3*	*117*
1921-22	*96.1*	*233*	*413*	*265*	*144*	*75.5*	*53.1*	*56.7*	*50.1*	*36.2*	*28.5*	*29.2*	*124*
1922-23	*53.5*	*160*	*372*	*230*	*131*	*92.7*	*57.9*	*42.1*	*28.9*	*40.8*	*28.3*	*29.9*	*106*
1923-24	*74.3*	*198*	*358*	*270*	*141*	*95.9*	*51.1*	*35.4*	*30.5*	*24.6*	*42.0*	*40.6*	*114*
1924-25	*44.8*	*198*	*236*	*169*	*116*	*84.1*	*49.0*	*48.0*	*43.0*	*43.8*	*65.6*	*57.1*	*96.4*
1925-26	*142*	*296*	*346*	*254*	*140*	*78.8*	*49.7*	*34.8*	*31.0*	*28.3*	*32.2*	*35.7*	*123*
1926-27	*71.2*	*173*	*142*	*143*	*92.1*	*73.3*	*61.6*	*64.9*	*62.5*	*44.1*	*41.9*	*45.8*	*84.9*
1927-28	*64.6*	*192*	*386*	*310*	*165*	*128*	*113*	*113*	*96.3*	*65.9*	*56.5*	*62.8*	*146*
1928-29	*98.4*	*296*	*375*	*272*	*150*	*81.7*	*54.6*	*43.9*	*34.0*	*26.6*	*22.2*	*26.4*	*124*
1929-30	*38.8*	*118*	*282*	*174*	*113*	*71.2*	*43.3*	*31.0*	*24.8*	*20.4*	*24.2*	*29.6*	*81.1*
1930-31	*73.5*	*168*	*232*	*200*	*126*	*79.2*	*46.6*	*34.2*	*27.9*	*23.4*	*25.3*	*32.4*	*89.4*
Highest	142	296	455	436	202	128	113	113	96.3	88.3	65.6	65.0	146
Average	79.4	202	317	258	145	90.5	61.3	50.9	42.2	38.0	37.5	42.0	114
Lowest	38.8	118	142	143	92.1	71.2	43.3	31.0	24.8	20.4	22.2	26.4	81.1

NOTE.—Estimated monthly discharge shown in italics.

COLUMBIA RIVER ABOVE WENATCHEE RIVER, WASH.

No gaging station. Monthly discharge derived by adjustment between flow at Grand Coulee and Vernita gaging stations, taking into account the yield of intervening tributaries. Drainage area, 87,200 square miles. Flood discharge during June 1894 about 735,000 second-feet.

TABLE No. 25.—*Derived monthly discharge, in units of 1,000 second-feet, of Columbia River above Wenatchee River, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar	Mean for year
1913-14	*72.2*	*202*	*466*	*310*	*169*	*112*	*67.8*	*57.5*	*44.3*	*39.5*	*38.2*	*52.4*	*136*
1914-15	*106*	*240*	*322*	*274*	*143*	*84.8*	*67.8*	*68.8*	*54.2*	*34.9*	*31.6*	*39.5*	*123*
1915-16	*93.6*	*186*	*199*	*193*	*168*	*101*	*54.6*	*52.8*	*44.2*	*31.2*	*34.8*	*67.2*	*102*
1916-17	*127*	*229*	*349*	*447*	*211*	*123*	*65.9*	*47.6*	*35.9*	*28.5*	*29.0*	*28.0*	*144*
1917-18	*54.6*	*187*	*398*	*348*	*163*	*91.9*	*69.3*	*44.2*	*45.1*	*93.1*	*58.4*	*48.6*	*134*
1918-19	*98.6*	*226*	*327*	*278*	*149*	*97.0*	*70.7*	*51.7*	*41.7*	*38.7*	*48.4*	*44.8*	*123*
1919-20	*92.8*	*215*	*324*	*251*	*150*	*89.2*	*48.9*	*34.0*	*26.2*	*25.2*	*28.9*	*30.8*	*110*
1920-21	*43.4*	*143*	*248*	*332*	*188*	*96.2*	*93.4*	*64.8*	*50.9*	*50.8*	*49.3*	*66.0*	*119*
1921-22	*97.1*	*238*	*425*	*276*	*149*	*78.4*	*54.1*	*58.8*	*52.5*	*37.4*	*28.9*	*30.0*	*127*
1922-23	*53.5*	*161*	*381*	*238*	*134*	*95.5*	*59.6*	*43.4*	*30.0*	*41.8*	*29.0*	*30.7*	*108*
1923-24	*74.9*	*201*	*366*	*279*	*144*	*98.0*	*52.5*	*36.4*	*31.3*	*25.1*	*42.7*	*42.7*	*116*
1924-25	*45.5*	*202*	*243*	*172*	*118*	*86.4*	*50.3*	*49.1*	*44.3*	*44.9*	*67.0*	*59.0*	*98.6*
1925-26	*142*	*301*	*355*	*262*	*143*	*81.3*	*51.8*	*36.1*	*32.1*	*29.3*	*32.8*	*36.5*	*126*
1926-27	*71.6*	*177*	*146*	*147*	*94.5*	*75.5*	*62.5*	*66.8*	*64.3*	*46.2*	*43.2*	*47.9*	*87.2*
1927-28	*65.1*	*194*	*394*	*319*	*168*	*130*	*117*	*115*	*98.5*	*67.7*	*58.6*	*63.4*	*149*
1928-29	*99.0*	*296*	*384*	*278*	*153*	*84.2*	*56.3*	*46.0*	*36.2*	*29.2*	*24.7*	*27.3*	*127*
1929-30	*39.2*	*118*	*286*	*178*	*116*	*74.2*	*46.3*	*33.9*	*27.0*	*22.4*	*24.6*	*29.8*	*83.2*
1930-31	*72.9*	*169*	*235*	*203*	*129*	*81.8*	*48.9*	*36.6*	*30.1*	*24.9*	*25.7*	*32.4*	*91.1*
Highest	142	301	466	447	211	130	117	115	98.5	93.1	67.0	67.2	149
Average	80.5	205	325	266	149	93.4	63.2	52.4	43.8	39.5	38.7	43.2	117
Lowest	39.2	118	146	147	94.5	74.2	46.3	33.9	26.2	22.4	24.6	27.3	83.2

NOTE.—Estimated monthly discharge shown in italics.

COLUMBIA RIVER AT VERNITA, WASH.

Gaging station located at Wenatchee prior to December 31, 1916; thereafter at Vernita, 6 miles below Priest Rapids. Drainage area at Wenatchee, 88,500 square miles; at Vernita, 95,500 square miles. Intervening inflow very small in proportion to total. Records available May 1, 1913, to March 31, 1931. Maximum discharge, during period of record, 528,000 second-feet June 15 and 16, 1913; minimum discharge, about 21,000 second-feet during middle of January 1930 when stage-discharge relation was affected by ice. Flood discharge, June 7, 1894, about 740,000 second-feet.

TABLE No. 26.—*Monthly discharge, in units of 1,000 second-feet, of Columbia River at Vernita, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	*76.2*	209	480	323	174	116	70.5	60.2	46.6	41.5	39.6	55.0	141
1914-15	111	249	332	282	147	87.6	69.9	71.5	56.5	35.8	32.6	41.2	127
1915-16	98.2	189	202	196	172	104	56.0	54.5	46.0	32.4	36.2	70.4	105
1916-17	135	241	361	459	219	127	67.7	48.2	37.2	29.4	30.4	28.9	149
1917-18	55.0	191	410	356	168	95.8	72.1	45.7	50.8	99.9	61.4	50.3	138
1918-19	103	233	335	286	154	99.4	73.2	53.7	45.1	40.7	50.7	46.1	127
1919-20	96.6	221	335	261	154	92.2	49.7	36.4	28.1	27.5	31.1	32.1	114
1920-21	44.4	146	253	338	192	99.5	97.6	65.6	53.1	53.3	52.7	69.4	123
1921-22	101	246	439	286	153	81.9	56.1	61.3	58.3	38.6	29.7	31.1	132
1922-23	54.8	165	391	245	136	97.9	61.3	44.9	31.6	44.1	30.2	31.9	111
1923-24	79.0	208	375	287	148	99.9	53.8	37.8	33.0	26.2	47.1	45.8	120
1924-25	47.5	208	251	175	119	88.3	51.7	50.7	47.7	46.9	69.4	61.4	102
1925-26	145	309	366	269	145	83.4	53.8	37.6	34.6	31.1	34.4	39.6	130
1926-27	75.3	181	149	149	96.3	77.3	64.6	69.0	67.1	48.3	44.6	49.5	89.6
1927-28	66.9	199	406	329	172	132	120	119	103	72.1	61.2	65.7	154
1928-29	102	303	396	284	155	85.6	57.8	47.0	37.1	30.1	25.3	28.2	130
1929-30	40.3	122	294	183	117	75.3	47.2	34.6	27.6	23.3	25.6	31.5	85.3
1930-31	76.6	173	239	206	130	82.9	49.4	37.1	30.9	25.6	27.1	33.7	93.0
Highest	145	309	480	459	219	132	120	119	103	99.9	69.4	70.4	154
Average	83.8	211	334	273	153	95.9	65.1	54.2	46.4	41.5	40.5	45.1	121
Lowest	40.3	122	149	149	96.3	75.3	47.2	34.6	27.6	23.3	25.3	28.2	85.3

NOTE.—Estimated discharge shown in italics.

KOOTENAI RIVER AT NELSON, B.C.

Gaging station located at outlet of Kootenai Lake. Drainage area, 17,700 square miles. Records available, January 1913 to March 1931. Maximum discharge during period of record, 146,000 second-feet June 28, 1916; minimum discharge, 4,080 second-feet, January 29, and February 1 and 2, 1930. Results furnished by Dominion Water Power and Hydrometric Bureau of Canada.

TABLE No. 27.—*Monthly discharge, in second-feet, of Kootenai River at Nelson, B.C.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	20,500	46,500	123,000	75,200	39,900	27,500	19,600	13,500	10,800	11,200	8,500	9,900	33,900
1914-15	22,600	64,400	90,800	80,000	36,900	20,900	18,500	21,500	13,600	9,300	7,600	8,000	33,000
1915-16	20,500	45,600	48,700	49,100	36,800	21,600	13,800	13,200	10,200	7,600	6,800	10,200	23,700
1916-17	25,100	52,400	97,700	121,000	52,600	28,500	15,000	10,500	7,800	5,900	5,900	5,700	35,900
1917-18	8,000	36,000	95,900	88,500	38,200	20,500	14,500	9,500	8,900	13,500	9,800	9,000	29,500
1918-19	21,300	54,000	85,500	68,500	33,700	21,200	16,700	13,300	10,100	9,200	12,200	9,000	29,600
1919-20	19,300	58,000	99,500	69,100	35,000	22,100	11,200	8,000	6,400	6,100	5,800	5,600	28,900
1920-21	8,800	34,000	66,700	92,600	45,400	23,800	23,800	15,100	11,700	9,900	10,200	12,800	29,700
1921-22	20,400	55,300	115,000	78,200	34,800	17,300	12,400	12,400	10,900	8,200	6,100	5,500	31,500
1922-23	8,500	34,600	97,000	54,600	27,400	19,200	12,200	9,700	6,200	8,200	6,100	5,200	24,100
1923-24	13,500	51,400	101,000	74,000	32,700	19,700	11,700	8,100	6,400	4,700	7,300	7,800	28,200
1924-25	8,200	44,500	56,100	36,400	21,700	17,900	11,900	12,000	10,300	10,000	13,300	12,100	21,500
1925-26	32,700	77,300	101,000	65,200	30,400	17,600	11,000	7,600	6,500	5,200	4,700	5,300	30,500
1926-27	17,900	41,200	35,800	30,000	18,600	17,500	12,900	18,100	12,900	10,400	7,000	7,300	19,200
1927-28	11,100	45,200	100,000	81,300	36,900	33,800	29,800	27,000	19,400	13,200	10,800	10,700	35,000
1928-29	18,300	71,200	96,500	69,000	32,600	17,500	13,500	10,800	7,810	6,090	4,840	5,570	29,600
1929-30	7,870	32,900	82,000	45,900	23,600	14,300	9,300	6,590	5,510	4,960	4,810	5,940	20,400
1930-31	16,200	41,900	62,600	48,400	25,600	15,200	10,100	7,590	6,040	4,920	5,200	5,710	20,900
Highest	32,700	77,300	123,000	121,000	52,600	33,800	29,800	27,000	19,400	13,500	13,300	12,800	35,900
Average	16,700	49,200	86,400	68,200	33,700	20,900	14,900	12,500	9,530	8,250	7,610	7,850	28,100
Lowest	7,870	32,900	35,800	30,000	18,600	14,300	9,300	6,590	5,510	4,700	4,700	5,200	19,200

SOUTH FORK FLATHEAD RIVER NEAR COLUMBIA FALLS, MONT.

Gaging station located near mouth and below dam site of proposed Hungry Horse Reservoir. Drainage area, 1,640 square miles. Records available September 20, 1910, to September 30, 1916, and April 13, 1923, to March 31, 1931 (quite fragmentary). Recording gage, after April 13, 1923. Maximum estimated discharge, June 19, 1916, 46,200 second-feet. Minimum discharge, 243 second-feet, March 11, 1930. Monthly discharge during period of missing or fragmentary records estimated by comparison with results at nearby gaging stations. It should be used with caution.

TABLE NO. 28.—*Monthly discharge in second-feet of South Fork Flathead River near Columbia Falls, Mont.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	*4,000*	*12,000*	*20,000*	*4,800*	*2,000*	*1,400*	*1,200*	*1,100*	*670*	*900*	*600*	*740*	*4,080*
1914-15	*4,200*	*9,800*	*10,000*	*3,300*	*1,600*	*1,400*	*1,500*	*1,900*	*670*	*900*	*800*	*520*	*3,050*
1915-16	*4,200*	*5,600*	*5,400*	*3,700*	*1,700*	*1,200*	*1,400*	*1,100*	*700*	*690*	*630*	*1,600*	*2,330*
1916-17	*4,700*	*9,400*	*20,000*	*9,400*	*2,100*	*2,500*	*1,100*	*1,500*	*900*	*450*	*520*	*430*	*4,420*
1917-18	*1,200*	*12,000*	*15,000*	*6,500*	*1,900*	*780*	*510*	*420*	*420*	*2,500*	*620*	*800*	*3,570*
1918-19	*4,400*	*10,000*	*14,000*	*3,200*	*1,700*	*880*	*850*	*660*	*540*	*730*	*480*	*490*	*3,160*
1919-20	*4,200*	*10,000*	*6,100*	*2,200*	*970*	*550*	*450*	*450*	*380*	*360*	*410*	*320*	*2,200*
1920-21	*1,700*	*9,400*	*11,000*	*4,200*	*1,400*	*1,500*	*1,800*	*1,300*	*960*	*450*	*450*	*1,300*	*2,970*
1921-22	*4,800*	*14,000*	*17,000*	*5,800*	*1,600*	*720*	*660*	*630*	*1,600*	*980*	*530*	*580*	*4,080*
1922-23	*790*	*12,000*	*12,000*	*2,500*	*970*	*630*	*480*	*470*	*480*	*650*	*430*	*420*	*2,660*
1923-24	*2,900*	11,600	11,400	3,530	1,230	601	568	564	*520*	*400*	*590*	*650*	*2,880*
1924-25	2,800	15,200	8,330	2,410	908	453	553	913	*790*	*870*	*780*	*1,000*	*2,930*
1925-26	*8,700*	*19,000*	*11,000*	*3,400*	*1,300*	*930*	*734*	*700*	*800*	*600*	*530*	*670*	*4,040*
1926-27	*5,000*	*11,000*	*5,500*	*1,600*	*535*	*780*	*1,300*	*1,200*	*1,600*	*1,300*	*1,000*	*840*	*2,650*
1927-28	*4,100*	*14,000*	*17,000*	*5,100*	*1,600*	*1,500*	*3,380*	*3,380*	*1,700*	*1,400*	*1,200*	*1,600*	*4,660*
1928-29	*5,500*	22,300	12,200	5,580	1,490	715	900	740	530	453	430	606	4,310
1929-30	2,110	10,900	10,600	2,490	811	493	445	392	372	309	538	470	2,500
1930-31	8,490	9,180	6,830	1,860	690	558	843	1,000	758	694	755	1,230	2,740
Highest	8,700	22,300	20,000	9,400	2,100	2,500	3,380	3,380	1,700	2,500	1,200	1,600	4,660
Average	4,100	12,100	11,900	3,950	1,360	977	1,030	1,020	799	813	627	793	3,290
Lowest	790	5,600	5,400	1,600	535	453	430	392	372	309	410	320	2,200

NOTE.—Estimated discharge shown in italics.

FLATHEAD RIVER NEAR POLSON, MONT.

Gaging station located about 12 miles below lake outlet. Drainage area, 7,010 square miles. Records available July 23, 1907, to March 31, 1931. Recording gage after 1929. Maximum discharge during period of record, 82,100 second-feet, May 29-30, 1928. Estimated maximum flow during 1894 flood, as determined from varying base data, 100,000 second-feet to 115,000 second-feet. Minimum discharge, 1,360 second-feet, December 9-14, 1919, and March 14, 1920.

TABLE NO. 29.—*Monthly discharge, in second-feet, of Flathead River near Polson, Mont.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	6,510	24,400	64,400	28,600	10,800	5,540	3,800	4,240	3,690	3,120	3,000	2,890	13,400
1914-15	7,100	26,700	30,000	15,400	6,670	4,040	5,320	8,370	5,640	3,630	2,790	2,490	9,880
1915-16	6,510	18,200	18,100	16,200	9,740	5,260	4,820	4,760	4,490	3,520	3,040	4,770	8,310
1916-17	11,900	25,800	48,000	55,600	17,500	11,100	6,730	4,600	3,630	2,670	2,470	2,240	16,100
1917-18	2,960	22,400	51,700	35,500	11,400	4,770	3,070	2,610	2,580	8,720	4,130	3,770	12,800
1918-19	10,300	29,700	44,200	23,000	8,430	4,690	3,360	3,230	2,630	2,250	2,400	2,340	11,400
1919-20	5,350	24,900	34,900	14,500	5,410	3,110	2,300	2,220	1,670	1,560	1,600	1,510	8,250
1920-21	2,630	18,200	36,200	27,000	9,900	5,160	5,120	4,310	3,860	3,480	3,250	5,800	10,400
1921-22	12,000	33,700	54,000	25,900	9,670	4,810	3,690	3,420	3,810	4,070	3,120	2,770	13,400
1922-23	3,460	22,600	49,500	20,900	8,100	4,740	3,400	2,880	2,650	2,740	2,760	2,460	10,500
1923-24	5,090	29,300	47,800	26,400	9,970	4,900	3,100	2,890	2,670	2,640	2,910	3,120	11,700
1924-25	4,060	31,300	37,000	18,000	7,700	4,490	3,190	3,200	3,170	*3,800*	*3,400*	*4,800*	*10,400*
1925-26	20,800	46,700	50,700	27,100	10,400	6,420	*4,620*	*3,550*	*3,300*	*2,600*	*2,200*	*3,200*	*15,200*
1926-27	9,210	26,000	17,300	9,060	*4,230*	*4,420*	7,690	8,450	8,400	5,810	4,380	4,020	*9,110*
1927-28	5,470	32,800	63,000	42,200	14,100	9,580	10,100	*8,600*	*7,900*	*6,000*	*5,300*	*5,700*	*17,600*
1928-29	*8,340*	48,900	53,000	*31,700*	12,500	6,090	*4,950*	*4,560*	3,630	3,090	2,730	2,830	*15,200*
1929-30	3,650	20,400	39,600	16,800	6,520	3,630	2,630	2,210	2,180	1,870	2,150	2,470	8,690
1930-31	10,200	25,900	27,100	13,100	5,860	3,530	3,250	3,390	3,110	2,540	2,660	2,920	8,650
Highest	20,800	48,900	64,400	55,600	17,500	11,100	10,100	8,600	8,400	8,720	5,300	5,800	17,600
Average	7,530	28,200	42,600	24,800	9,380	5,350	4,510	4,300	3,830	3,560	3,020	3,340	11,730
Lowest	2,630	18,200	17,300	9,060	4,230	3,110	2,300	2,210	1,670	1,560	1,600	1,510	8,250

NOTE.—Estimated discharge shown in italics.

CLARK FORK NEAR HERON, MONT.

Located about 4 miles above Montana-Idaho boundary. Drainage area, 21,900 square miles. Records available September 21, 1928, to March 31, 1931. Recording gage after October 29, 1928. Monthly discharge prior to October 1928 estimated by adjustment between the flow at Plains, Mont., and Newport, Wash., taking into account natural storage in Pend Oreille Lake and differences in drainage areas. Maximum discharge since September 1928 was 72,600 second-feet May 27, 1929; minimum discharge, 1,640 second-feet January 13, 1930, when regimen was affected by upstream regulation for power.

TABLE No. 30.—*Monthly discharge, in second-feet, of Clark Fork near Heron, Mont.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	*27,700*	*60,500*	*116,000*	*50,000*	*20,600*	*12,200*	*10,400*	*11,900*	*8,840*	*10,400*	*8,270*	*12,700*	*29,200*
1914-15	*26,200*	*55,100*	*52,100*	*28,600*	*12,800*	*9,000*	*12,000*	*18,600*	*11,600*	*8,150*	*7,500*	*9,200*	*21,000*
1915-16	*19,800*	*35,000*	*37,700*	*29,100*	*17,100*	*10,700*	*10,300*	*10,100*	*9,780*	*5,760*	*10,900*	*22,200*	*18,200*
1916-17	*35,700*	*61,400*	*90,100*	*90,900*	*30,900*	*18,500*	*13,300*	*10,600*	*8,350*	*7,400*	*8,100*	*6,700*	*31,900*
1917-18	*18,600*	*65,100*	*104,000*	*61,500*	*19,600*	*10,800*	*8,700*	*7,680*	*12,900*	*27,100*	*13,200*	*14,300*	*30,400*
1918-19	*28,100*	*61,200*	*77,000*	*34,600*	*16,300*	*9,000*	*9,280*	*8,770*	*7,480*	*10,000*	*9,540*	*9,920*	*28,500*
1919-20	*22,200*	*52,100*	*55,200*	*20,800*	*9,260*	*7,240*	*4,900*	*5,900*	*4,500*	*5,690*	*6,490*	*7,080*	*16,800*
1920-21	*12,100*	*46,600*	*65,700*	*40,000*	*14,300*	*11,200*	*13,200*	*11,500*	*10,500*	*11,600*	*13,500*	*17,400*	*22,300*
1921-22	*25,400*	*68,400*	*88,100*	*35,200*	*13,700*	*8,680*	*7,320*	*7,790*	*10,500*	*7,990*	*7,200*	*7,210*	*24,000*
1922-23	*14,700*	*52,600*	*86,300*	*31,200*	*12,900*	*8,780*	*7,420*	*6,430*	*6,380*	*9,880*	*6,180*	*7,500*	*20,900*
1923-24	*19,400*	*55,300*	*76,900*	*39,000*	*15,000*	*8,640*	*7,440*	*6,980*	*6,720*	*4,980*	*11,100*	*8,960*	*21,700*
1924-25	12,400	37,800	49,100	23,000	10,800	7,180	6,970	8,370	18,300	10,300	16,200	13,900	19,600
1925-26	*42,200*	*82,400*	*72,500*	*38,200*	*14,700*	*10,600*	*8,840*	*8,000*	*7,740*	*6,770*	*7,990*	*9,090*	*25,800*
1926-27	*20,300*	*42,100*	*24,300*	*12,700*	*7,490*	*8,090*	*12,600*	*14,000*	*15,300*	*10,600*	*10,700*	*11,600*	*15,800*
1927-28	*18,900*	*64,200*	*103,000*	*59,800*	*20,700*	*17,200*	*19,400*	*28,400*	*22,800*	*16,400*	*13,300*	*17,300*	*33,500*
1928-29	*24,700*	*91,700*	*76,600*	*47,300*	*19,000*	*11,200*	9,450	9,010	7,180	5,000	5,390	7,450	*26,300*
1929-30	10,900	40,000	60,700	26,000	19,600	6,530	6,210	5,640	6,040	4,720	7,430	7,550	16,000
1930-31	27,500	45,600	42,600	20,100	9,860	6,990	7,610	7,560	6,760	5,930	6,190	7,260	16,200
Highest	42,200	91,700	116,000	90,900	30,900	18,500	19,400	28,400	22,800	27,100	16,200	22,200	33,500
Average	22,600	57,600	71,000	38,200	15,300	10,100	9,770	10,400	10,100	9,370	9,400	11,000	23,000
Lowest	10,900	35,000	24,300	12,700	7,490	6,530	4,900	5,640	4,500	4,720	5,390	6,700	15,800

NOTE.—Estimated discharge shown in italics.

CLARK FORK AT NEWPORT, WASH.

Results obtained from gages located below Priest River, Idaho, at Newport, Wash., and at Metaline Falls, Wash. (See Geological Survey Water-Supply Paper 532, p. 92.) Drainage area, 24,200 square miles. Records available June 26, 1903, to March 31, 1931. Recording gage after November 13, 1928. Maximum discharge during period of record, 136,000 second-feet, June 15, 1913; minimum discharge, 2,200 second-feet, December 12, 1919. Estimated flood discharge during June 1894, 217,000 second-feet.

TABLE No. 31.—*Monthly discharge, in second-feet, of Clark Fork at Newport, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	25,900	58,300	122,000	70,900	29,000	15,900	11,800	13,000	11,800	11,800	10,200	14,700	33,000
1914-15	27,000	52,900	62,100	39,200	18,000	10,700	12,200	19,200	16,000	11,000	9,410	10,600	24,100
1915-16	19,800	35,900	41,900	35,300	22,900	13,100	11,500	11,500	11,700	8,290	10,800	22,100	20,400
1916-17	41,400	64,800	86,000	113,000	45,000	23,200	16,500	12,900	10,500	9,260	9,380	8,630	36,900
1917-18	17,800	54,300	112,000	83,700	29,700	14,200	10,400	9,140	11,300	31,000	18,900	16,000	34,100
1918-19	29,800	63,900	79,200	52,500	20,800	12,900	10,100	10,200	9,550	10,000	12,900	11,600	27,000
1919-20	23,000	48,800	65,800	31,100	13,300	7,990	6,470	6,730	5,160	6,460	8,330	8,010	19,200
1920-21	12,400	40,800	69,200	54,600	21,600	13,000	13,900	13,400	13,300	13,900	14,300	19,900	25,100
1921-22	28,000	62,300	101,000	52,000	19,800	10,900	9,150	8,880	11,300	10,800	9,160	8,510	27,700
1922-23	15,100	43,100	96,200	47,500	18,200	11,100	8,530	7,890	6,880	11,600	8,090	9,090	23,600
1923-24	19,300	49,800	84,100	54,500	21,800	11,600	8,520	8,050	8,100	6,240	11,500	12,000	24,600
1924-25	12,900	50,300	61,400	32,500	15,000	9,100	7,700	8,880	8,780	11,800	18,500	17,000	21,200
1925-26	41,500	81,600	93,200	52,500	20,700	12,900	10,300	9,110	8,950	8,650	9,160	10,400	30,000
1926-27	17,900	45,300	33,800	17,600	9,500	8,750	12,000	15,200	17,900	14,300	12,300	14,300	18,300
1927-28	18,400	59,500	113,000	82,200	29,800	19,400	20,500	27,900	29,900	20,600	17,800	18,300	38,100
1928-29	27,900	80,600	104,000	59,200	27,200	14,400	10,700	10,500	8,870	6,550	6,400	8,390	30,500
1929-30	12,100	33,600	67,100	35,600	14,600	8,000	6,660	6,220	6,680	5,490	7,320	8,730	17,700
1930-31	22,200	47,400	46,400	26,500	12,800	7,810	7,570	7,960	7,600	6,660	7,380	9,060	17,500
Highest	41,500	81,600	122,000	113,000	45,000	23,200	20,500	27,900	29,900	31,000	18,900	22,100	38,100
Average	22,900	54,100	79,900	52,200	21,600	12,500	10,800	11,500	11,300	11,400	11,200	12,600	26,100
Lowest	12,100	33,600	33,800	17,600	9,500	7,810	6,470	6,220	5,160	5,490	6,400	8,010	17,500

CLARK FORK AT METALINE FALLS, WASH.

Gaging station located just above Sullivan Creek, but measurements include the flow of Sullivan Creek. Drainage area, 25,100 square miles. Records available October 1, 1912, to March 31, 1931. Recording gage after October 1, 1930, at Z Canyon, 10 miles downstream, where flow is practically the same. Maximum flow during period of record, 139,000 second-feet June 16, 1913; minimum discharge, 2,500 second-feet, December 12, 1919. Flood discharge during June 1894 about 220,000 second-feet on basis of estimated flood discharge at Newport.

TABLE No. 32.—*Monthly discharge, in second-feet, of Clark Fork at Metaline Falls, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	26,500	59,900	126,000	71,600	29,500	16,300	12,100	13,300	12,100	12,100	10,500	15,000	33,800
1914–15	27,900	55,600	64,200	39,900	18,300	11,100	12,500	19,700	16,300	11,300	9,680	10,900	24,800
1915–16	20,800	37,200	42,700	35,700	23,200	13,400	11,800	11,800	12,000	8,540	11,100	22,500	20,900
1916–17	42,000	66,200	88,500	114,000	45,400	23,600	16,800	13,200	10,800	9,490	9,620	8,870	37,600
1917–18	18,100	55,700	115,000	84,900	30,100	14,500	10,700	9,450	11,600	31,300	19,200	16,300	34,800
1918–19	30,300	64,900	80,300	53,000	21,100	13,100	10,400	10,400	9,780	10,300	13,200	11,800	27,400
1919–20	23,700	51,000	67,700	31,700	13,600	8,340	6,760	7,090	5,470	6,800	8,640	8,200	19,900
1920–21	12,600	41,400	70,200	55,000	22,200	13,500	14,200	13,800	13,600	14,200	14,600	20,300	25,500
1921–22	28,700	64,300	103,000	52,700	20,200	11,200	9,380	9,130	11,500	11,000	9,540	9,020	28,400
1922–23	15,300	44,000	97,600	47,900	18,500	11,400	8,800	8,180	7,230	11,900	8,350	9,290	24,100
1923–24	19,600	51,100	85,400	55,000	22,100	11,800	8,700	8,250	8,390	6,540	11,900	12,300	25,100
1924–25	13,200	51,300	61,800	32,700	15,200	9,210	7,900	9,140	9,020	12,100	19,000	17,400	21,500
1925–26	42,400	83,700	95,000	53,000	21,000	13,200	10,600	9,370	9,200	8,850	9,400	10,600	30,600
1926–27	18,300	46,500	34,500	17,800	9,640	8,960	12,300	15,600	18,400	14,600	12,600	14,600	18,700
1927–28	18,800	61,000	115,000	83,000	30,300	19,900	21,000	28,700	30,700	21,100	18,300	18,700	38,900
1928–29	28,500	82,700	106,000	59,800	27,600	14,700	11,000	11,000	9,100	6,800	6,630	8,650	31,100
1929–30	12,400	33,400	69,100	39,200	15,900	8,280	6,830	6,350	6,730	5,550	7,380	8,840	18,400
1930–31	21,500	48,100	47,900	28,100	13,200	7,980	7,740	8,050	7,710	6,770	7,680	9,430	17,900
Highest	42,400	83,700	126,000	114,000	45,400	23,600	21,000	28,700	30,700	31,300	19,200	22,500	38,900
Average	23,400	55,400	81,700	53,100	22,100	12,800	11,100	11,800	11,600	11,600	11,500	12,900	26,600
Lowest	12,400	33,400	34,500	17,800	9,640	7,980	6,760	6,360	5,470	5,550	6,630	8,200	17,900

PRIEST RIVER NEAR COOLIN, IDAHO

Gaging station located at outlet of Priest Lake. Drainage area, 572 square miles. Records available, July 13, 1912, to January 8, 1913; April 18, 1913, to September 30, 1918; and May 1, 1919, to March 31, 1931. Water-stage recorder after November 24, 1914. Maximum discharge during period of record, 7,290 second-feet May 30, 1917; minimum discharge, 120 second-feet, December 7, 1929.

TABLE No. 33.—*Monthly discharge, in second-feet, of Priest River near Coolin, Idaho*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	*1,550*	3,340	4,890	2,080	833	514	451	542	586	779	743	717	1,390
1914–15	2,060	4,300	3,520	1,780	628	380	567	1,050	764	496	422	552	1,380
1915–16	1,760	2,240	1,580	939	596	332	289	375	447	431	435	707	845
1916–17	1,280	3,760	4,810	3,200	999	552	330	250	246	283	296	321	1,370
1917–18	557	3,780	5,910	2,200	621	330	221	184	299	707	567	558	1,330
1918–19	*1,570*	3,300	3,360	1,400	656	434	*300*	*250*	*250*	*260*	*260*	*350*	*1,050*
1919–20	*1,700*	4,260	3,600	1,420	569	304	209	253	257	298	303	324	1,130
1920–21	562	2,300	2,710	1,450	560	485	766	737	882	808	806	1,050	1,100
1921–22	2,490	4,400	4,680	1,490	571	308	263	354	502	464	407	364	1,360
1922–23	554	2,850	3,810	1,060	451	323	270	324	300	513	414	354	936
1923–24	994	3,480	3,570	1,580	585	325	231	234	273	271	493	523	1,050
1924–25	553	3,170	1,740	589	331	214	194	386	429	499	717	691	794
1925–26	2,690	4,420	3,030	1,140	415	210	159	158	255	268	292	295	1,110
1926–27	1,000	2,180	807	391	242	330	690	648	1,100	925	687	671	808
1927–28	1,020	3,650	4,480	1,790	564	821	1,370	1,280	1,130	678	547	722	1,510
1928–29	1,650	3,870	2,880	1,310	536	296	263	274	255	225	221	247	1,010
1929–30	409	2,410	2,290	1,060	434	236	178	156	176	193	226	286	674
1930–31	1,400	2,340	1,360	695	352	208	175	198	194	197	208	307	638
Highest	2,690	4,420	5,910	3,200	999	821	1,370	1,280	1,130	925	806	1,050	1,510
Average	1,310	3,340	3,280	1,420	552	367	385	425	464	461	447	502	1,080
Lowest	409	2,180	807	391	242	208	159	156	176	193	208	247	638

NOTE.—Estimated discharge shown in italics.

SPOKANE RIVER AT POST FALLS, IDAHO

Gaging station located about 10 miles below Coeur d'Alene Lake outlet, and one fourth mile below Washington Water Power Co. dam. Drainage area, 3,880 square miles. Records available, January 1, 1913, to March 31, 1931. Water-stage recorder after November 22, 1920. Maximum discharge, during period of record, 39,800 second-feet May 18, 1917; minimum discharge, 540 second-feet, September 5, 1926. Flow partly regulated by storage in and release from Coeur d'Alene Lake Reservoir.

TABLE No. 34.—*Monthly discharge, in second-feet, of Spokane River at Post Falls, Idaho (exclusive of diversion into Spokane Valley Farm Co.'s canal)*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	19,600	25,600	20,800	4,540	1,480	1,410	2,320	3,590	2,270	2,700	5,310	10,000	8,290
1914–15	16,300	15,200	4,520	1,510	1,390	1,200	1,220	4,130	3,130	1,750	1,310	5,470	4,770
1915–16	10,900	6,670	4,320	2,050	1,560	1,490	1,440	1,520	2,180	2,570	5,030	14,300	4,500
1916–17	21,400	22,300	18,300	10,700	1,680	1,530	1,490	1,730	1,800	1,860	2,680	2,650	7,340
1917–18	14,100	31,800	25,600	5,890	2,130	1,840	1,610	1,330	6,340	23,500	8,850	7,570	10,900
1918–19	17,200	15,800	7,350	1,590	1,210	1,210	1,280	1,760	3,600	5,170	5,840	7,990	5,820
1919–20	19,800	19,200	7,580	1,700	1,180	1,130	1,140	1,160	1,230	1,270	1,970	5,660	5,250
1920–21	9,740	15,700	7,910	1,730	1,230	1,100	2,500	3,850	4,210	9,680	8,720	14,000	6,690
1921–22	16,500	21,900	10,100	1,430	1,150	1,050	1,110	1,550	6,120	2,220	1,270	2,280	5,600
1922–23	10,300	19,600	11,800	1,320	992	973	1,030	1,350	1,570	6,770	2,370	3,410	5,140
1923–24	15,900	19,000	13,400	2,250	1,070	1,270	1,100	1,380	2,330	1,730	9,920	6,490	6,280
1924–25	7,960	14,500	2,420	1,180	1,150	974	948	1,950	4,970	3,780	14,700	10,200	5,340
1925–26	23,200	19,100	8,320	1,410	1,490	1,280	1,230	1,170	1,380	2,030	5,940	7,150	6,120
1926–27	10,200	6,620	1,580	1,460	991	1,010	1,740	4,610	10,400	4,970	7,040	8,730	4,940
1927–28	12,200	23,900	17,600	2,560	1,580	1,420	5,460	13,100	14,900	8,730	6,220	10,900	9,890
1928–29	15,200	22,600	7,810	1,520	1,000	913	1,100	1,150	1,190	1,090	1,020	1,750	4,710
1929–30	7,060	13,100	5,060	1,190	1,110	1,240	960	972	935	1,310	2,490	3,870	3,280
1930–31	11,300	7,060	3,530	1,020	1,110	1,070	1,020	965	1,010	996	1,910	6,780	3,150
Highest	23,200	31,800	25,600	10,700	2,130	1,840	5,460	13,100	14,900	23,500	14,700	14,300	10,900
Average	14,400	17,800	9,890	2,500	1,310	1,230	1,590	2,630	3,880	4,560	5,140	7,180	6,000
Lowest	7,060	6,620	1,580	1,020	991	913	948	965	935	996	1,020	1,750	3,150

SPOKANE RIVER AT SPOKANE, WASH.

Gaging station located at several different points above and below Spokane Falls, but within the city limits of Spokane. Drainage area, 4,350 square miles. Records available, April 1, 1891, to March 31, 1931. Water-stage recorder since July 31, 1915. Maximum discharge during period of record, 49,000 second-feet May 31, 1894; minimum discharge, 452 second-feet, December 16, 1929. Flow partly regulated by storage in and release from Coeur d'Alene Lake Reservoir.

TABLE No. 35.—*Monthly discharge, in second-feet, of Spokane River at Spokane, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	19,500	26,600	21,600	5,190	1,960	1,870	2,470	3,650	2,730	3,000	5,350	9,910	8,650
1914–15	15,800	15,000	4,990	2,060	1,860	1,670	1,580	3,900	3,350	2,430	1,980	5,160	4,990
1915–16	10,200	6,820	4,630	2,360	1,950	1,910	1,910	2,000	2,470	2,750	4,740	13,700	4,620
1916–17	21,500	22,700	18,300	11,000	2,380	2,130	2,070	2,300	2,330	2,330	2,780	2,890	7,730
1917–18	14,200	32,900	25,800	6,470	2,730	2,430	2,280	1,980	6,500	24,400	9,210	7,730	11,400
1918–19	16,300	15,100	7,550	2,200	1,790	1,750	1,760	2,180	3,890	5,380	6,390	8,210	6,030
1919–20	19,100	18,400	7,750	2,250	1,780	1,700	1,700	1,680	1,700	1,720	2,280	5,770	5,480
1920–21	9,840	15,300	8,340	2,370	1,810	1,710	2,840	4,160	4,450	9,830	9,190	14,500	7,020
1921–22	17,200	22,600	11,300	2,330	1,780	1,640	1,810	2,080	6,590	2,930	1,840	2,620	6,240
1922–23	10,500	20,500	13,300	2,150	1,560	1,540	1,560	1,820	2,050	7,310	3,200	3,660	5,770
1923–24	16,100	19,500	14,200	3,210	1,730	1,910	1,710	1,870	2,710	2,220	10,000	7,150	6,820
1924–25	8,220	15,000	3,200	1,650	1,620	1,400	1,440	2,300	5,100	4,000	14,800	10,500	5,720
1925–26	23,800	19,800	9,360	2,180	2,060	1,910	1,820	1,760	1,870	2,470	6,060	7,280	6,680
1926–27	10,300	7,370	2,140	1,960	1,530	1,510	2,160	4,750	10,500	5,330	7,140	9,050	5,300
1927–28	12,400	24,700	18,600	3,530	2,180	2,040	5,640	13,100	15,900	9,300	6,840	11,100	10,500
1928–29	15,600	23,000	8,960	2,480	1,770	1,600	1,690	1,760	1,750	1,560	1,490	2,050	5,320
1929–30	7,160	13,500	5,730	1,870	1,540	1,720	1,480	1,460	1,360	1,590	2,650	4,030	3,680
1930–31	11,300	7,510	4,400	1,520	1,440	1,420	1,390	1,350	1,340	1,340	2,060	6,610	3,470
Highest	23,800	32,900	25,800	11,000	2,730	2,430	5,640	13,100	15,900	24,400	14,800	14,500	11,400
Average	14,400	18,100	10,600	3,150	1,860	1,770	2,070	3,010	4,260	4,990	5,440	7,330	6,410
Lowest	7,160	6,820	2,140	1,520	1,440	1,400	1,390	1,350	1,340	1,340	1,490	2,050	3,470

SPOKANE RIVER NEAR LONG LAKE, WASH.

Gaging station located 1½ miles below Little Falls power plant of Washington Power Co. and 4 miles below Chamokane Creek. Drainage area, 6,380 square miles. Records available, November 5, 1912, to March 31, 1931. Water-stage recorder since records started. Maximum discharge, during period of record, 41,300 second-feet May 18, 1917; minimum discharge, 198 second-feet, December 12, 1929. Flow partly regulated by storage in and release from Coeur d'Alene Lake and Long Lake Reservoirs.

TABLE No. 36.—*Monthly discharge, in second-feet, of Spokane River near Long Lake, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	22,600	27,300	22,800	6,720	2,920	2,700	3,260	4,380	3,510	4,390	7,210	12,400	10,000
1914–15	17,800	17,000	6,430	2,880	2,560	2,300	2,370	3,680	2,860	2,580	2,940	6,250	5,810
1915–16	11,700	8,350	5,810	3,100	2,660	2,520	2,650	2,690	3,280	3,460	6,740	17,000	5,830
1916–17	23,900	24,000	19,700	13,200	3,330	2,830	2,810	2,970	3,040	2,960	3,580	4,230	8,880
1917–18	16,700	34,500	29,200	8,190	3,550	3,110	2,920	2,760	6,280	25,700	10,700	8,910	12,700
1918–19	18,000	17,100	8,880	2,870	2,290	2,120	2,200	2,550	4,320	6,000	7,800	10,400	7,030
1919–20	22,400	21,000	9,160	3,060	2,650	2,570	2,500	2,620	2,700	2,680	3,410	6,630	6,770
1920–21	11,000	16,600	9,120	3,000	2,310	2,240	3,340	4,720	5,430	11,100	12,000	17,600	8,190
1921–22	19,800	24,800	11,900	2,900	2,440	2,320	2,430	2,690	7,200	3,450	2,420	4,240	7,230
1922–23	13,800	22,500	14,100	2,770	2,260	2,200	2,220	2,270	2,700	8,630	3,840	5,230	6,890
1923–24	18,500	21,200	16,200	3,840	2,300	2,480	2,410	2,540	3,310	3,270	11,900	7,920	7,950
1924–25	8,950	15,900	3,890	2,420	2,410	2,260	2,220	3,040	5,900	5,730	18,500	12,400	6,900
1925–26	25,400	21,600	10,200	2,940	2,710	2,620	2,500	2,420	2,630	3,220	8,130	8,640	7,720
1926–27	11,400	8,190	2,780	2,600	2,200	2,210	2,880	5,330	11,700	6,750	10,400	11,600	6,480
1927–28	14,300	26,600	20,000	4,510	2,950	3,000	6,720	15,700	18,300	11,600	9,040	14,700	12,300
1928–29	18,000	25,400	10,100	3,400	2,600	2,410	2,480	2,500	2,620	2,440	2,640	3,520	6,500
1929–30	8,390	14,400	6,510	2,550	2,270	2,410	2,260	2,390	1,900	2,280	3,980	5,720	4,580
1930–31	12,000	7,760	4,870	2,250	2,150	2,180	2,090	2,130	2,160	2,120	2,960	8,070	4,230
Highest	25,400	34,500	29,200	13,200	3,550	3,110	6,720	15,700	18,300	25,700	18,500	17,600	12,700
Average	16,400	19,700	11,800	4,070	2,590	2,470	2,790	3,740	4,990	6,020	7,120	9,190	7,550
Lowest	8,300	7,760	2,780	2,250	2,150	2,120	2,090	2,130	1,900	2,120	2,420	3,520	4,230

OKANOGAN RIVER AT OKANOGAN, WASH.

Original gaging station located at Okanogan, one fourth mile above Salmon Creek. Present gaging station located about 13 miles above Okanogan and about 7 miles below Tonasket. Inflow between the two locations very small in proportion to total flow. Drainage area, 7,740 square miles at original location; 7,250 square miles at present location. Records available, May 10, 1911, to September 30, 1925 (original), and April 17, 1929, to March 31, 1931 (present). Water-stage-recorder after May 21, 1929. Monthly discharge for remainder of 18 years ending March 31, 1931, was estimated by comparison with sum of flow at gaging stations on Okanogan River at Okanogan Falls, British Columbia, and Similkameen River near mouth. Maximum discharge during period of record, 22,200 second-feet June 20, 1916; minimum discharge, 236 second-feet September 5, 1929.

TABLE No. 37.—*Monthly discharge, in second-feet, of Okanogan River at Okanogan, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	1,680	7,160	12,200	5,150	2,300	1,610	1,630	1,590	1,370	1,520	1,230	1,250	3,230
1914-15	3,330	9,480	8,650	3,990	1,610	1,160	1,290	1,500	1,110	972	1,070	1,080	2,940
1915-16	3,180	5,420	4,580	2,670	1,900	1,180	1,190	1,430	1,050	771	1,120	1,860	2,200
1916-17	2,850	9,640	15,500	8,730	2,980	1,710	1,200	988	841	794	808	863	3,920
1917-18	886	5,980	13,100	5,790	1,850	1,140	1,020	1,170	1,000	2,320	1,180	979	3,040
1918-19	2,330	9,170	11,400	3,640	1,800	928	1,020	1,080	890	936	857	904	2,920
1919-20	2,380	10,100	11,700	5,340	1,760	1,070	853	1,160	903	868	1,100	788	3,170
1920-21	844	4,740	8,290	5,750	1,680	946	1,870	1,180	897	818	919	1,170	2,430
1921-22	1,760	9,830	14,600	5,110	1,600	823	1,230	1,640	1,990	1,610	1,290	1,380	3,580
1922-23	1,550	7,000	11,900	2,610	981	816	987	1,110	979	1,280	986	1,030	2,600
1923-24	2,340	9,050	11,700	5,240	1,870	1,220	1,180	1,160	1,040	858	1,660	1,330	3,220
1924-25	1,440	10,200	5,340	1,600	629	452	755	806	1,230	1,290	1,470	800	2,180
1925-26	3,600	11,400	6,930	2,170	743	476	*578*	*588*	*764*	*715*	*920*	*1,340*	*2,530*
1926-27	*3,520*	*3,390*	*1,690*	*750*	*424*	*358*	*642*	*602*	*478*	*450*	*755*	*1,090*	*1,180*
1927-28	*1,320*	*5,140*	*10,400*	*2,670*	*1,070*	*2,050*	*3,390*	*2,910*	*2,770*	*3,210*	*2,760*	*2,500*	*3,340*
1928-29	*3,510*	*14,000*	*8,170*	*5,000*	*2,590*	*1,640*	*1,860*	*1,610*	*754*	*362*	*319*	*446*	*3,380*
1929-30	506	3,890	5,530	1,330	406	270	416	413	399	360	581	529	1,220
1930-31	3,240	5,090	5,060	1,840	515	365	442	588	443	439	600	525	1,640
Highest	3,600	14,000	15,500	8,730	2,980	2,050	3,390	2,910	2,770	3,210	2,760	2,500	3,920
Average	2,240	7,820	9,300	3,850	1,480	1,010	1,200	1,200	1,050	1,090	1,090	1,100	2,710
Lowest	506	3,390	1,690	750	406	270	416	413	399	360	319	446	1,180

NOTE.—Estimated monthly discharge shown in italics.

CHELAN RIVER AT CHELAN, WASH.

Gaging station located below outlet of Lake Chelan. Drainage area, 950 square miles. Records available, November 1, 1903, to March 31, 1931. Water-stage recorder since November 11, 1928. Maximum discharge, during period of record, 11,600 second-feet June 8, 1921; practically no flow during part of January 30, 1917, when outlet to lake was blocked with ice. Flow regulated by storage in, and release from, Chelan Lake Reservoir, capacity about 665,000 acre-feet. Measured flow has been corrected for the natural and artificial regulation so that results, presented below, represent natural inflow to reservoir.

TABLE No. 38.—*Monthly inflow, in second-feet, to Chelan Lake Reservoir*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	1,870	5,110	7,970	4,650	1,980	1,180	667	694	340	818	484	890	2,230
1914-15	3,230	5,940	5,390	3,870	1,400	815	880	1,330	724	405	279	961	2,110
1915-16	3,230	3,250	2,710	1,870	1,380	548	486	635	584	247	626	1,640	1,430
1916-17	3,130	5,630	8,710	6,330	3,060	1,100	411	371	320	273	317	307	2,510
1917-18	1,010	4,910	6,790	5,610	2,020	970	480	605	1,570	2,340	884	680	2,330
1918-19	2,320	5,190	6,720	4,020	1,690	1,070	914	630	1,090	904	580	668	2,160
1919-20	2,500	5,560	6,470	5,380	2,000	958	394	832	563	693	605	945	2,250
1920-21	852	2,940	4,320	4,390	1,680	1,240	1,770	928	646	890	1,130	1,220	1,840
1921-22	1,850	6,880	9,010	4,750	2,100	761	1,340	1,330	1,890	558	371	475	2,620
1922-23	1,230	4,650	7,040	2,910	1,570	864	538	286	452	701	299	478	1,760
1923-24	2,670	5,720	6,600	4,420	1,630	750	579	259	496	335	972	862	2,110
1924-25	1,580	6,860	3,900	2,470	1,160	674	683	593	1,590	782	884	906	1,850
1925-26	3,110	7,290	5,660	3,300	1,330	550	291	244	519	394	497	999	2,020
1926-27	3,090	3,070	2,600	1,570	826	445	1,290	689	760	363	524	293	1,300
1927-28	1,590	3,820	7,440	2,960	1,430	1,080	1,490	1,340	1,350	1,280	694	1,110	2,130
1928-29	1,650	7,370	4,520	2,890	1,100	623	922	407	436	374	342	385	1,760
1929-30	731	3,660	4,420	1,940	1,140	655	472	286	368	140	510	790	1,260
1930-31	2,840	3,020	3,550	2,340	1,210	694	452	429	374	473	416	621	1,370
Highest	3,230	7,370	9,010	6,330	3,060	1,240	1,770	1,340	1,890	2,340	1,130	1,640	2,620
Average	2,140	5,050	5,770	3,650	1,590	830	780	660	780	665	580	790	1,950
Lowest	731	2,940	2,600	1,570	826	445	291	244	320	140	279	293	1,260

WENATCHEE RIVER NEAR LEAVENWORTH, WASH.

Gaging station located half a mile below Beaver Creek and about three fourths mile above proposed dam site. Drainage area, 591 square miles. Records available (staff gage), November 27, 1910, to September 30, 1929. Monthly discharge, October 1929 to March 1931, determined by comparison with flow at

Dryden. Maximum discharge during period of record, 20,800 second-feet December 13, 1921; minimum discharge, 250 second-feet, October 18 and 19, 1925.

TABLE No. 39.—*Monthly discharge, in second-feet, of Wenatchee River near Leavenworth, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	2,140	5,990	9,570	5,260	1,700	1,130	1,240	1,290	830	1,160	666	1,510	2,710
1914–15	3,410	5,920	4,560	2,760	981	710	949	2,230	893	491	431	1,030	2,040
1915–16	3,630	2,610	1,860	1,060	764	402	618	940	589	548	738	1,660	1,280
1916–17	3,090	6,160	9,370	6,440	2,590	981	485	557	408	429	604	487	2,640
1917–18	913	5,210	8,030	6,150	1,740	754	517	678	3,640	3,940	1,250	976	2,830
1918–19	2,880	4,810	6,720	2,770	1,070	647	937	998	1,970	1,140	868	792	2,140
1919–20	3,000	6,010	6,470	4,990	1,700	759	456	1,400	1,060	1,500	1,200	1,020	2,470
1920–21	1,260	3,480	4,180	3,280	1,010	1,540	2,470	1,250	932	1,390	2,180	2,100	2,090
1921–22	2,840	7,230	9,150	4,330	1,570	917	1,330	1,590	3,770	915	723	643	2,930
1922–23	1,670	5,140	6,900	2,010	850	621	533	579	651	1,260	592	699	1,790
1923–24	4,080	6,380	6,050	3,720	1,600	625	477	647	907	689	3,010	1,930	2,500
1924–25	1,930	7,130	3,950	1,930	756	507	677	880	2,060	1,280	1,290	1,300	1,980
1925–26	3,810	7,820	5,600	2,770	930	523	420	549	1,310	748	925	1,990	2,290
1926–27	3,800	3,500	2,220	976	530	408	1,360	864	1,170	601	492	523	1,370
1927–28	1,770	4,920	8,770	3,550	1,130	986	1,740	2,390	2,100	2,200	956	1,560	2,670
1928–29	2,330	8,350	5,120	2,470	790	518	915	509	410	335	306	561	1,890
1929–30	1,010	4,550	4,680	1,920	683	406	*250*	*240*	*320*	*280*	*630*	*1,100*	*1,340*
1930–31	*3,200*	*3,400*	*3,000*	*1,700*	*560*	*300*	*390*	*500*	*550*	*500*	*810*	*970*	*1,310*
Highest	4,080	8,350	9,570	6,440	2,590	1,540	2,470	2,390	3,770	3,940	3,010	2,100	2,930
Average	2,600	5,480	5,900	3,230	1,160	707	876	1,000	1,300	1,080	982	1,160	2,130
Lowest	913	2,610	1,860	976	530	300	250	240	320	280	306	487	1,280

NOTE.—Estimated monthly discharge shown in italics.

WENATCHEE RIVER AT DRYDEN, WASH.

Gaging stations located at Cashmere, Dryden, and Peshastin; drainage areas, 1,000, 1,200, and 1,280 square miles, respectively. Variation in yield much less than in drainage areas. Records available (staff gages), July 27, 1904, to August 31, 1908; April 26, 1909, to September 30, 1917, at Cashmere and Dryden; March 1, 1929, to March 31, 1931, at Peshastin. Monthly discharge, September 1908 to April 1909, estimated by comparison with flow of Yakima River; October 1917 to February 1929, by comparison with flow of Wenatchee River at gaging station near Leavenworth. Maximum discharge during period of record, 24,500 second-feet June 17, 1916; minimum discharge, 270 second-feet October 2, 1929. Flood discharge at end of December 1917 about 27,100 second-feet.

TABLE No. 40.—*Monthly discharge, in second-feet, of Wenatchee River at Dryden, Wash.*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913–14	3,970	9,060	14,000	7,700	2,360	1,590	1,660	1,720	1,200	1,790	1,040	2,340	4,050
1914–15	5,570	9,350	7,190	3,920	1,350	1,030	1,350	2,960	1,240	787	705	1,550	3,090
1915–16	5,580	4,070	2,770	1,520	1,110	689	875	1,350	975	803	1,110	3,300	2,010
1916–17	6,320	9,870	14,200	10,000	3,840	1,570	831	804	690	708	901	790	4,220
1917–18	1,510	7,900	11,900	9,040	2,370	1,220	*770*	*940*	*5,400*	*6,000*	*1,900*	*1,500*	*4,250*
1918–19	*4,500*	*7,200*	*10,000*	*4,000*	*1,500*	*980*	*1,400*	*1,400*	*2,900*	*1,700*	*1,300*	*1,300*	*3,190*
1919–20	*4,700*	*9,000*	*9,700*	*7,100*	*2,400*	*1,200*	*680*	*1,900*	*1,600*	*2,300*	*1,800*	*1,600*	*5,670*
1920–21	*2,000*	*5,200*	*6,200*	*4,700*	*1,400*	*2,300*	*3,700*	*1,700*	*1,400*	*2,100*	*3,300*	*3,300*	*3,110*
1921–22	*4,400*	*10,800*	*13,700*	*6,200*	*2,200*	*1,400*	*1,980*	*2,210*	*5,830*	*1,390*	*1,100*	*1,020*	*4,350*
1922–23	*2,610*	*7,670*	*10,300*	*2,870*	*1,180*	*940*	*796*	*804*	*972*	*1,910*	*897*	*1,110*	*2,680*
1923–24	*6,380*	*9,520*	*9,030*	*5,310*	*2,220*	*947*	*712*	*899*	*1,350*	*1,040*	*4,560*	*3,060*	*3,740*
1924–25	*3,010*	*10,600*	*5,900*	*2,760*	*1,050*	*768*	*1,010*	*1,220*	*3,080*	*1,940*	*1,950*	*2,060*	*2,960*
1925–26	*5,950*	*11,700*	*8,350*	*3,950*	*1,290*	*794*	*627*	*762*	*1,960*	*1,130*	*1,400*	*3,160*	*3,430*
1926–27	*5,940*	*5,220*	*3,310*	*1,390*	*736*	*618*	*2,030*	*1,200*	*1,750*	*911*	*745*	*830*	*2,060*
1927–28	*2,770*	*7,340*	*13,100*	*5,070*	*1,570*	*1,490*	*2,600*	*3,320*	*3,130*	*3,350*	*1,450*	*2,480*	*3,970*
1928–29	*3,640*	*12,500*	*7,640*	*3,530*	*1,100*	*785*	*1,370*	*707*	*612*	*508*	*464*	*806*	*2,820*
1929–30	1,480	6,360	6,680	2,670	862	442	376	329	474	421	953	1,680	1,900
1930–31	4,930	5,030	4,510	2,420	783	458	577	697	518	759	1,220	1,540	1,950
Highest	6,380	12,500	14,200	10,000	3,840	2,300	3,700	3,320	5,630	6,000	4,560	3,300	4,350
Average	4,180	8,240	8,800	4,680	1,630	1,070	1,300	1,380	1,940	1,640	1,490	1,860	3,190
Lowest	1,480	4,070	2,770	1,390	736	442	376	329	474	421	464	790	1,900

NOTE.—Estimated monthly discharge shown in italics

CHIWAWA RIVER AT PROPOSED DAM SITE

Estimated yield at proposed dam site based on results at gaging station located 3 miles above mouth. Drainage area, 181 square miles. Records available (staff gage), May 29, 1911, to May 9, 1912, and July 1, 1913, to October 31, 1914. Monthly discharge for remainder of 18 years ending March 31, 1931, derived by comparison of flow at the Chiwawa gaging station with that at gaging station on Wenatchee River near Leavenworth and by taking into account differences in drainage area. (See Water-Supply Paper 486, pp. 30 and 59). Maximum discharge, during period of record, 2,410 second-feet May 8, 1912; minimum discharge, 90 second-feet when stage-discharge relation was affected by ice. Derived results subject to considerable uncertainty. They should be used with caution.

TABLE NO. 41.—*Derived monthly discharge, in second-feet, of Chiwawa River at proposed dam site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean for year
1913-14	*576*	*1,600*	*2,590*	*1,170*	*426*	*311*	*268*	*292*	*208*	*244*	*153*	*316*	*681*
1914-15	*1,160*	*1,570*	*1,250*	*764*	*241*	*183*	*216*	*432*	*182*	*91*	*83*	*189*	*531*
1915-16	*1,060*	*621*	*408*	*192*	*164*	*87*	*148*	*175*	*117*	*104*	*151*	*335*	*296*
1916-17	*887*	*1,620*	*2,500*	*1,550*	*641*	*245*	*122*	*106*	*85*	*83*	*122*	*91*	*673*
1917-18	*257*	*1,350*	*2,050*	*1,480*	*481*	*190*	*130*	*128*	*753*	*764*	*256*	*184*	*668*
1918-19	*817*	*1,250*	*1,710*	*662*	*265*	*161*	*234*	*190*	*405*	*224*	*178*	*148*	*521*
1919-20	*845*	*1,570*	*1,650*	*1,210*	*423*	*192*	*114*	*266*	*218*	*294*	*247*	*192*	*602*
1920-21	*356*	*898*	*1,070*	*795*	*249*	*387*	*613*	*239*	*192*	*273*	*445*	*394*	*493*
1921-22	*803*	*1,890*	*2,350*	*1,030*	*387*	*230*	*332*	*302*	*782*	*179*	*148*	*120*	*715*
1922-23	*472*	*1,330*	*1,760*	*485*	*210*	*156*	*133*	*109*	*133*	*247*	*121*	*132*	*441*
1923-24	*1,150*	*1,660*	*1,550*	*901*	*395*	*156*	*119*	*124*	*187*	*135*	*608*	*242*	*601*
1924-25	*546*	*1,850*	*1,010*	*465*	*187*	*128*	*169*	*168*	*424*	*250*	*265*	*244*	*477*
1925-26	*1,080*	*2,030*	*1,430*	*664*	*231*	*131*	*104*	*104*	*270*	*146*	*189*	*372*	*564*
1926-27	*1,070*	*912*	*568*	*234*	*152*	*103*	*340*	*163*	*241*	*119*	*101*	*99*	*341*
1927-28	*499*	*1,280*	*2,240*	*849*	*280*	*247*	*434*	*457*	*431*	*433*	*196*	*293*	*637*
1928-29	*659*	*2,180*	*1,320*	*597*	*195*	*129*	*228*	*96*	*85*	*67*	*63*	*106*	*480*
1929-30	*286*	*1,190*	*1,200*	*462*	*169*	*103*	*62*	*45*	*65*	*55*	*130*	*207*	*332*
1930-31	*901*	*885*	*766*	*411*	*138*	*76*	*98*	*94*	*72*	*98*	*166*	*182*	*324*
Highest	1,160	2,180	2,590	1,550	641	387	613	457	782	764	608	394	715
Average	746	1,430	1,520	773	287	179	215	194	269	211	201	214	521
Lowest	257	621	408	192	132	76	62	45	65	55	63	91	296

NOTE.—Derived monthly discharge shown in italics.

272. (*c*) *Natural lake stages.*—Inflow, available for regulation by storage in most of the proposed reservoirs, had to be derived from lake outflow by taking into account change in lake contents between the last days of each month. The lake elevations upon which changes in contents were based, are presented in tables nos. 42 to 46. Estimated elevations have been printed in italics.

KOOTENAI LAKE, AT KOOTENAI LANDING

Elevations, according to 1928 datum of the Geodetic Survey of Canada, were furnished by the Dominion Water Power and Hydrometric Bureau of Canada. They were converted to United States Coast and Geodetic Survey datum by adding 0.20 foot. Elevation 50 percent of the time, about 1,742.40 feet.

TABLE NO. 42.—*Kootenai Lake stages on the last day of each month*

[Add 1,700 to determine elevation in feet, U.S. C. and G. S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	*45.92*	*54.00*	56.52	*48.50*	*45.52*	*44.40*	*42.50*	*41.20*	*40.50*	*40.90*	*40.30*	41.24
1914–15	46.74	53.64	54.44	49.54	44.24	*42.84*	*42.63*	42.74	*42.32*	*41.00*	40.24	*41.10*
1915–16	46.70	49.50	49.40	48.50	*46.20*	42.90	*42.10*	*41.80*	*41.70*	*40.49*	*40.50*	43.84
1916–17	*46.60*	50.84	63.24	*54.20*	*48.20*	*44.20*	41.74	40.99	39.04	*39.89*	39.69	39.59
1917–18	42.19	53.49	57.14	50.79	45.24	*42.99*	41.39	40.84	41.59	41.49	40.59	42.19
1918–19	46.09	49.59	56.69	48.59	44.99	43.19	42.69	41.49	40.79	42.34	41.09	41.04
1919–20	47.29	57.19	56.29	48.29	44.99	42.29	40.69	40.39	40.14	39.89	39.59	40.19
1920–21	42.19	48.84	54.64	51.69	45.39	44.44	43.59	42.29	41.29	40.84	41.74	42.19
1921–22	45.54	56.79	57.24	48.99	44.79	42.29	41.90	41.45	41.10	40.20	39.70	39.80
1922–23	42.15	52.30	54.30	46.50	44.35	42.55	41.74	40.49	40.24	40.39	39.64	39.79
1923–24	*45.20*	53.19	56.89	48.99	44.79	42.39	41.09	*40.20*	39.99	*39.60*	40.69	40.14
1924–25	41.69	52.40	48.00	45.00	44.20	*42.20*	41.69	*41.15*	41.49	41.09	41.99	41.89
1925–26	48.39	*58.79*	56.04	47.74	44.09	42.34	40.89	40.19	39.94	39.49	*39.59*	39.89
1926–27	*46.20*	46.79	46.29	44.39	42.99	42.54	44.59	*42.40*	41.34	40.43	40.34	40.59
1927–28	44.99	51.44	58.54	50.34	45.44	46.64	*46.37*	44.69	42.59	41.84	41.09	43.04
1928–29	45.09	60.99	54.19	49.19	44.09	42.09	42.19	41.09	*40.20*	39.77	39.39	40.34
1929–30	41.89	51.39	51.79	46.09	43.39	41.74	40.81	39.69	39.79	39.04	39.79	40.14
1930–31	47.34	49.39	51.49	47.17	43.99	43.14	40.94	40.24	39.49	39.63	39.66	40.16
Average	45.12	52.81	54.62	48.58	44.83	43.06	42.20	41.30	40.75	40.46	40.31	40.95

NOTE.—Estimated stages are shown in italics. Those for the last day of April, May, and December, 1913, were not furnished by the Dominion Water Power and Hydrometric Bureau of Canada. They were derived from a relation between flow of Kootenay River at Nelson, British Columbia, and lake height.

FLATHEAD LAKE AT POLSON AND SOMERS, MONT.

Gaging station located at Polson prior to April 25, 1922; thereafter observations were taken at both Polson and Somers. Records available August 23, 1908, to March 31, 1931; fragmentary prior to January 1910, and for certain periods in 1917 and 1924–28. Water-stage recorders after April 1922. Gaps in record were filled on basis of relation between outflow and lake height. Maximum elevation during period of record, 2,896 feet (U.S. Geological Survey datum) at Somers, May 30, 1928; minimum elevation 2,881.30 feet at Somers, average for December 9, 1929. Flood stage during 1894, about 2,900 feet. Elevation 50 percent of time, about 2,883.2 feet.

TABLE NO. 43.—*Flathead Lake stages on the last day of each month*

[Add 2,800 to determine elevation in feet, U.S. G. S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	85.70	92.40	91.60	86.00	84.00	83.00	82.80	83.00	82.50	82.40	82.20	82.40
1914–15	85.70	89.50	87.70	84.50	83.20	82.90	83.70	84.30	83.10	82.60	82.30	82.40
1915–16	85.70	86.60	86.70	85.60	83.70	83.20	83.10	83.10	82.80	82.40	82.40	84.50
1916–17	86.40	88.30	95.60	88.80	85.20	84.60	83.90	83.10	82.70	82.30	*82.20*	*82.10*
1917–18	*83.25*	91.80	92.70	*86.60*	*83.95*	*82.80*	82.35	82.15	82.90	84.05	83.05	83.15
1918–19	86.40	88.30	91.20	85.30	83.70	82.80	82.60	82.40	82.30	82.30	82.20	82.20
1919–20	85.60	91.70	88.00	84.10	83.10	82.20	81.80	81.90	81.80	81.80	81.90	81.90
1920–21	83.80	88.60	90.50	86.00	83.60	83.10	83.40	83.00	82.70	82.60	82.80	83.60
1921–22	86.00	92.80	90.40	85.60	83.50	82.60	82.40	82.40	82.70	82.40	82.00	82.00
1922–23	83.35	90.70	89.52	84.86	83.32	82.50	82.10	82.00	81.70	82.10	81.80	81.90
1923–24	84.80	90.90	90.10	85.55	83.65	83.60	82.25	*82.12*	*81.80*	*81.95*	*82.15*	*82.30*
1924–25	83.82	90.58	88.15	*85.00*	83.40	82.50	82.30	82.30	83.50	*82.56*	*83.07*	*83.11*
1925–26	88.30	*93.98*	90.60	*85.70*	84.00	83.50	82.72	82.35	*82.18*	*81.90*	*82.18*	82.70
1926–27	87.20	87.18	85.18	83.35	82.35	*83.10*	84.50	83.80	*83.72*	*82.91*	*82.79*	*82.66*
1927–28	85.40	90.90	94.20	87.00	84.40	84.35	85.02	*84.15*	*83.69*	*83.28*	*83.21*	*83.72*
1928–29	85.67	95.80	90.44	86.58	83.94	82.88	82.97	82.74	82.29	82.02	81.83	82.11
1929–30	83.50	89.88	88.32	84.48	82.88	82.10	81.80	81.52	81.74	81.50	81.74	81.91
1930–31	87.50	88.08	86.88	84.14	82.72	82.30	82.27	82.32	81.92	81.82	81.94	82.38
Average	85.45	90.44	89.88	85.51	83.59	83.00	82.89	82.70	82.56	82.38	82.32	82.61

NOTE.—Estimated stages are shown in italics.

PRIEST LAKE, NEAR COOLIN, IDAHO

Gaging station on wharf at Coolin, prior to November 23, 1914, and at a point near the outlet, April 21, 1928, to March 31, 1931; elevations during intervening period estimated on basis of stage and flow at river gaging station, 600 feet below the outlet, or by comparison with Pend Oreille Lake stages. Maximum stage, 1913 to 1931, about 2,442.5 feet, May 30, 1917; minimum stage 2,435.07 feet, November 18–20, 1925. Elevation 50 percent of the time, about 2,436.50 feet.

TABLE No. 44.—*Priest Lake stages on the last day of each month*

[Add 2,400 to determine elevation in feet, U.S. C. and G. S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	38.45	41.34	39.76	37.52	36.53	36.27	36.22	36.72	36.34	36.92	36.72	37.02
1914–15	39.52	40.52	39.12	37.12	36.12	36.27	36.74	37.20	*36.50*	*36.14*	*36.18*	*36.82*
1915–16	*38.90*	*38.66*	*37.55*	*36.91*	*36.17*	*35.92*	*35.93*	*36.14*	*36.24*	*36.23*	*36.30*	*37.51*
1916–17	*38.90*	*40.41*	*40.84*	*38.10*	*36.70*	*36.26*	*35.73*	*35.73*	*35.70*	*35.82*	*35.88*	*35.99*
1917–18	*37.38*	*42.20*	*40.34*	*37.31*	*36.19*	*35.77*	*35.48*	*35.51*	*36.25*	*36.65*	*36.41*	*37.00*
1918–19	*38.74*	*39.62*	*38.75*	*37.06*	*36.44*	*35.94*	*35.75*	*35.65*	*35.70*	*35.75*	*35.70*	*36.50*
1919–20	*40.16*	*41.21*	*38.94*	*36.99*	*36.06*	*35.60*	*35.55*	*35.75*	*35.89*	*35.89*	*35.80*	*36.06*
1920–21	*37.14*	*38.93*	*38.73*	*37.01*	*36.11*	*36.76*	*36.82*	*37.22*	*36.92*	*36.84*	*37.11*	*38.21*
1921–22	*39.32*	*41.28*	*39.26*	*36.96*	*36.17*	*35.76*	*35.92*	*36.16*	*36.45*	*36.22*	*36.01*	*35.99*
1922–23	*37.32*	*40.36*	*38.41*	*36.62*	*36.00*	*35.67*	*36.00*	*35.79*	*36.14*	*36.29*	*36.00*	*35.99*
1923–24	*38.88*	*39.79*	*38.94*	*36.95*	*36.17*	*35.61*	*35.54*	*35.65*	*35.66*	*35.82*	*36.47*	*36.28*
1924–25	*36.91*	*39.06*	*37.14*	*36.08*	*35.75*	*35.38*	*35.64*	*36.03*	*36.28*	*36.42*	*36.82*	*36.73*
1925–26	*39.66*	*40.27*	*38.39*	*36.57*	*35.73*	*35.42*	*35.26*	*35.40*	*35.70*	*35.65*	*35.80*	*35.79*
1926–27	*38.86*	*37.54*	*36.40*	*35.67*	*35.73*	*36.13*	*36.60*	*36.89*	*37.08*	*36.83*	*36.73*	*36.67*
1927–28	*36.66*	*40.03*	*39.39*	*36.91*	*36.14*	*37.30*	*37.73*	*37.50*	*36.96*	*37.13*	*36.38*	*37.83*
1928–29	39.07	41.08	37.96	37.45	36.57	36.10	36.29	36.33	36.45	36.45	36.44	36.70
1929–30	38.19	39.04	38.58	37.08	36.28	35.88	35.78	35.54	36.08	35.95	36.31	36.62
1930–31	39.18	37.87	37.67	36.58	35.98	35.62	35.70	35.80	35.76	36.10	36.54	37.42
Average	38.51	39.96	38.68	36.94	36.16	35.98	36.04	36.17	36.23	36.28	36.31	36.73

NOTE.—Estimated stages are shown in italics.

PEND OREILLE LAKE AT SANDPOINT AND HOPE, IDAHO

Records available at Sandpoint from March 18, 1914, to September 30, 1922, and at Hope from September 17, 1921, to March 31, 1931. Water-stage recorder at Hope after October 7, 1930. Estimated stages were based upon relation between flow of Clark Fork at Newport, Wash., and lake height. Maximum elevation during period of record, 2,068.67 feet (U.S. Coast and Geodetic Survey datum), May 31 and June 1, 1928; minimum elevation 2,046.60 feet, average for January 28, 1930. Crest elevation during June 1894 was 2,076.08 feet; during 1913 about 2,069.1 feet. Elevation 50 percent of the time about 2,048.9 feet.

TABLE No. 45.—*Pend Oreille Lake stages on the last day of each month*

[Add 2,000 to determine elevation in feet, U. S. C. & G. S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	*55.03*	*61.93*	*65.08*	*54.43*	*50.28*	*48.58*	*48.28*	*48.88*	*47.88*	*48.38*	*48.23*	49.08
1914–15	53.38	59.78	56.38	51.08	48.38	47.88	*49.68*	*50.28*	*48.58*	*47.73*	47.48	48.13
1915–16	51.88	54.33	54.03	51.88	49.18	48.33	48.20	48.33	48.23	*47.23*	*48.83*	52.98
1916–17	55.68	58.73	67.18	59.28	*51.88*	*50.03*	48.68	48.23	*47.73*	*47.48*	*47.73*	47.53
1917–18	51.58	64.73	66.03	55.38	49.78	48.23	47.61	47.41	*50.28*	51.38	*49.43*	50.68
1918–19	54.88	58.33	61.98	*51.98*	50.18	*48.13*	48.18	48.18	*47.63*	*49.13*	*48.23*	48.78
1919–20	52.38	59.28	*55.73*	49.98	*47.83*	47.88	47.08	*47.18*	*47.28*	*47.58*	47.23	47.83
1920–21	49.88	*53.18*	*60.18*	52.88	*48.88*	*48.53*	48.98	*48.98*	*48.33*	48.48	*49.68*	*51.08*
1921–22	53.88	*64.08*	*61.33*	52.18	48.98	48.08	47.65	47.79	48.53	47.67	47.35	47.71
1922–23	50.17	61.57	*60.27*	51.57	48.87	47.93	47.65	47.37	47.82	48.07	47.65	47.87
1923–24	*51.57*	60.37	60.72	52.77	49.22	47.80	47.55	47.59	47.45	47.27	48.57	47.95
1924–25	49.92	60.37	55.37	50.37	48.28	47.49	47.47	47.68	48.37	48.89	49.57	49.77
1925–26	57.82	65.37	59.87	52.27	49.17	48.32	47.89	47.65	47.75	47.44	47.74	48.37
1926–27	53.75	55.12	51.37	48.69	47.80	47.97	49.35	49.42	49.42	48.39	48.81	48.87
1927–28	52.72	61.62	66.67	55.19	50.32	50.07	50.67	52.92	50.67	50.17	48.97	51.35
1928–29	53.49	68.67	59.32	54.02	49.67	48.20	48.11	47.89	47.53	47.17	47.13	47.95
1929–30	49.42	57.86	57.25	50.72	48.09	47.27	47.06	46.73	47.22	46.65	47.86	47.83
1930–31	54.39	55.59	53.98	49.80	47.95	47.38	47.52	47.43	47.01	47.14	47.28	48.07
Average	52.88	60.33	59.62	52.47	49.15	48.23	48.20	48.33	48.21	48.12	48.21	48.99

NOTE.—Estimated stages are shown in italics.

COEUR D'ALENE LAKE, AT COEUR D'ALENE, IDAHO

Gaging station located at Johnson wharf, 800 feet southeast of railroad station. Records available February 15, 1905, to March 31, 1931. Water-stage recorder since March 24, 1921. Maximum elevation during period of record, 2,133.10 feet (U.S. Coast and Geodetic Survey datum, see Water-Supply Paper 632, p. 100); minimum elevation 2,117 feet September 24–25, 1905, and October 14 to November 3, 1906. Crest elevation 1894 flood, 2,134.7 feet. Lake regulated below elevation about 2,123.6 feet, since July 1906. Elevation 50 percent of the time about 2,122.3 feet.

TABLE No. 46.—*Coeur d'Alene Lake stages on the last day of each month*

[Add 2,100 to determine elevation in feet, U. S. C. & G. S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	29.45	31.55	24.20	23.60	23.42	22.60	21.24	20.20	19.32	23.06	22.20	23.46
1914–15	26.34	23.90	23.48	23.24	21.92	21.46	21.74	22.52	20.33	19.00	20.34	22.66
1915–16	22.42	23.62	23.56	22.70	21.30	19.94	18.80	18.82	20.86	19.88	21.30	28.54
1916–17	28.48	26.50	26.06	22.18	22.60	22.28	21.50	21.50	20.74	20.36	20.00	19.06
1917–18	28.86	32.44	25.86	23.31	22.68	20.28	18.58	17.66	30.29	23.34	21.30	25.56
1918–19	26.36	23.72	23.39	23.12	22.42	21.26	20.90	20.62	20.06	23.95	22.15	24.58
1919–20	28.70	25.96	22.66	21.88	20.76	19.74	18.76	18.66	18.76	21.34	22.12	22.14
1920–21	24.02	24.53	23.46	23.48	22.54	22.78	22.50	21.91	22.31	21.08	23.02	25.99
1921–22	26.83	27.43	23.57	23.47	22.57	21.82	21.27	20.82	20.32	18.94	18.82	19.98
1922–23	25.23	27.37	23.48	23.28	22.61	21.77	21.20	20.30	20.54	20.47	19.28	22.02
1923–24	27.10	25.94	23.61	23.59	23.26	21.92	21.41	21.25	20.82	20.16	22.86	20.37
1924–25	24.22	23.53	23.60	22.88	21.51	20.80	20.45	21.65	21.36	21.44	23.71	24.42
1925–26	27.27	26.48	23.53	23.40	21.89	20.62	19.72	19.30	21.22	20.53	21.33	22.57
1926–27	25.03	24.24	24.22	22.43	21.52	21.59	22.70	23.50	20.68	20.49	23.28	22.65
1927–28	28.80	27.36	23.89	23.50	22.09	22.86	21.92	27.92	21.51	22.03	20.48	26.06
1928–29	26.00	27.27	23.53	23.23	22.10	21.26	20.75	20.57	19.90	19.13	18.59	22.53
1929–30	24.62	23.94	23.62	23.38	21.94	20.42	19.82	18.97	20.24	19.03	22.01	23.19
1930–31	23.98	23.90	23.89	23.58	22.09	20.98	20.49	20.69	20.17	21.01	21.81	23.32
Average	26.32	26.09	23.87	23.12	22.18	21.35	20.76	20.94	21.08	20.85	21.37	23.28

273. *d. Modified flow at power sites.*—Tables Nos. 47 to 65 indicate modified flow available at each power site, as derived in accordance with plan no. 4, when developed with Grand Coulee High Dam. Each table is preceded by a brief statement setting forth amount of upstream storage involved and the extent to which allowance was made for future irrigation.

COLUMBIA RIVER AT GRAND COULEE AND FOSTER CREEK POWER SITES

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 625,000 acres in Montana, Idaho, British Columbia, and Washington. Upstream regulation in six reservoirs, exclusive of Columbia River and Grand Coulee Reservoirs, aggregating 5,950,000 acre-feet of storage.

Reregulation in Columbia River Reservoir behind high dam for joint benefit of Grand Coulee and other downstream power sites, by use of 5,028,000 acre-feet of storage. Regulation of Grand Coulee Reservoir, at infrequent intervals, to avoid excessive pumping; maximum requirement 328,900 acre-feet.

TABLE No. 47.—*Modified discharge, in units of 1,000 second-feet, of Columbia River at Grand Coulee and Foster Creek power sites*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	58.0	90.8	398	235	136	96.2	66.4	66.4	66.4	66.4	66.4	66.4
1914-15	83.0	115	246	224	120	76.9	68.0	66.1	65.6	65.6	65.6	65.8
1915-16	73.6	71.3	153	155	141	83.9	64.0	64.0	64.0	64.0	64.0	64.4
1916-17	80.0	129	291	372	159	96.3	57.1	54.5	54.9	55.6	56.6	57.8
1917-18	64.2	86.8	339	260	129	77.6	74.6	74.6	74.6	74.6	74.6	75.1
1918-19	81.2	117	262	213	122	86.2	70.6	65.4	65.4	65.4	65.4	65.4
1919-20	79.2	94.0	245	198	126	74.9	50.9	49.4	49.6	50.0	50.8	52.8
1920-21	56.2	68.0	151	276	166	91.4	90.3	75.6	75.6	75.6	75.6	75.6
1921-22	85.3	123	337	212	122	64.6	58.1	60.1	56.4	57.1	58.1	59.3
1922-23	65.9	66.7	296	180	112	83.8	59.2	54.8	55.4	56.3	57.4	58.8
1923-24	65.0	87.0	300	220	118	86.1	54.2	52.7	53.3	54.1	54.9	55.6
1924-25	60.1	73.4	178	138	106	79.5	68.4	68.4	68.4	68.4	68.4	68.4
1925-26	90.0	222	287	208	118	69.8	53.3	51.9	52.4	53.3	54.2	55.2
1926-27	62.4	61.8	97.2	127	85.0	72.4	68.1	66.7	66.7	66.7	66.7	66.7
1927-28	67.2	72.3	354	246	148	128	111	105	88.9	88.9	88.9	88.9
1928-29	89.0	199	304	222	119	70.2	56.1	51.1	51.5	52.1	52.7	54.1
1929-30	56.9	66.7	156	135	95.1	65.9	51.4	50.0	50.0	50.8	51.9	53.8
1930-31	59.2	70.0	141	172	111	75.4	52.6	51.2	51.7	52.0	53.1	55.7
Highest	90.0	222	398	372	166	128	111	105	88.9	88.9	88.9	88.9
Average	70.9	101	252	211	124	82.2	65.2	62.7	61.7	62.0	62.5	63.3
Lowest	56.2	61.8	97.2	127	85.0	64.6	50.9	49.4	49.6	50.0	50.8	52.8

COLUMBIA RIVER AT CHELAN POWER SITE

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 685,000 acres in Montana, Idaho, British Columbia, and Washington. Upstream regulation in six reservoirs, exclusive of Columbia River and Grand Coulee Reservoirs, aggregating 5,950,000 acre-feet of storage.

Reregulation in Columbia River Reservoir behind high dam for joint benefit of Grand Coulee and other downstream power sites, by use of 5,028,000 acre-feet of storage. Regulation of Grand Coulee Reservoir, at infrequent intervals, to avoid excessive pumping; maximum requirement 328,900 acre-feet.

TABLE No. 48.—*Modified discharge, in units of 1,000 second-feet, of Columbia River at Chelan power site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	60.5	98.8	417	254	144	104	70.5	70.5	70.4	68.7	68.8	68.6
1914-15	87.1	128	264	237	127	82.0	71.5	68.0	69.3	67.1	67.6	67.6
1915-16	77.1	78.3	161	161	149	90.3	66.7	66.8	67.1	65.9	66.2	66.6
1916-17	88.0	149	311	388	171	104	60.7	55.7	57.4	57.2	58.7	59.2
1917-18	63.0	88.8	359	278	137	84.4	80.0	77.4	76.6	79.1	78.4	76.9
1918-19	84.7	128	275	226	129	90.1	74.2	68.1	67.7	67.3	68.5	66.7
1919-20	81.7	101	265	212	133	80.0	52.5	52.1	51.5	51.2	53.0	53.4
1920-21	55.2	70.0	160	285	173	94.6	94.4	75.9	78.6	77.7	77.3	77.6
1921-22	87.5	133	360	226	128	69.9	60.0	63.4	59.6	59.1	59.3	61.3
1922-23	65.5	68.7	313	192	115	87.9	62.4	57.8	58.0	58.7	59.4	60.4
1923-24	64.7	95.0	315	232	123	89.4	57.1	55.4	55.5	55.5	56.7	57.6
1924-25	60.1	79.4	188	140	107	82.3	70.4	70.5	70.8	70.3	71.3	70.4
1925-26	89.0	233	303	217	122	73.2	56.8	54.5	54.8	55.6	55.8	56.7
1926-27	62.6	64.8	98.2	129	87.4	75.2	69.4	70.0	69.8	69.9	69.2	69.7
1927-28	67.0	74.3	367	260	154	132	117	111	95.5	95.0	94.8	92.0
1928-29	92.2	208	324	233	125	73.2	58.7	53.8	53.4	53.5	53.6	54.9
1929-30	56.6	68.3	167	141	96.8	67.5	53.6	51.9	51.1	52.4	53.1	54.9
1930-31	61.4	78.0	151	177	113	77.5	54.1	52.9	52.8	52.8	54.1	56.0
Highest	92.2	233	417	388	173	132	117	111	95.5	95.0	94.8	92.0
Average	72.4	108	267	222	130	86.5	68.3	65.3	64.4	64.3	64.8	65.0
Lowest	55.2	64.8	98.2	129	87.4	67.5	52.5	51.9	51.1	51.2	53.0	53.4

COLUMBIA RIVER AT ROCKY REACH POWER SITE

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 712,000 acres in Montana, Idaho, British Columbia, and Washington. Upstream regulation in seven reservoirs, exclusive of Columbia River and Grand Coulee Reservoirs, aggregating 6,615,000 acre-feet of storage.

Reregulation in Columbia River Reservoir behind high dam for joint benefit of Grand Coulee and other downstream power sites, by use of 5,028,000 acre-feet of storage. Regulation of Grand Coulee Reservoir, at infrequent intervals, to avoid excessive pumping; maximum requirement 328,900 acre-feet.

TABLE NO. 49.—*Modified discharge, in units of 1,000 second-feet, of Columbia River at Rocky Reach power site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	62.6	101	422	262	149	109	73.8	73.8	73.9	71.1	71.5	71.3
1914–15	88.4	131	271	243	131	85.6	74.2	69.9	72.4	69.0	69.6	69.7
1915–16	78.5	80.3	163	163	153	94.6	69.1	69.2	69.8	68.0	68.4	68.6
1916–17	94.0	155	315	395	180	110	63.7	57.6	60.1	59.5	61.1	61.3
1917–18	63.8	88.8	364	290	143	89.5	84.4	80.5	79.5	82.8	82.1	79.5
1918–19	87.4	131	277	233	135	93.8	77.8	71.2	70.8	70.1	72.0	69.3
1919–20	83.4	101	270	219	138	83.9	54.8	54.8	54.1	53.2	55.4	55.3
1920–21	56.3	70.0	161	289	177	97.5	97.2	77.2	81.6	80.2	79.5	79.9
1921–22	89.4	136	365	235	132	74.1	62.2	66.1	62.3	61.2	61.0	63.6
1922–23	66.4	68.7	317	198	119	91.4	65.4	60.7	60.8	61.4	61.8	62.6
1923–24	65.0	95.0	319	238	126	92.2	59.8	58.0	58.0	57.6	58.8	59.8
1924–25	61.2	80.4	193	143	109	85.4	72.9	73.0	73.3	72.4	73.8	72.7
1925–26	88.0	234	308	223	125	76.1	59.8	57.1	57.2	57.8	57.6	58.3
1926–27	62.3	66.8	102	132	90.3	78.0	71.2	72.8	72.6	72.8	71.5	72.2
1927–28	68.0	74.3	371	267	159	135	121	114	99.1	98.1	98.2	94.0
1928–29	94.0	206	332	238	128	75.4	60.7	56.0	55.4	55.3	55.3	56.7
1929–30	58.1	69.6	172	145	99.2	69.5	55.8	54.1	53.1	54.5	54.9	56.6
1930–31	62.0	80.0	154	179	115	79.6	56.2	55.1	54.4	54.3	55.4	57.1
Highest	94.0	234	422	395	180	135	121	114	99.1	98.1	98.2	94.0
Average	73.8	109	271	227	134	90.0	71.1	67.8	67.1	66.6	67.1	67.1
Lowest	56.3	66.8	102	132	90.3	69.5	54.8	54.1	53.1	53.2	54.9	55.3

COLUMBIA RIVER AT ROCK ISLAND RAPIDS AND VANTAGE POWER SITES

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 742,000 acres in Montana, Idaho, British Columbia, and Washington. Upstream regulation in nine reservoirs, exclusive of Columbia River and Grand Coulee Reservoirs, aggregating 8,097,000 acre-feet of storage.

Reregulation in Columbia River Reservoir behind high dam for joint benefit of Grand Coulee and other downstream power sites, by use of 5,028,000 acre-feet of storage. Regulation of Grand Coulee Reservoir, at infrequent intervals, to avoid excessive pumping; maximum requirement 328,900 acre-feet.

TABLE No. 50.—*Modified discharge, in units of 1,000 second-feet, of Columbia River at Rock Island Rapids and Vantage power sites*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	66.4	104	429	272	154	114	77.4	77.4	77.5	74.2	74.4	74.5
1914-15	92.0	136	278	250	136	89.9	77.6	72.5	76.0	71.6	72.4	72.5
1915-16	81.5	82.3	166	167	159	99.4	72.1	72.1	73.2	70.9	71.3	72.3
1916-17	101	163	320	403	187	115	67.4	60.0	63.3	62.3	64.2	64.0
1917-18	65.4	89.8	370	294	148	95.0	89.0	83.6	83.8	88.0	86.1	82.5
1918-19	91.0	136	281	240	141	97.9	81.7	74.5	74.5	73.3	75.7	72.1
1919-20	86.3	104	277	226	142	88.4	57.4	58.1	57.2	56.3	58.7	57.9
1920-21	58.1	71.0	164	294	182	102	101	79.0	85.2	83.7	83.0	83.5
1921-22	92.5	139	372	242	137	79.0	65.2	69.3	66.6	63.9	63.4	66.3
1922-23	68.1	69.7	322	205	122	95.4	68.8	63.9	64.0	64.7	64.6	65.3
1923-24	67.0	98.0	324	244	131	95.7	62.8	61.0	61.0	60.3	62.4	63.2
1924-25	63.2	81.4	199	146	111	89.0	75.8	75.9	76.9	75.4	77.1	76.1
1925-26	89.0	236	316	229	128	79.8	63.5	60.1	60.6	61.1	60.4	61.6
1926-27	64.1	69.8	104	135	93.5	81.5	74.0	76.3	76.3	76.5	74.5	75.4
1927-28	69.9	76.3	376	276	163	138	124	118	104	102	102	96.9
1928-29	96.6	207	341	244	131	78.4	63.4	58.6	58.0	58.0	57.7	59.1
1929-30	60.1	71.0	178	150	102	72.3	58.5	56.7	55.5	57.3	57.4	59.3
1930-31	63.6	82.0	156	181	117	81.7	57.6	56.4	56.2	55.8	57.3	58.8
Highest	101	236	429	403	187	138	124	118	104	102	102	96.9
Average	76.4	112	276	233	138	94.0	74.3	70.7	70.5	69.7	70.1	70.1
Lowest	58.1	69.7	104	135	93.5	72.3	57.4	56.4	55.5	55.8	57.3	57.9

COLUMBIA RIVER AT PRIEST RAPIDS POWER SITE

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 742,000 acres in Montana, Idaho, British Columbia, and Washington. Upstream regulation in nine reservoirs, exclusive of Columbia River and Grand Coulee Reservoirs, aggregating 8,097,000 acre-feet of storage.

Reregulation in Columbia River Reservoir behind high dam for joint benefit of Grand Coulee and other downstream power sites, by use of 5,028,000 acre-feet of storage. Regulation of Grand Coulee Reservoir, at infrequent intervals to avoid excessive pumping; maximum requirement 328,900 acre-feet.

TABLE No. 51.—*Modified discharge, in units of 1,000 second-feet, of Columbia River at Priest Rapids power site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	66.8	105	430	273	155	115	78.7	78.8	78.3	74.7	74.8	74.8
1914-15	92.4	137	279	251	137	91.2	78.8	73.9	76.8	72.1	72.8	72.8
1915-16	81.8	83.3	167	168	160	101	73.4	73.5	74.0	71.4	71.7	72.6
1916-17	101	164	321	404	189	116	68.6	61.3	64.1	62.8	64.6	64.3
1917-18	65.8	90.8	371	295	150	96.2	90.3	85.0	84.6	88.5	86.5	82.8
1918-19	91.3	136	282	241	142	99.2	82.9	75.9	75.3	73.8	76.1	72.4
1919-20	86.6	104	278	227	143	89.7	58.7	59.4	58.0	56.8	59.1	58.1
1920-21	58.4	72.0	165	295	183	103	102	80.4	86.0	84.2	83.4	83.8
1921-22	92.9	140	374	243	138	80.3	66.4	70.6	67.3	64.4	63.8	66.6
1922-23	68.5	70.7	323	206	123	96.7	70.0	65.2	64.8	65.2	65.0	65.6
1923-24	67.3	99.0	325	246	132	97.0	64.1	62.3	61.7	60.8	62.8	63.4
1924-25	63.6	82.4	200	147	113	90.3	77.1	77.3	77.6	75.9	77.5	76.3
1925-26	89.0	237	317	230	129	81.1	64.8	61.5	61.3	61.6	60.8	61.8
1926-27	64.5	70.8	106	136	94.8	82.8	75.3	77.6	77.1	77.0	74.9	75.7
1927-28	70.3	77.3	377	277	165	139	126	119	104	103	102	97.1
1928-29	96.9	208	342	245	132	79.8	64.6	60.0	58.8	58.5	58.1	59.4
1929-30	60.4	71.7	179	151	103	73.6	59.8	58.0	56.2	57.8	57.8	59.5
1930-31	63.9	83.0	158	182	118	83.0	58.9	57.8	56.9	56.3	57.7	59.0
Highest	101	237	430	404	189	139	126	119	104	103	102	97.1
Average	76.7	113	277	234	139	95.3	75.6	72.1	71.3	70.3	70.5	70.3
Lowest	58.4	70.7	106	136	94.8	73.6	58.7	57.8	56.2	56.3	57.7	58.1

COLUMBIA RIVER AT MOUTH OF SNAKE RIVER

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 1,027,000 acres in Montana, Idaho, British Columbia, and Washington. Upstream regulation in 14 reservoirs, exclusive of Columbia River and Grand Coulee Reservoirs, aggregating 9,072,000 acre-feet of storage.

Reregulation in Columbia River Reservoir behind high dam for joint benefit of Grand Coulee and other downstream power sites, by use of 5,028,000 acre-feet of storage. Regulation of Grand Coulee Reservoir, at infrequent intervals, to avoid excessive pumping; maximum requirement 328,900 acre-feet.

TABLE No. 52.—*Effect of Upstream regulation on discharge of Columbia River at mouth of Snake River, in units of 1,000 second-feet*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	−16.0	−114	−57.1	−50.0	−15.5	+3.0	+9.9	+19.3	+31.2	+33.2	+35.1	+19.2
1914-15	−25.2	−122	−59.5	−31.1	−6.5	+7.5	+10.7	+3.1	+19.8	+36.3	+40.1	+31.0
1915-16	−22.9	−116	−41.9	−27.8	−9.1	+0.6	+19.1	+19.7	+27.5	+39.0	+35.4	+1.6
1916-17	−40.6	−87.1	−46.7	−55.5	−27.3	−6.9	+2.7	+13.9	+26.4	+33.3	+34.1	+34.8
1917-18	+4.2	−110	−45.5	−60.9	−15.3	+4.4	+19.9	+40.0	+33.3	−11.5	+25.0	+31.9
1918-19	−18.2	−107	−59.9	−45.2	−8.6	+3.7	+11.5	+22.9	+29.7	+33.0	+25.3	+25.7
1919-20	−16.5	−127	−63.7	−34.5	−7.5	+1.4	+10.7	+23.8	+29.4	+29.3	+27.9	+25.5
1920-21	+7.5	−83.9	−94.7	−42.9	−5.9	+7.3	+6.6	+15.5	+32.4	+30.8	+30.6	+13.8
1921-22	−14.7	−116	−72.4	−42.8	−11.7	+2.3	+12.1	+10.1	+8.6	+25.7	+34.0	+34.9
1922-23	+7.1	−105	−74.4	−39.1	−9.6	+2.7	+10.5	+21.1	+32.7	+21.0	+34.7	+33.1
1923-24	−18.2	−119	−56.9	−41.6	−13.0	+1.0	+12.0	+25.3	+28.3	+34.5	+15.6	+17.1
1924-25	+9.5	−136	−57.7	−28.4	−3.3	+5.9	+27.1	+27.3	+29.5	+29.0	+8.0	+14.4
1925-26	−62.1	−82.3	−56.1	−39.0	−12.6	+1.6	+12.7	+24.6	+26.3	+30.4	+26.3	+21.7
1926-27	−17.4	−121	−50.1	−13.1	+1.6	+9.4	+12.4	+9.4	+9.5	+28.7	+30.2	+25.6
1927-28	−3.2	−132	−35.9	−52.2	−4.3	+10.9	+7.3	+0.9	+1.0	+30.8	+41.0	+30.9
1928-29	−11.6	−105	−61.1	−39.5	−19.6	−2.0	+8.6	+13.7	+21.2	+28.4	+32.7	+30.6
1929-30	+13.6	−60.3	−122	−32.5	−11.1	+2.2	+14.3	+24.2	+28.2	+34.4	+32.1	+27.5
1930-31	−19.2	−100	−88.4	−23.9	−9.0	+4.0	+11.2	+21.4	+25.6	+30.7	+30.5	+24.8
Average	−13.6	−108	−63.6	−38.9	−10.5	+3.3	+12.2	+18.7	+24.5	+28.7	+29.9	+24.7

KOOTENAI RIVER AT POWER SITES BETWEEN KOOTENAI LAKE AND MOUTH

Regulation of 715,000 acre-feet of storage in Kootenai Reservoir for direct benefit of power sites on lower Kootenai River.

TABLE No. 53.—*Regulated discharge, in second-feet, of Kootenai River below Kootenai Lake*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	20,500	46,500	123,000	75,200	38,900	25,200	15,900	12,100	12,100	12,100	12,100	12,100
1914-15	23,400	64,400	90,800	80,000	33,300	17,900	18,100	21,700	12,800	10,700	10,700	10,700
1915-16	21,100	45,600	48,700	49,100	36,800	15,200	12,200	12,600	10,600	10,600	10,600	11,700
1916-17	25,100	52,400	97,700	121,000	52,600	24,800	10,100	9,000	8,400	8,400	8,400	8,400
1917-18	10,100	36,000	95,900	88,500	36,700	15,800	12,100	12,100	12,100	12,100	12,100	12,100
1918-19	20,300	54,000	85,500	68,500	31,600	17,400	15,700	11,800	11,800	11,800	11,800	11,800
1919-20	20,800	58,000	99,500	69,100	32,900	16,400	8,400	8,400	8,400	8,400	8,400	8,400
1920-21	9,300	34,000	66,700	92,600	44,100	21,900	22,000	12,900	12,900	12,900	12,900	12,800
1921-22	20,800	55,300	115,000	78,200	32,300	12,100	11,600	11,500	10,200	9,300	9,300	9,300
1922-23	10,500	34,600	97,000	54,600	24,000	15,400	10,600	8,500	8,500	8,500	8,500	8,500
1923-24	15,000	51,400	101,000	74,000	30,200	14,700	9,100	8,600	8,600	8,600	8,600	8,600
1924-25	9,100	44,500	56,100	34,400	23,100	13,800	12,600	12,600	12,600	12,600	12,600	12,600
1925-26	34,500	77,300	101,000	65,200	26,500	14,000	8,100	7,800	7,800	7,800	7,800	7,800
1926-27	18,700	41,200	35,800	26,600	15,700	16,500	17,000	13,600	10,900	10,900	10,900	10,900
1927-28	12,800	45,200	100,000	81,300	36,900	33,800	29,800	24,300	15,100	14,400	14,400	14,400
1928-29	16,900	71,200	96,500	69,000	28,600	13,300	13,700	8,500	8,500	8,500	8,500	8,500
1929-30	8,200	32,900	82,000	45,900	18,300	10,900	7,600	7,600	7,600	7,600	7,600	7,600
1930-31	16,300	41,900	62,600	48,400	21,400	13,400	7,500	7,500	7,500	7,500	7,500	7,500
Highest	34,500	77,300	123,000	121,000	52,600	33,800	29,800	24,300	15,100	14,400	14,400	14,400
Average	17,400	49,200	86,400	67,900	31,300	17,400	13,400	11,700	10,400	10,200	10,200	10,200
Lowest	8,200	32,900	35,800	26,600	15,700	10,900	7,500	7,500	7,500	7,500	7,500	7,500

SOUTH FORK OF FLATHEAD RIVER AT HUNGRY HORSE POWER SITE

Regulation of 1,100,000 acre-feet in Hungry Horse Reservoir for direct benefit of Hungry Horse power site.

TABLE No. 54.—*Regulated discharge, in second-feet, of South Fork of Flathead River at Hungry Horse power site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	4,000	6,840	6,840	4,300	3,360	3,360	3,360	3,360	3,360	3,350	3,350	3,350
1914–15	1,930	1,930	1,920	3,430	3,420	3,430	3,420	3,430	3,430	3,420	3,430	3,430
1915–16	715	715	714	715	3,140	3,130	3,140	3,130	3,140	3,130	3,130	3,140
1916–17	4,700	5,530	5,520	9,400	3,220	3,220	3,230	3,210	3,220	3,220	3,220	3,220
1917–18	3,210	4,390	4,380	6,500	3,280	3,280	3,280	3,280	3,280	3,280	3,280	3,280
1918–19	4,400	2,880	2,880	3,200	3,090	3,080	3,080	3,080	3,080	3,080	3,080	3,080
1919–20	708	708	708	2,600	2,600	2,600	2,600	2,600	2,590	2,600	2,600	2,600
1920–21	2,590	1,090	1,110	4,200	3,430	3,430	3,430	3,430	3,430	3,440	3,440	3,430
1921–22	4,800	6,390	6,380	5,800	2,910	2,930	2,930	2,940	2,930	2,930	2,920	2,930
1922–23	2,930	2,910	2,910	2,810	2,810	2,790	2,800	2,800	2,810	2,800	2,800	2,810
1923–24	2,900	2,410	2,410	3,530	2,910	2,900	2,910	2,900	2,900	2,910	2,900	2,900
1924–25	2,900	2,730	2,740	2,990	2,990	2,990	2,990	2,990	2,990	2,980	2,990	2,990
1925–26	6,870	6,890	6,890	3,400	3,070	3,060	3,070	3,070	3,060	3,070	3,070	3,060
1926–27	1,120	1,110	1,110	3,160	3,160	3,150	3,160	3,150	3,160	3,160	3,160	3,160
1927–28	4,100	6,390	6,360	5,100	4,250	4,240	4,250	4,250	4,250	4,250	4,250	4,250
1928–29	5,500	8,230	8,240	5,580	2,920	2,920	2,910	2,920	2,920	2,920	2,920	2,910
1929–30	2,920	1,660	1,660	2,730	2,730	2,730	2,720	2,730	2,730	2,730	2,730	2,730
1930–31	2,080	2,080	2,070	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,970
Highest	6,870	8,230	8,240	9,400	4,250	4,240	4,250	4,250	4,250	4,250	4,250	4,250
Average	3,240	3,600	3,600	4,020	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120
Lowest	708	708	708	715	2,600	2,600	2,600	2,600	2,590	2,600	2,600	2,600

FLATHEAD RIVER AT POWER SITES BETWEEN FLATHEAD LAKE AND MOUTH

Allowance made for future irrigation of about 125,000 acres. Upstream regulation of 1,100,000 acre-feet in Hungry Horse Reservoir. Reregulation of 1,540,000 acre-feet in Flathead Reservoir for direct benefit of power sites on lower Flathead River.

TABLE No. 55.—*Modified discharge, in second-feet, of Flathead River below Flathead Lake*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	13,400	11,100	49,000	16,600	9,010	9,020	9,010	9,020	9,010	9,010	9,010	9,010
1914–15	9,020	10,800	10,800	9,450	9,450	9,430	9,450	9,430	9,450	9,450	9,440	9,450
1915–16	7,020	7,010	7,020	8,790	8,790	8,770	8,770	8,770	8,770	8,770	8,780	8,770
1916–17	11,900	18,800	35,600	40,800	11,100	10,500	9,030	9,040	9,040	9,040	9,040	9,040
1917–18	9,010	9,040	40,900	22,300	9,510	9,510	9,510	9,510	9,510	9,510	9,520	9,510
1918–19	9,510	23,700	23,700	10,300	8,210	8,210	8,210	8,210	8,210	8,210	8,200	8,210
1919–20	8,320	8,320	16,100	7,010	7,010	7,010	7,020	7,010	7,020	7,020	7,020	7,020
1920–21	7,010	7,020	16,200	17,200	9,740	9,740	9,730	9,730	9,730	9,730	9,730	9,730
1921–22	9,730	22,500	37,800	15,500	8,570	8,570	8,570	8,570	8,560	8,560	8,560	8,560
1922–23	8,030	8,030	32,900	11,200	8,260	8,250	8,260	8,250	8,260	8,250	8,250	8,250
1923–24	8,250	13,000	33,300	16,500	8,340	8,320	8,320	8,320	8,320	8,320	8,320	8,320
1924–25	8,320	8,320	24,900	11,600	8,910	8,920	8,930	8,920	8,930	8,930	8,920	8,930
1925–26	8,920	11,600	39,000	16,600	9,070	9,070	9,060	9,060	9,060	9,060	9,060	9,060
1926–27	7,020	7,020	7,020	9,500	9,500	9,480	9,480	9,480	9,480	9,480	9,480	9,480
1927–28	9,480	13,300	58,900	26,700	12,600	12,600	12,600	12,600	12,600	12,600	12,600	12,600
1928–29	12,100	32,900	37,000	23,100	8,920	8,920	8,920	8,900	8,900	8,900	8,900	8,900
1929–30	8,900	8,900	16,900	8,650	7,630	7,630	7,630	7,630	7,630	7,630	7,630	7,630
1930–31	9,530	9,550	9,550	8,130	8,130	8,130	8,130	8,130	8,130	8,130	8,130	8,130
Highest	13,400	41,600	58,900	40,800	12,600	12,600	12,600	12,600	12,600	12,600	12,600	12,600
Average	9,190	14,500	27,600	15,600	9,040	9,000	8,920	8,920	8,920	8,920	8,920	8,920
Lowest	7,010	7,010	7,020	7,010	7,010	7,010	7,020	7,010	7,020	7,020	7,020	7,020

CLARK FORK AT MONTANA-IDAHO BOUNDARY, AND AT ROCK ISLAND GORGE AND CABINET GORGE POWER SITES

Allowance made for future irrigation of about 350,000 acres. Regulation in two upstream reservoirs aggregating 2,640,000 acre-feet of storage.

TABLE No. 56.—*Modified discharge, in second-feet, of Clark Fork at Montana-Idaho boundary*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	34,400	46,400	98,400	36,200	17,900	15,400	15,500	16,600	14,100	16,200	14,200	18,700
1914-15	28,000	38,400	30,700	21,000	14,700	14,100	16,000	19,600	15,300	13,900	14,000	16,100
1915-16	20,200	23,000	24,400	20,000	15,300	13,900	14,200	14,000	14,000	10,900	16,600	26,100
1916-17	35,500	53,500	75,400	74,400	23,600	17,600	15,500	15 000	13,700	13,700	14,600	13,400
1917-18	24,500	50,800	90,900	46,700	16,800	15,200	15,100	14,500	19,800	27,800	18,500	19,900
1918-19	27,100	54,300	54,300	20,300	15,200	12,200	14,000	13,700	13,000	15,900	15,200	15,700
1919-20	25,000	34,600	34,100	11,600	9,970	10,800	9,550	10,600	9,770	11,100	11,800	12,500
1920-21	16,300	34,600	43,600	28,500	13,300	15,500	17,700	16,800	16,300	17 800	19,900	21,200
1921-22	23,000	56,400	69,700	23,100	11,700	12,100	12,600	12,800	15,200	12,400	12,600	12,900
1922-23	19,100	37,200	67,400	19,800	12,200	12,000	12,200	11,700	11,900	15,300	11,600	13,200
1923-24	22,400	38,200	60,300	27,400	12,500	11,700	12,600	12,300	12,300	10,600	16,400	14,100
1924-25	16,500	34,000	34,900	14,900	11,100	11,300	12,600	14,000	24,000	15,300	21,600	17,900
1925-26	30,100	76,500	58,500	25,900	12,500	12,900	13,200	13,400	13,400	13,200	14,800	14,800
1926-27	18,000	22,200	11,800	11,500	11,900	12,800	14,300	15,000	16,300	14,200	15,700	17,000
1927-28	22,800	43,800	96,600	42,700	18,400	19,900	21,900	32,300	27,400	23,000	20,500	24,100
1928-29	28,300	74,800	58,500	37,100	14,500	13,700	13,300	13,300	12,400	10,700	11,500	13,400
1929-30	16,000	27,800	35,800	16,200	10,800	10,200	11,100	11,000	11,400	10,400	12,800	12,600
1930-31	26,700	28,400	22,900	13,500	11,300	11,300	12,400	12,200	11,700	11,400	11,600	12,400
Highest	35,500	76,500	98,400	74,400	23,600	19,900	21,900	32,300	27,400	27,800	21,600	26,100
Average	24,100	43,000	53,800	27,300	14,100	13,500	14,100	14,900	15,100	14,700	16,200	16,400
Lowest	16,000	22,200	11,800	11,500	9,970	10,200	9,550	10,600	9,770	10,400	11,500	12,400

CLARK FORK AT ALBANY FALLS POWER SITE

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 435,000 acres in Montana and Idaho. Upstream regulation in three reservoirs aggregating 3,209,000 acre-feet of storage. Re-regulation by use of 1,611,000 acre-feet in Pend Oreille Reservoir for direct benefit of power sites on lower Clark Fork.

TABLE No. 57.—*Modified discharge, in second-feet, of Clark Fork at Albany Falls power site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	25,900	43,400	102,000	40,000	21,500	21,500	21,500	21,500	21,500	21,500	21,500	21,500
1914-15	24,500	32,600	28,300	23,000	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
1915-16	19,000	19,000	19,000	19,000	19,900	19,900	19,900	19,900	19,900	19,900	19,900	22,300
1916-17	41,400	58,500	70,600	80,600	26,900	20,900	20,900	20,900	20,900	20,900	20,900	20,900
1917-18	20,900	46,400	96,100	46,200	23,400	23,400	23,400	23,400	23,400	23,400	23,400	23,900
1918-19	32,100	59,700	46,400	22,900	19,900	19,900	19,900	19,900	19,900	19,900	19,900	19,900
1919-20	20,000	28,300	31,400	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500
1920-21	15,500	30,000	40,000	27,400	22,400	22,400	22,400	22,400	22,400	22,400	22,400	22,400
1921-22	28,000	52,300	63,400	25,700	17,900	17,900	17,900	17,900	17,900	17,900	17,900	17,900
1922-23	18,000	32,500	61,800	22,300	17,600	17,600	17,600	17,600	17,600	17,600	17,600	17,600
1923-24	17,600	36,800	54,800	30,300	17,900	17,900	17,900	17,900	17,900	17,900	17,900	17,900
1924-25	17,900	27,100	26,900	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	21,600
1925-26	30,100	75,500	66,000	28,600	18,800	18,800	18,800	18,800	18,800	18,800	18,800	15,600
1926-27	14,200	14,000	14,000	18,900	18,900	18,900	18,900	18,900	18,900	18,900	18,900	18,900
1927-28	24,000	31,100	111,000	44,700	29,300	29,300	29,300	29,300	29,300	29,300	29,300	29,300
1928-29	20,000	82,000	68,800	33,800	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000
1929-30	18,000	21,600	25,600	16,000	15,800	15,800	15,800	15,800	15,800	16,100	15,800	15,800
1930-31	18,900	18,900	18,900	15,900	15,900	15,900	15,900	15,900	15,900	15,900	15,900	15,900
Highest	41,400	82,000	111,000	80,600	29,300	29,300	29,300	29,300	29,300	29,300	29,300	29,300
Average	22,600	39,400	52,500	29,400	20,000	19,600	19,600	19,600	19,600	19,600	19,600	19,800
Lowest	14,200	14,000	14,000	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500

CLARK FALLS AT METALINE FALLS POWER SITE

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 435,000 acres in Montana and Idaho. Upstream regulation in four reservoirs aggregating 4,820,000 acre-feet of storage.

TABLE No. 58.—*Modified discharge, in second-feet, of Clark Fork at Metaline Falls power site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	26,500	45,000	106,000	40,700	22,000	21,900	21,800	21,800	21,800	21,800	21,800	21,800
1914–15	25,400	35,300	30,400	23,700	21,100	21,200	21,100	21,300	21,100	21,100	21,100	21,100
1915–16	20,000	20,300	19,800	19,400	20,200	20,200	20,200	20,200	20,200	20,100	20,200	22,700
1916–17	42,000	59,900	73,100	81,600	27,300	21,300	21,200	21,200	21,200	21,100	21,100	21,200
1917–18	21,200	47,800	99,100	47,400	23,800	23,700	23,700	23,700	23,700	23,700	23,700	24,200
1918–19	32,600	60,700	47,500	23,400	20,200	20,100	20,200	20,100	20,100	20,200	20,200	20,100
1919–20	20,700	30,500	33,300	16,100	15,800	15,800	15,800	15,900	15,800	15,800	15,800	15,700
1920–21	15,700	30,600	41,000	27,800	23,000	22,900	22,700	22,800	22,700	22,700	22,700	22,800
1921–22	28,700	54,300	65,400	26,400	18,300	18,200	18,100	18,100	18,100	18,100	18,200	18,400
1922–23	18,200	33,400	63,200	22,700	17,900	17,900	17,900	17,900	17,900	17,900	17,900	17,800
1923–24	17,900	38,100	56,100	30,800	18,200	18,100	18,100	18,100	18,200	18,200	18,300	18,200
1924–25	18,200	28,100	27,300	19,000	19,000	18,900	19,000	19,000	19,000	19,100	19,300	22,000
1925–26	31,000	77,600	67,800	29,100	19,100	19,100	19,100	19,100	19,000	19,000	19,000	15,800
1926–27	14,600	15,200	14,700	19,100	19,000	19,100	19,200	19,300	19,400	19,200	19,200	19,200
1927–28	24,400	32,600	113,000	45,500	29,800	29,800	29,800	30,100	30,100	29,800	29,800	29,700
1928–29	20,600	84,100	70,800	34,400	18,400	18,300	18,300	18,500	18,200	18,200	18,200	18,200
1929–30	18,300	21,400	27,600	19,600	17,100	16,100	15,900	16,000	15,800	16,200	15,900	15,900
1930–31	18,200	19,600	20,400	17,500	16,300	16,100	16,000	15,900	16,000	16,000	16,200	16,200
Highest	42,000	84,100	113,000	81,600	29,800	29,800	29,800	30,100	30,100	29,800	29,800	29,700
Average	23,000	40,800	54,300	30,200	20,400	19,900	19,900	19,900	19,900	19,900	19,900	20,100
Lowest	14,600	15,200	14,700	16,100	15,800	15,800	15,800	15,900	15,800	15,800	15,800	15,700

PRIEST RIVER AT POWER SITES BETWEEN PRIEST LAKE AND MOUTH

Allowance made for future irrigation of about 20,000 acres in Priest River drainage basin. Regulation of 569,000 acre-feet in Priest Reservoir for direct benefit of power sites on Priest River.

TABLE No. 59.—*Modified discharge, in second-feet, of Priest River below Priest Lake*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	987	987	987	1,220	1,220	1,220	1,220	1,220	1,220	1,220	1,220	1,220
1914–15	1,220	1,220	1,220	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140
1915–16	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140
1916–17	1,150	1,150	1,150	1,150	1,280	1,280	1,280	1,280	1,280	1,280	1,280	1,280
1917–18	1,280	1,300	1,310	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130
1918–19	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130
1919–20	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130
1920–21	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130	1,130
1921–22	1,130	1,130	1,130	973	973	973	973	973	973	973	973	973
1922–23	973	973	973	973	973	973	973	973	973	973	973	973
1923–24	973	973	973	973	973	973	973	973	973	973	973	973
1924–25	973	973	973	973	973	973	973	973	973	973	973	973
1925–26	973	973	973	973	973	973	973	973	973	973	973	973
1926–27	973	973	973	973	973	973	973	973	973	973	973	973
1927–28	973	973	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170
1928–29	1,160	1,160	1,160	1,000	950	950	950	950	950	950	950	950
1929–30	950	950	950	950	950	950	950	950	950	950	950	950
1930–31	630	630	630	630	630	630	630	630	630	630	630	630
Highest	1,280	1,300	1,310	1,220	1,280	1,280	1,280	1,280	1,280	1,280	1,280	1,280
Average	1,050	1,050	1,060	1,040	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050
Lowest	630	630	630	630	630	630	630	630	630	630	630	630

SPOKANE RIVER AT POST FALLS POWER SITE

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin irrigation project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 20,000 acres in Idaho. Regulation of 415,000 acre-feet in Coeur d'Alene Reservoir to maintain as uniform a flow as possible at Spokane for the direct benefit of power sites on Spokane River.

TABLE No. 60.—*Modified discharge, in second-feet, of Spokane River at Post Falls power site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	18,300	27,200	15,800	4,020	2,860	2,910	3,200	3,330	2,940	4,000	4,880	8,700
1914–15	14,100	13,200	4,100	2,360	2,440	2,440	2,550	3,160	2,730	2,290	2,300	5,510
1915–16	6,500	5,630	4,120	2,490	2,410	2,390	2,340	2,340	2,550	2,670	4,800	14,900
1916–17	20,300	19,900	17,800	8,100	2,280	2,370	2,410	2,420	2,510	2,550	2,950	2,800
1917–18	13,200	30,200	24,800	3,970	2,670	2,670	2,600	2,640	10,100	17,500	10,400	10,600
1918–19	12,900	13,700	6,970	2,290	2,310	2,390	2,420	2,490	3,110	5,870	5,550	5,870
1919–20	20,800	16,700	5,210	1,980	1,940	1,950	1,950	2,020	2,100	2,110	2,280	5,090
1920–21	9,130	11,600	7,090	2,880	2,960	2,910	3,190	3,580	4,130	7,640	9,980	13,300
1921–22	17,100	20,200	6,890	1,980	2,260	2,270	2,180	2,350	3,270	2,730	2,900	3,110
1922–23	9,110	18,600	8,590	1,740	2,000	2,000	2,030	2,120	2,150	4,230	3,940	4,540
1923–24	13,400	17,600	11,500	2,070	2,130	2,150	2,180	2,320	2,440	2,340	8,190	7,950
1924–25	7,630	9,740	2,270	2,240	2,230	2,270	2,210	2,450	4,080	4,310	10,900	13,700
1925–26	18,300	20,300	5,920	1,900	2,100	2,030	2,080	2,100	2,230	2,280	5,010	6,880
1926–27	6,890	5,920	2,320	2,370	2,340	2,370	2,460	4,170	8,020	6,620	6,640	8,880
1927–28	13,300	20,700	14,700	3,370	3,740	3,710	4,640	12,600	9,270	9,710	9,700	12,800
1928–29	15,000	20,200	4,740	1,320	1,500	1,560	1,680	1,650	1,740	1,840	1,850	2,880
1929–30	6,770	7,680	4,690	1,480	1,720	1,680	1,640	1,680	1,770	1,940	3,260	4,410
1930–31	6,320	5,850	3,340	1,590	1,740	1,750	1,720	1,710	1,810	1,790	2,000	5,980
Highest	20,800	30,200	24,800	8,100	3,740	3,710	4,640	12,600	10,100	17,500	10,900	14,900
Average	12,700	15,800	8,380	2,680	2,310	2,320	2,420	3,060	3,720	4,580	5,420	7,660
Lowest	6,320	5,630	2,270	1,320	1,500	1,560	1,640	1,650	1,740	1,790	1,850	2,800

SPOKANE RIVER AT SPOKANE; AT UPPER FALLS AND MONROE STREET POWER SITES

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin Irrigation Project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Additional allowance made for future irrigation of about 20,000 acres in Idaho. Upstream regulation of 415,000 acre-feet in Coeur d'Alene Reservoir.

TABLE No. 61.—*Modified discharge, in second-feet, of Spokane River at Spokane*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	18,200	28,400	16,700	4,730	3,420	3,420	3,420	3,420	3,420	4,310	4,920	8,600
1914–15	13,600	13,000	4,640	2,970	2,970	2,970	2,970	2,970	2,970	2,970	2,970	5,200
1915–16	5,810	5,810	4,500	2,870	2,870	2,870	2,870	2,870	2,870	2,870	4,520	14,300
1916–17	20,500	20,500	17,800	8,460	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040
1917–18	13,300	31,200	25,200	4,620	3,340	3,340	3,340	3,340	10,200	18,500	10,700	10,700
1918–19	12,000	13,000	7,240	2,960	2,960	2,960	2,960	2,960	3,410	6,100	6,100	6,100
1919–20	20,100	15,900	5,440	2,590	2,590	2,590	2,590	2,590	2,590	2,590	2,590	5,200
1920–21	9,240	11,300	7,580	3,600	3,600	3,600	3,600	3,950	4,390	7,810	10,400	13,800
1921–22	17,800	20,800	8,550	2,940	2,940	2,940	2,940	2,940	3,450	3,450	3,450	3,450
1922–23	9,330	19,400	10,200	2,640	2,640	2,640	2,640	2,640	2,640	4,780	4,780	4,780
1923–24	13,600	18,200	12,400	3,090	2,850	2,850	2,850	2,850	2,850	2,850	8,260	8,620
1924–25	7,900	10,300	3,110	2,760	2,760	2,760	2,760	2,860	4,230	4,550	11,000	14,000
1925–26	19,000	21,100	7,020	2,740	2,740	2,740	2,740	2,740	2,740	2,740	5,130	7,010
1926–27	7,010	6,700	2,940	2,940	2,940	2,940	2,940	4,370	8,130	6,990	6,750	9,190
1927–28	13,500	21,600	15,800	4,400	4,400	4,400	4,880	12,600	10,300	10,300	10,300	13,000
1928–29	15,400	20,600	5,950	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	3,170
1929–30	6,890	8,100	5,430	2,220	2,220	2,202	2,220	2,220	2,220	2,220	3,420	4,570
1930–31	6,340	6,340	4,290	2,150	2,150	2,150	2,150	2,150	2,150	2,150	2,150	5,800
Highest	20,500	31,200	25,200	8,460	4,400	4,400	4,880	12,600	10,300	18,500	11,000	14,300
Average	12,800	16,200	9,130	3,390	2,930	2,930	2,960	3,490	4,110	5,030	5,710	7,810
Lowest	5,810	5,810	2,940	2,150	2,150	2,150	2,150	2,150	2,150	2,150	2,150	3,040

CHELAN RIVER BELOW LAKE CHELAN

Allowance made for future irrigation of about 12,000 acres. Regulation of 665,000 acre-feet in Chelan Reservoir for direct benefit of power site below Lake Chelan.

TABLE No. 62.—*Modified discharge in second-feet, of Chelan River below Lake Chelan*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	1,850	2,170	2,170	2,170	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
1914-15	2,100	2,100	2,100	2,100	1,730	1,730	1,730	1,730	1,730	1,730	1,730	1,730
1915-16	1,730	1,730	1,730	1,730	1,730	1,730	1,730	1,730	1,730	1,730	1,730	1,730
1916-17	3,110	3,150	3,150	3,150	2,990	1,890	1,890	1,890	1,890	1,890	1,890	1,890
1917-18	1,890	2,040	2,040	2,040	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
1918-19	2,300	2,300	2,300	2,300	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320
1919-20	2,180	2,180	2,180	2,180	1,970	1,970	1,970	1,970	1,970	1,970	1,970	1,970
1920-21	1,970	1,970	1,970	1,970	1,970	1,970	1,970	1,970	1,970	1,970	1,970	1,970
1921-22	1,970	3,140	3,140	3,140	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,040
1922-23	2,040	2,040	2,040	2,040	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020
1923-24	2,050	2,050	2,050	2,050	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940
1924-25	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940
1925-26	2,040	2,040	2,040	2,040	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550
1926-27	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550
1927-28	1,580	1,930	1,930	1,930	1,930	1,930	1,930	1,930	1,930	1,930	1,930	1,930
1928-29	1,930	1,930	1,930	1,930	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530
1929-30	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,520	1,520	1,520	1,520	1,520
1930-31	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,350	1,350	1,350	1,350	1,350
Highest	3,110	3,150	3,150	3,150	2,990	2,320	2,320	2,320	2,320	2,320	2,320	2,320
Average	1,950	2,060	2,060	2,060	1,920	1,850	1,850	1,850	1,850	1,850	1,850	1,850
Lowest	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,350	1,350	1,350	1,350	1,350

WENATCHEE RIVER BELOW WENATCHEE RESERVOIR

Upstream regulation in Chiwawa Reservoir by use of 482,000 acre-feet of storage. Reregulation of 1,000,000 acre-feet in Wenatchee Reservoir for direct benefit of power sites on Wenatchee River.

TABLE No. 63.—*Modified discharge, in second-feet, of Wenatchee River below Wenatchee Reservoir*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190
1914-15	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190
1915-16	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190
1916-17	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
1917-18	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
1918-19	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
1919-20	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
1920-21	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
1921-22	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
1922-23	2,290	2,290	2,290	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220
1923-24	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220
1924-25	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,230	2,230	2,230	2,230
1925-26	2,230	2,230	2,230	2,230	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130
1926-27	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130
1927-28	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130
1928-29	2,130	2,130	2,130	2,130	2,130	2,120	2,120	2,120	2,120	2,120	2,120	2,120
1929-30	2,120	2,120	2,120	2,120	2,120	2,120	2,120	2,120	2,120	2,120	2,120	2,120
1930-31	1,310	1,310	1,310	1,310	1,310	1,310	1,310	1,300	1,300	1,300	1,300	1,300
Highest	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
Average	2,170	2,170	2,170	2,170	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160
Lowest	1,310	1,310	1,310	1,310	1,310	1,310	1,310	1,300	1,300	1,300	1,300	1,300

WENATCHEE RIVER AT DRYDEN POWER SITE

Upstream regulation in two reservoirs aggregating 1,482,000 acre-feet of storage.

TABLE No. 64.—*Modified discharge, in second-feet, of Wenatchee River at Dryden Power Site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	4,020	5,270	6,620	4,640	2,850	2,650	2,620	2,610	2,570	2,830	2,570	3,030
1914–15	4,340	5,630	4,820	3,350	2,560	2,510	2,600	2,910	2,540	2,490	2,480	2,720
1915–16	4,130	3,660	3,090	2,660	2,540	2,470	2,460	2,600	2,590	2,450	2,560	3,840
1916–17	5,510	6,000	7,110	5,850	3,550	2,870	2,640	2,530	2,570	2,570	2,580	2,600
1917–18	2,880	4,990	6,150	5,190	2,920	2,750	2,550	2,550	4,050	4,360	2,940	2,820
1918–19	3,910	4,680	5,560	3,530	2,720	2,620	2,760	2,690	3,230	2,850	2,720	2,800
1919–20	3,980	5,280	5,520	4,400	2,990	2,730	2,520	2,790	2,830	3,090	2,900	2,870
1920–21	3,030	4,010	4,300	3,710	2,680	3,050	3,520	2,740	2,760	3,000	3,410	3,500
1921–22	3,850	5,860	6,840	4,170	2,920	2,770	2,940	2,910	4,150	2,770	2,660	2,670
1922–23	3,230	4,820	5,680	3,070	2,540	2,540	2,480	2,440	2,530	2,860	2,520	2,620
1923–24	4,510	5,360	5,200	3,800	2,830	2,540	2,450	2,470	2,650	2,560	3,780	3,340
1924–25	3,300	5,690	4,170	3,040	2,510	2,480	2,550	2,560	3,240	2,890	2,890	2,990
1925–26	4,370	6,110	4,990	3,410	2,490	2,400	2,340	2,340	2,780	2,510	2,600	3,310
1926–27	4,280	3,850	3,230	2,540	2,340	2,350	2,800	2,470	2,710	2,440	2,380	2,440
1927–28	3,140	4,540	6,460	3,660	2,570	2,640	2,990	3,070	3,160	3,270	2,630	3,050
1928–29	3,440	6,290	4,650	3,190	2,440	2,390	2,570	2,320	2,310	2,290	2,280	2,360
1929–30	2,590	3,920	4,130	2,870	2,290	2,150	2,240	2,210	2,260	2,250	2,440	2,690
1930–31	3,050	2,940	2,810	2,020	1,530	1,470	1,500	1,500	1,470	1,560	1,710	1,870
Highest	5,510	6,290	7,110	5,850	3,550	3,050	3,520	3,070	4,150	4,360	3,780	3,840
Average	3,750	4,940	5,070	3,620	2,630	2,520	2,590	2,540	2,800	2,720	2,670	2,860
Lowest	2,590	2,940	2,810	2,020	1,530	1,470	1,500	1,500	1,470	1,560	1,710	1,870

CHIWAWA RIVER AT CHIWAWA POWER SITE

Regulation of 482,000 acre-feet in Chiwawa Reservoir for direct benefit of Chiwawa Power Site.

TABLE No. 65.—*Regulated discharge, in second-feet of Chiwawa River at Chiwawa Power Site*

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	548	548	548	548	548	548	548	548	548	548	548	548
1914–15	548	548	548	548	548	548	548	548	548	548	548	548
1915–16	548	548	548	548	548	548	548	548	548	548	548	548
1916–17	548	548	548	548	548	548	548	548	548	548	548	548
1917–18	548	548	548	548	548	548	548	548	548	548	548	548
1918–19	548	548	548	548	548	548	548	548	548	548	548	548
1919–20	548	548	548	548	548	548	548	548	548	548	548	548
1920–21	548	548	548	548	548	548	548	548	548	548	548	548
1921–22	548	548	548	548	548	548	548	548	548	548	548	548
1922–23	548	548	548	548	548	548	548	548	548	548	548	548
1923–24	548	548	548	548	548	548	548	548	548	548	548	548
1924–25	548	548	548	548	548	548	548	548	548	548	548	548
1925–26	548	548	548	548	548	548	548	548	548	548	548	548
1926–27	548	548	548	548	548	548	548	548	548	548	548	548
1927–28	548	548	548	548	548	548	548	548	548	548	548	548
1928–29	548	548	548	548	548	548	548	548	548	548	548	548
1929–30	548	548	548	548	548	548	548	548	548	548	548	548
1930–31	324	324	324	324	324	324	324	324	324	324	324	324
Highest	548	548	548	548	548	548	548	548	548	548	548	548
Average	536	536	536	536	536	536	536	536	536	536	536	536
Lowest	324	324	324	324	324	324	324	324	324	324	324	324

274. *e. Regulated elevations at some reservoir sites.*—Elevations, on the last day of each month, as derived for some of the more critical reservoir sites, are shown in tables nos. 66 to 70. They refer to Plan No. 4, when developed by Grand Coulee high dam.

FLATHEAD RESERVOIR

Upstream regulation of 1,100,000 acre-feet in Hungry Horse Reservoir. Reregulation in Flathead Reservoir between elevations 2,880.0 feet and 2,893.0 feet, United States Geological Survey datum, providing 1,540,000 acre-feet of storage. Regulated elevation 50 percent of time about 2,887.8 feet.

TABLE No. 66.—*Regulated stage of Flathead Reservoir on the last day of each month*

[Add 2,800 to determine elevation in feet, U.S.G.S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	82.1	93.0	93.0	93.0	92.5	90.8	89.1	88.0	86.2	84.3	82.4	80.6
1914-15	81.8	89.7	93.0	92.5	90.6	88.7	88.3	89.1	87.4	85.2	82.9	80.7
1915-16	82.0	86.2	89.1	89.9	89.1	87.8	86.6	85.5	84.2	82.3	80.5	81.3
1916-17	83.3	86.8	93.0	93.0	93.0	93.0	92.2	90.2	88.2	86.0	84.0	81.7
1917-18	80.6	92.2	93.0	93.0	91.9	89.7	87.5	85.3	83.8	84.9	82.5	80.7
1918-19	84.5	85.8	93.0	93.0	92.1	90.6	89.1	87.6	86.0	84.0	82.3	80.4
1919-20	80.4	90.5	93.0	92.7	91.6	89.9	88.2	87.0	85.3	83.5	81.9	80.0
1920-21	80.0	86.6	93.0	93.0	91.6	89.9	88.6	86.6	84.5	82.6	81.0	80.8
1921-22	84.5	93.0	93.0	93.0	92.0	90.4	88.9	87.6	86.1	84.4	82.5	80.5
1922-23	80.5	90.8	93.0	93.0	92.2	90.8	89.2	87.6	85.6	84.2	82.3	80.4
1923-24	81.7	91.5	93.0	93.0	92.6	92.0	89.4	87.7	85.7	84.1	82.7	81.2
1924-25	80.4	92.6	93.0	93.0	91.7	90.0	88.1	86.3	85.6	83.0	81.8	80.6
1925-26	90.9	93.0	93.0	93.0	92.7	92.0	90.2	88.3	86.4	84.0	82.1	80.6
1926-27	84.4	88.9	89.5	88.0	85.5	84.8	86.2	85.9	86.0	84.3	82.7	80.7
1927-28	81.4	93.0	93.0	93.0	92.3	92.1	91.9	89.5	88.0	85.6	83.4	81.5
1928-29	81.5	93.0	93.0	93.0	92.8	91.5	90.5	89.3	87.4	85.4	83.4	81.6
1929-30	80.5	88.2	93.0	93.0	91.7	90.2	88.5	86.7	85.3	83.3	81.8	80.3
1930-31	83.1	88.3	93.0	93.0	91.5	90.0	88.6	87.2	85.4	83.5	81.9	80.4
Average	82.4	90.2	92.6	92.5	91.5	90.2	89.0	87.5	86.0	84.1	82.3	80.8

PRIEST RESERVOIR

No upstream regulation. Regulation in Priest Reservoir between elevations 2,436.7 feet and 2,459.0 feet, United States Coast and Geodetic Survey datum, providing 569,000 acre-feet of storage. Regulated elevation 50 percent of time about 2,448.0 feet.

TABLE No. 67.—*Regulated stage of Priest Reservoir on the last day of each month*

[Add 2,400 to determine elevation in feet, U.S.C. & G.S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	39.2	47.8	54.9	54.7	52.7	50.7	48.8	47.7	45.8	45.3	44.0	43.0
1914-15	47.5	55.5	59.0	58.4	56.2	54.6	53.7	53.9	52.4	50.5	49.0	48.2
1915-16	51.6	53.8	53.6	52.3	50.1	47.9	45.8	44.2	42.5	40.7	39.1	39.2
1916-17	40.9	48.7	57.1	59.0	57.0	54.9	52.2	49.9	47.4	45.0	42.9	40.5
1917-18	40.1	50.7	59.0	58.5	56.2	53.9	51.6	49.4	48.1	47.5	46.0	45.2
1918-19	47.8	53.6	57.6	56.4	54.6	52.5	50.4	48.3	46.2	44.0	42.0	40.8
1919-20	45.8	54.1	57.2	55.9	53.6	51.2	49.0	47.2	45.1	43.1	41.0	39.2
1920-21	38.9	43.4	46.8	45.7	43.1	42.1	41.2	40.6	39.7	38.8	38.3	39.2
1921-22	43.6	53.2	59.0	57.9	56.1	54.2	52.7	51.5	50.7	49.3	47.8	46.3
1922-23	46.6	53.7	58.0	56.4	54.4	52.6	51.2	49.6	48.3	47.3	45.8	44.3
1923-24	47.1	53.7	58.4	57.8	56.0	54.0	52.2	50.6	49.0	47.5	47.0	45.7
1924-25	45.3	52.4	52.2	50.1	48.0	45.8	44.1	43.0	41.9	40.8	40.6	39.8
1925-26	46.8	55.4	58.0	56.5	54.3	52.2	50.2	48.4	47.0	45.2	43.8	42.1
1926-27	45.1	46.7	45.0	42.5	40.5	39.2	38.9	38.4	38.9	38.5	37.8	36.9
1927-28	37.0	47.0	53.7	52.7	50.3	50.6	51.4	51.5	50.9	49.9	47.8	48.1
1928-29	50.3	58.2	59.0	59.0	57.1	55.2	53.8	52.3	50.8	49.0	47.4	46.0
1929-30	46.1	50.3	52.7	51.3	49.1	47.0	45.0	42.8	41.4	39.4	38.1	36.7
1930-31	41.1	44.1	45.4	44.2	42.7	41.2	40.1	39.2	38.0	37.2	36.7	36.7
Average	44.5	51.2	54.8	53.8	51.8	50.0	48.5	47.1	45.8	44.4	43.1	42.1

PEND OREILLE RESERVOIR

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin Irrigation Project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Upstream regulation in three reservoirs, aggregating 3,209,000 acre-feet of storage. Re-regulation in Pend Oreille Reservoir, for direct benefit of power sites on lower Clark Fork, between elevations 2,049.20 feet and 2,066.80 feet, United States Coast and Geodetic Survey datum, providing 1,611,000 acre-feet of storage. Regulated elevation 50 percent of time about 2,058.04 feet.

TABLE No. 68.—*Regulated stage of Pend Oreille Reservoir on the last day of each month*

[Add 2,000 to determine elevation in feet, U. S. C. & G. S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	59.17	64.70	66.80	66.80	66.13	63.41	60.64	59.19	55.67	53.76	50.49	51.08
1914–15	57.53	63.92	66.80	66.80	63.98	60.67	59.64	59.80	57.72	54.55	51.70	50.32
1915–16	54.26	59.05	64.31	66.80	65.27	62.63	60.07	57.77	55.40	50.43	50.14	57.08
1916–17	59.44	59.44	65.94	66.80	66.80	66.33	64.33	62.30	59.21	56.06	53.79	50.30
1917–18	56.53	63.54	63.54	66.80	64.14	60.09	55.66	51.10	50.79	57.95	56.96	56.96
1918–19	58.50	58.50	66.80	66.80	65.20	61.31	58.57	56.01	52.76	52.01	50.88	50.10
1919–20	57.08	63.58	66.80	65.22	62.49	60.38	57.30	55.24	52.37	50.63	49.60	49.20
1920–21	52.25	58.69	64.01	66.80	62.20	58.86	56.84	54.67	51.89	50.61	50.88	53.16
1921–22	53.30	59.96	66.80	66.80	63.95	61.16	58.58	56.48	56.14	53.79	51.65	49.73
1922–23	53.38	60.04	66.80	66.80	64.44	61.80	59.13	56.39	53.68	53.80	51.14	49.72
1923–24	56.40	60.42	66.80	66.80	64.52	61.48	58.89	56.42	53.81	49.84	50.68	49.73
1924–25	51.22	59.60	66.80	65.86	61.96	57.99	54.77	52.47	50.44	49.88	53.96	53.96
1925–26	60.18	65.45	66.80	66.80	63.97	61.30	58.70	56.24	53.95	51.52	50.41	51.87
1926–27	57.91	65.82	66.80	62.95	59.13	56.03	53.97	52.40	52.30	50.62	50.19	50.98
1927–28	53.43	65.60	65.60	66.80	61.25	56.37	52.36	56.16	57.54	55.92	52.32	52.00
1928–29	61.22	62.50	62.50	66.80	65.90	64.21	62.35	60.52	57.99	54.22	51.13	49.77
1929–30	50.95	58.04	66.80	66.80	63.97	60.95	58.43	55.85	54.22	50.73	50.56	49.29
1930–31	56.79	64.13	66.80	65.31	62.54	59.75	57.79	55.84	53.43	51.25	49.63	49.35
Average	56.09	61.83	65.97	66.36	63.77	60.82	58.22	56.38	54.41	52.64	51.44	51.37

COEUR D'ALENE RESERVOIR

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin Irrigation Project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. No upstream regulation. Regulation in Coeur d'Alene Reservoir for direct benefit of power sites on Spokane River, between elevations 2,118.26 feet and 2,129.10 feet, United States Coast and Geodetic Survey datum, providing 415,000 acre-feet of storage. Modified elevation 50 percent of time about 2,124.73 feet.

TABLE No. 69.—*Modified stage of Coeur d'Alene Reservoir on the last day of each month*

[Add 2,100 to determine elevation in feet, U. S. C. & G. S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913–14	30.82	30.82	29.10	29.10	27.20	24.84	21.94	21.47	19.11	19.93	19.93	24.01
1914–15	29.03	29.10	29.10	27.79	25.62	23.38	20.51	23.41	22.13	19.59	18.89	21.14
1915–16	27.43	29.10	29.10	27.92	25.98	23.81	20.66	18.85	20.04	18.85	20.74	27.54
1916–17	28.54	29.10	29.10	29.10	28.45	27.20	25.62	24.77	22.96	21.03	20.11	18.85
1917–18	29.66	34.89	29.10	29.10	27.96	25.60	22.71	18.93	26.62	27.03	24.09	22.93
1918–19	29.10	29.10	29.10	27.96	26.08	23.66	20.66	18.81	19.37	21.84	20.48	26.29
1919–20	29.10	29.10	29.10	28.17	26.53	24.84	22.46	20.51	18.63	19.30	19.44	20.74
1920–21	23.79	29.10	29.10	27.56	24.73	21.29	19.30	19.30	19.89	23.21	22.64	26.59
1921–22	26.59	29.10	29.10	28.20	26.22	24.05	21.14	18.89	24.90	23.00	19.59	18.89
1922–23	25.92	29.10	29.10	28.30	26.57	24.73	22.27	19.67	18.63	24.09	19.93	20.11
1923–24	28.80	29.10	29.10	29.10	27.51	25.62	23.67	21.54	20.84	18.78	24.68	19.37
1924–25	23.84	29.10	29.10	27.28	25.03	21.98	18.59	18.70	20.44	19.30	27.01	22.57
1925–26	31.42	29.10	29.10	28.26	26.57	24.81	22.42	20.00	20.00	18.74	21.47	23.31
1926–27	29.10	29.10	28.05	25.68	22.60	19.44	18.81	20.63	23.10	19.22	22.85	21.87
1927–28	27.03	29.10	29.10	27.71	23.93	19.56	20.33	27.73	29.27	28.41	23.24	25.21
1928–29	25.21	29.10	29.10	28.97	27.62	26.29	25.24	24.50	22.92	20.48	18.26	19.67
1929–30	22.57	29.10	29.10	28.43	26.76	25.28	23.81	21.54	20.88	18.29	19.70	19.70
1930–31	27.94	29.10	29.10	28.03	26.29	24.73	23.00	21.58	19.26	18.26	18.89	22.24
Average	27.55	29.52	29.04	28.15	26.20	23.95	21.84	21.16	21.61	21.08	21.22	22.28

COLUMBIA RIVER RESERVOIR

COLUMBIA BASIN PUMPING WITH SUPPLEMENTAL PUMPING—PLAN NO. 4

Columbia Basin Irrigation Project, 1,199,430 acres, assumed to be served by pumping from Columbia River at Grand Coulee. Upstream regulation in six reservoirs, aggregating 5,950,000 acre-feet of storage.

Reregulation in Columbia River Reservoir behind high dam for joint benefit of Grand Coulee and other downstream power sites, between elevations 1,207.6 feet and 1,287.6 feet, United States Geological Survey datum, providing 5,028,000 acre-feet of storage. Regulated elevation 50 percent of time about 1,282.2 feet.

TABLE NO. 70.—*Regulated stage of Columbia River Reservoir on the last day of each month*

[Add 1,200 to determine elevation in feet, U.S.G.S. datum]

Storage year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1913-14	17.6	87.6	87.6	87.6	87.6	87.6	86.1	79.6	65.0	47.3	30.5	17.6
1914-15	22.5	87.6	87.6	87.6	87.6	87.6	87.6	87.6	75.7	56.2	36.5	17.6
1915-16	17.6	87.6	87.6	87.6	87.6	87.6	79.8	74.3	60.0	39.2	18.0	17.6
1916-17	42.3	87.6	87.6	87.6	87.6	87.6	87.6	86.3	76.7	63.3	48.6	29.9
1917-18	16.3	87.6	87.6	87.6	87.6	87.6	82.7	69.1	56.0	49.7	35.9	17.6
1918-19	17.6	87.6	87.6	87.6	87.6	87.6	87.5	80.1	65.6	49.3	34.1	17.6
1919-20	17.6	87.6	87.6	87.6	87.6	87.6	86.4	78.8	67.4	54.5	40.6	24.4
1920-21	7.6	50.4	87.6	87.6	87.6	87.6	87.6	83.5	66.5	48.3	31.6	17.6
1921-22	17.6	87.6	87.6	87.6	87.6	87.6	86.2	87.6	81.4	68.7	54.0	35.1
1922-23	16.7	80.6	87.6	87.6	87.6	87.6	87.6	82.2	68.6	55.1	38.8	18.5
1923-24	16.4	87.6	87.6	87.6	87.6	87.6	85.9	78.7	67.2	53.1	44.1	34.4
1924-25	16.7	87.6	87.6	87.6	87.6	87.6	77.5	67.7	52.2	35.0	24.2	17.6
1925-26	48.5	87.6	87.6	87.6	87.6	87.6	83.9	76.4	65.6	51.7	40.4	24.8
1926-27	17.6	78.5	87.6	87.6	87.6	87.6	87.6	82.2	72.6	54.7	38.6	20.5
1927-28	17.6	87.6	87.6	87.6	87.6	87.6	87.6	87.6	79.2	62.8	44.7	30.6
1928-29	17.6	87.6	87.6	87.6	87.6	87.6	87.6	84.0	75.9	64.6	51.3	35.2
1929-30	17.6	34.5	87.6	87.6	87.6	87.6	82.7	74.7	62.4	45.6	30.0	10.3
1930-31	7.6	53.6	87.6	87.6	87.6	87.6	83.5	75.0	63.6	48.1	31.6	11.4
Average	19.6	79.8	87.6	87.6	87.6	87.6	85.3	79.7	67.9	52.6	37.4	22.1

(F) RESERVATIONS

1. LANDS

275. The total drainage area of the Columbia River in the United States above the mouth of Snake River is about 41,230,000 acres, of which 47½ percent is held as Federal reservations and State-owned lands, as follows:

	Acres	Percent
National Forests	14,940,000	36
Glacier National Park	618,000	1.5
Indian reservations	781,000	2
Vacant public lands	1,255,000	3
State-owned lands	2,000,000	5
Total	19,594,000	47.5

276. Table no. 71 gives in more detail the acreage of each type of reserve in the drainage area of the Columbia above the mouth of Snake River. Tables nos. 72 to 76 list the acreages of the national forests, Indian reservations, military reservations, U.S. public lands, and State-owned lands within the area The locations of the national forests, Indian and military reservations, and Glacier National Park are shown on plate no. 25.[2]

[2] Not printed.

TABLE NO. 71.—*United States reservations and public lands, and State-owned lands in the Columbia River Drainage Basin above the mouth of Snake River in the States of Washington, Idaho, and Montana*

	Columbia River Drainage Basin			Entire State		
	Washington	Idaho	Montana	Washington	Idaho	Montana
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
National forests	4,489,000	2,067,000	8,384,000			
Glacier National Park, part			618,000			
Indian reservations, unallotted	726,000	1,900	52,600			
National Bison Range			18,500			
Military reservations	1,622		1,520			
Vacant public lands (United States)	830,000	155,579	270,000			
Power-site reserves				93,200	194,000	127,000
Power-site classifications				192,000	236,000	53,700
Public water reserves				920	15,400	9,100
Reservoir sites (includes bird-preserve areas, 7,900 acres)				36,300		9,080
Miscellaneous reservations				560		
State-owned lands	1,200,000	365,000	436,000			

TABLE NO. 72.—*National forests in the Columbia River Drainage Basin above the mouth of Snake River*

Washington	Acres	Idaho	Acres	Montana	Acres
Rainier, part	[1] 789,000	Kaniksu, part	192,839	Kootenai	1,361,696
Wenatchee	881,784	Pend Oreille	676,619	Blackfeet	836,346
Chelan	1,796,644	Coeur d'Alene	674,344	Cabinet	837,783
Colville	748,035	St. Joe	522,880	Flathead	1,722,492
Kaniksu, part	273,143	Administrative sites	200	Lolo	890,654
Administrative sites	170			Missoula	976,925
				Bitterroot	1,051,255
				Deerlodge, part	[1] 353,000
				Helena, part	[1] 353,000
				Administrative sites	1,517
Total	[1] 4,489,000	Total	[1] 2,067,000	Total	[1] 8,384,000

[1] Approximate

TABLE NO. 73.—*Indian reservations, unallotted lands in the Columbia River Drainage Basin above the mouth of Snake River*

Washington	Acres	Idaho	Acres	Montana	Acres
Colville	220,000	Coeur d'Alene	1,906	Flathead	52,588
Kalispel	821				
Spokane	82,648				
Yakima	422,444				
Total	[1] 726,000				

[1] Approximate.

TABLE NO. 74.—*Military reservations, in the Columbia River Drainage Basin above the mouth of Snake River*

	Acres
Washington, Fort George Wright	1,622
Montana, Fort Missoula	1,520

TABLE No. 75.—*United States public lands, unappropriated and unreserved on July 1, 1930, in the Columbia River Drainage Basin above the mouth of Snake River*

Washington	Acres	Idaho	Acres	Montana	Acres
County		*County*		*County*	
Adams	[1] 7,000	Benewah	28,678	Flathead	[1] 6,000
Benton	[1] 31,000	Bonner	20,929	Granite	42,293
Chelan	30,435	Boundary	4,932	Lake	3,320
Douglas	40,721	Kootenai	18,777	Lewis and Clark	[1] 25,000
Ferry	165,896	Shoshone	[1] 82,000	Lincoln	9,491
Franklin	[1] 7,000			Mineral	4,410
Grant	127,463			Missoula	49,188
Kittitas	33,877			Powell	68,167
Lincoln	12,920			Ravalli	14,814
Okanogan	162,580			Sanders	31,753
Pend Oreille	41,810			Silver Bow	[1] 15,000
Spokane	644				
Stevens	141,125				
Yakima	27,304				
Total	[1] 830,000	Total	[1] 155,000	Total	[1] 270,000

[1] Approximate.

TABLE No. 76.—*State-owned lands in the Columbia River Drainage Basin above the mouth of Snake River, Sept. 30, 1930*

Washington	Acres	Idaho	Acres	Montana	Acres
County		*County*		*County*	
Adams	[1] 43,000	Benewah	31,007	Flathead	136,885
Benton	[1] 53,000	Bonner	152,583	Granite	19,635
Chelan	46,429	Boundary	96,973	Lake	
Douglas	109,898	Kootenai	34,174	Lewis and Clark	
Ferry	22,271	Shoshone	[1] 50,000	Lincoln	60,660
Franklin	[1] 20,000			Mineral	21,386
Grant	117,583			Missoula	61,666
Kittitas	161,381			Powell	56,593
Lincoln	50,756			Ravalli	26,316
Okanogan	254,722			Sanders	52,567
Pend Oreille	30,608			Silver Bow	
Spokane	24,363				
Stevens	101,521				
Yakima	164,948				
Total	[1] 1,200,000	Total	365,000	Total	[1] 436,000

[1] Approximate

2. WATER

277. *State laws and regulations.*—The State of Idaho has an inhibition on the use of water embodied in an act of the legislature approved January 24, 1927, entitled:

An act authorizing the Governor of Idaho to appropriate and hold in trust for the people of the State all the unappropriated water of Priest, Pend Oreille, and Coeur d'Alene Lakes, and declaring the preservation of the water in said lakes to be a beneficial use thereof; also declaring the land belonging to the State of Idaho adjacent to said lakes to be now devoted to a public use more necessary than the use thereof for storage reservoir purposes, and declaring an emergency.

278. *Treaty of 1846.*—Following considerable discussion during the early 1840's as to the boundary between the United States and Canada west of the Rocky Mountains there was negotiated between the United States and Great Britain the treaty of August 5, 1846, which defined the international boundary westward to the Pacific, and provided that navigation on the Columbia River below the boundary should remain open to certain commercial interests. The following extract is that part of the treaty of August 5, 1846, pertinent to the Columbia River:

ARTICLE II. From the point at which the forty-ninth parallel of north latitude shall be found to intersect the great northern branch of the Columbia River, the navigation of said branch shall be free and open to the Hudson's Bay Co., and to all British subjects trading with the same, to the point where the said branch meets the main stream of the Columbia, and thence down the said main stream to the ocean, with free access into and through the said river or rivers, it being understood that all the usual portages along the line thus described shall, in like manner, be free and open. In navigating the said river or rivers, British subjects with their goods and produce shall be treated on the same footing as citizens of the United States; it being, however, always understood that nothing in this article shall be construed as preventing, or intended to prevent, the Government of the United States from making any regulations respecting the navigation of the said river or rivers not inconsistent with the present treaty.

279. Technically, this treaty makes the maintenance of navigation, equal to its original condition at least, obligatory upon the United States, and forestalls the construction of high dams or other impeding structures across the channel without also including compensatory navigation locks in the dam structures. Practically, the Hudson's Bay Co. and its British associates have long since ceased to make use of the provisions of the treaty, and that they will ever do so in the future is an extremely remote possibility. However, this situation will need to be made the subject of a supplemental compact between the two Governments before final plans for any impeding structures are definitely formulated.

280. *The International Joint Commission.*—Another treaty which relates to the boundary waters between the United States and Canada was signed at Washington, January 11, 1909, and ratified May 5, 1910. It provides for settlement by a commission of all questions that may arise in connection with any change effecting the natural level, flow, or navigability of boundary waters, or any other questions involving matters along the common frontier, that may be submitted to it by either Government for examination and report. The treaty also provides that this Commission shall be known as the International Joint Commission and shall be composed of 6 members, 3 to be appointed by the President of the United States, and 3 on the recommendation of the Governor in Council of the Dominion of Canada, by His Britannic Majesty. The money appropriated by Congress for the United States Commissioners is expended under the direction of the Secretary of State.

(G) POPULATION

1. GENERAL

281. The economic feasibility of navigation, irrigation, and power development which are elements of any comprehensive plan for the utilization of the waters of Columbia River depends primarily and to a large degree upon the growth of population of Idaho, Washington, and Oregon, and to a lesser degree, but very directly, upon the growth of population of California and the United States. It is important, therefore, to make as reliable a forecast as possible of the population growth of these areas particularly during the next three or four decades.

2. PRESENT POPULATION AND FACTORS INFLUENCING THE RATE OF GROWTH

282. The growth of population in Washington, Oregon, and Idaho since 1870 is shown in table no. 77.

TABLE No. 77.—*Population of United States and Western States, 1870–1930*

[Source: United States Census]

Area	1870	1880	1890	1900	1910	1920	1930
United States	38, 558, 371	50, 155, 783	62, 947, 714	75, 994, 575	91, 972, 266	105, 710, 620	122, 774, 193
Washington, Oregon and Idaho	129, 877	300, 494	763, 484	1, 093, 411	2, 140, 349	2, 571, 876	2, 962, 214
Washington	23, 955	75, 116	357, 232	518, 103	1, 141, 990	1, 356, 621	1, 563, 396
Idaho	14, 999	32, 610	88, 548	161, 772	325, 594	431, 866	445, 032
Montana	20, 595	39, 159	142, 924	243, 329	376, 053	548, 889	537, 606
Oregon	90, 923	174, 768	317, 704	413, 536	672, 765	783, 389	953, 786
California	560, 247	864, 694	1, 213, 398	1, 485, 053	2, 377, 549	3, 426, 861	5, 677, 251

283. There were but 129,877 people in the States of Washington, Oregon, and Idaho in 1870. The discovery of gold, development of the cattle business in the bunch grass country of eastern Washington, Oregon, and in Idaho, and settlement in the farming areas in the valleys west of the mountains formed the foundation for the growth in population up to that period. Walla Walla was the metropolis of Washington, and it was not until 1880 that the population of Seattle exceeded that of Walla Walla. The settlement in the Willamette Valley gave Oregon more than twice the population of Washington, and more than five times the population of Idaho during this early period of settlement. In 1890 the improved land in the Northwest States was as follows:

	Acres
Washington	484, 346
Oregon	2, 198, 645
Idaho	197, 407

284. In the decade between 1870 and 1880 the general interest in mines, agriculture, and timber led to an increase of 152,617 in the States of Washington, Oregon, and Idaho, which was an increase of 117 percent during the decade.

285. In 1883 the Northern Pacific Railway was completed into Portland, and there was a rush for the lands, mines, and timber of the Northwest. The population of Washington more than quadrupled and that of Idaho more than doubled. The total increase of Washington, Oregon, and Idaho during that decade was 480,990, or 170 percent.

286. The panic of 1893 retarded development between 1890 and 1900; but the discovery of gold in Alaska and of silver in the Coeur d'Alene country of Idaho drew thousands of families to the Northwest. Irrigation development became an important factor affecting population growth during this period. Settlement in Yakima and other valleys of eastern Washington, Oregon, and in Idaho was appreciable between 1890 and 1900. In 1900 there were 1,132,624 acres of irrigated land in the Northwest States divided as follows:

	Acres
Washington	135, 470
Oregon	388, 436
Idaho	608, 718

287. The influence of the Klondike gold rush on business in Seattle can be seen by the following quotation from the History of the State of Washington, by Edmond S. Meany:

Countless numbers of those who remained at home sought to reap a share of the golden harvest by making articles to sell to adventurers. These goods included condensed and evaporated foods, such as potato chips, powdered squash, "crys-

tallized" eggs, and creepers to fasten to the shoes for facilitating the climb over ice, warm garments of all kinds, movable houses, protection against mosquitoes, such as veils, etc. In short, the industrial and economic life of Washington was profoundly affected by the series of events known as the "golden era" of Alaska.

288. The rate of increase during the decade between 1890 and 1900 was much below that of former decades, being but 43 percent, but the total numerical increase of 329,927 was more than twice as great as that of any previous period with the exception of the 1880 to 1890 decade, when railroad construction had so vital an influence on the settlement of the Northwest.

289. Irrigation development assumed large proportions between 1900 and 1910. It was during this period that the United States Reclamation Service was organized. The population of Idaho and Washington more than doubled, and the population of Oregon increased by 259,229. Approximately 1,318,731 acres were brought under irrigation in the three States during this decade, the total irrigated area being divided as follows:

	Acres
Washington	334, 378
Oregon	686, 129
Idaho	1, 430, 840

290. The growth in population has continued since 1910, but at a rapidly decreasing rate. In the decade from 1900 to 1910 the increase was 95 percent, from 1910 to 1920 it was 20.1 percent, and from 1920 to 1930 but 15.2 percent. There have been no special forces to cause an increase in population during this period and therefore there has been no special growth. (See plate no. 26.[2])

3. TRENDS IN POPULATION GROWTH

291. In the present study of population increase the forecast is based on an analysis of trends of growth. The figures secured by this method are conservative as compared to figures presented in other published studies. (See table no. 78.)

TABLE NO. 78.—*Various forecasts of population growth for Washington, Oregon, and Idaho, and for California and the United States*

Area	Year	Present forecast	San Francisco district forecast	Forecast by Whelpton	Forecast by Weeks
United States	1930	122, 774, 000			
	1940	138, 642, 000	[1] 136, 000, 000	[2] 138, 250, 000	
	1950	151, 487, 000	[1] 148, 000, 000	[2] 151, 620, 000	
	1960	162, 286, 000	[1] 160, 000, 000	[2] 162, 670, 000	
Washington, Oregon, and Idaho	1930	2, 957, 000			
	1940	3, 370, 000	[3] 3, 400, 000		
	1950	3, 843, 000	[3] 3, 870, 000		
	1960	4, 395, 000	[3] 4, 400, 000		
California	1930	5, 677, 000			
	1940	6, 842, 000	[4] 8, 000, 000		[5] 8, 650, 000
	1950	8, 417, 000	[4] 10, 000, 000		[5] 12, 466, 467
	1960	10, 237, 000	[4] 11, 500, 000		[5] 16, 715, 913

[1] Population, the Cyclical Rise and Fall of Population, Harris Foundation Lectures 1929, University of Chicago Press, 1930.
[2] Whelpton, P. M., Population of the United States 1925 to 1975, The American Journal of Sociology, vol. XXXIV, pp. 253–276, September 1928.
[3] Office of district engineer, Portland, Oreg.
[4] Report on Electric Power Requirements of the State of California and the Value of By-product Electric Power, proposed to be developed in connection with the State-Wide Plan of Water Conservation, by James E. McCaffrey, Hydroelectric Engr., and E. W. Kramer, Regional Engr., U.S. Forest Service, San Francisco, Calif., Dec. 31, 1930.
[5] Permissible Economic Rate of Irrigation Development in California, by David Weeks, Bulletin No. 35, Division of Water Resources, State Engineers, Sacramento, Calif.

[2] Not printed.

292. Population growth in eastern Washington, eastern Oregon, and Idaho depends quite largely upon agriculture and mining, while commerce and industry have a dominating influence on population growth west of the Cascades.

293. Records of rates of growth for industrial and agricultural communities show a fundamental difference in trend. The rate of increase is rapid in any new and growing community, but tends to decrease as conditions become stabilized. In industrial regions the rate is subject to great variations during the early development period due to the fact that industry is more sensitive to changing economic conditions than agriculture. The most striking and the most important difference in the trend of rates of increase for agricultural communities and for industrial and commercial centers, however, is the fact that the rate in industrial and commercial regions is sustained materially above the rate of births over deaths for a prolonged period, while the rate for agricultural sections rather quickly reaches a static condition where emigration is apt to be more important than immigration, and where the rate of increase is below the rate of births over deaths. This is due to the fact that the increase in opportunities for making a living does not equal the normal rate of births over deaths for an agricultural community with a naturally increasing population. This is why the country is a constant source of supply of population for urban centers.

294. This fundamental difference between the rate of growth of industrial and commercial centers and the rate of growth of agricultural sections is shown in plate no. 27.[2] The rates for New York and New England have been sustained at a relatively high percentage (varying from 13 to 24 percent per decade) during the past 100 years, while the rates of increase for Iowa and Missouri (varying from 385 percent to −0.3 percent per decade during the past 100 years) have rapidly declined to a relatively low percentage which is in general below the rate for births over deaths (6.5 percent in the Northwest during the past decade). The rate for the United States, on the other hand, shows a rate about halfway between the rate for New York and New England, on one side, and Iowa and Missouri, on the other. This is to be expected since the rate for the United States is affected by the influences of both agricultural and industrial communities. The rates of increase are given in table no. 79.

295. The rates of growth for the Northwest, which are shown in the following tabulations, show the same fundamental difference between the rate of growth for agricultural communities and industrial centers as is shown by the comparison between the rates for New York and New England and those for Iowa and Missouri in table no. 79.

296. From the graphic presentation of trends of population growth (pl. no. 27),[2] it is apparent that a forecast of the future can be made by an extension of the trends, provided no great and entirely unexpected happening occurs to change the trend. By basing the forecast of a new section upon the historical trends in older areas where the conditions influencing the rate of increase are similar, all of the unusual forces affecting population growth are included and the errors involved in attempting to weight the various influences which

[2] Not printed.

normally operate to increase or retard the rate of increase are largely avoided.

297. The accuracy of a prediction depends upon the accuracy of the analysis upon which the extension of the trend is based. In any statistical study of the trend of population growth it is apparent that there is a gradually increasing rate of decrease of the rate of increase. The form of the curve, therefore, depends upon fundamental and inherent forces which control population growth in any particular community.

298. It is necessary, therefore, to determine the general shape of the curve of growth by plotting the historical records of growth and to compare the results with the curve of other sections where population growth is governed by similar conditions. If an older community can be compared to a newer community where not only the fundamental conditions affecting growth appear to be the same but where the actual records show a similar curve of growth, a reasonable forecast of population increase for a period of 30 to 40 years can be made.

299. The graphic presentations made in plate no. 27 [2] are examples of such a comparison. The conditions governing the areas compared are similar and the correlations in the historical trends are striking. A reasonable forecast of population growth for the Northwest can be made by extending the historical trend in the area west of the Cascades with the longer records of growth in New York and New England and by extending the trend for the area east of the Cascades with the trend for Iowa and Missouri.

300. The chance for error comes in predicting the future rate of increase. A straight-line extension of the curve for the trend plotted on semilogarithmic paper does not take into account the increasing rate of decrease. By plotting the rates of increase by decades and determining the trend of rates from the graph a fairly reliable forecast can be made of future rates. Table no. 78 presents the rates for New York and New England combined, Iowa and Missouri combined, and the rates for the United States compared to western Washington and western Oregon, eastern Washington and eastern Oregon, Idaho, New York State, New England, and California. Table no. 78 gives a record of the rates of growth in these areas.

301. These rates were plotted on logarithmic paper and a straight line superimposed to show the trend of the rates. The rates for western Washington and western Oregon in 1920 and 1930 were shifted back to fit this line, and the rates for the following three decades as expressed by the trend were used as the future rates in this area. The same method of comparison was used with eastern Washington, eastern Oregon and Idaho, and Iowa and Missouri, while California was compared with New York.

[2] Not printed.

TABLE No. 79.—*Comparative rates of population growth in agricultural and industrial communities*

[These figures represent percent of increase by decades]

Location	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900	1910	1920	1930
Western Washington and western Oregon	----	----	----	----	----	----	----	61	185	167	35	99	22	22
Eastern Washington, eastern Oregon, and Idaho	----	----	----	----	----	----	----	----	212	172	62	91	17	5
Washington, Oregon, and Idaho combined	----	----	----	----	----	----	----	----	131	155	44	95	20	15
New York State	73	63	43	40	27	28	25	13	16	18	21	26	14	21
New England	22	19	13	18	14	22	15	11	15	17	19	17	13	10
New York and New England combined	35	34	25	27	20	24	21	13	15	17	21	21	13	16
Iowa	----	----	----	----	----	345	251	77	36	11	16	3	8	2.7
Missouri	----	----	237	111	173	76	773	45	26	23	16	6	3.3	6.6
Iowa and Missouri combined	----	----	----	----	----	105	112	57	30	21.1	16.3	3.4	5.3	5
California	----	----	----	----	----	----	310	47	54	40	22	63	44	65
United States	35	36	33	33	33	36	36	23	30	26	21	21	15	16.5

4. FORMULA USED TO TRANSLATE ASSUMED RATES OF INCREASE INTO ASSUMED POPULATION INCREASE

302. In order to translate the rate into population growth, it is necessary to use a formula which will measure the population growth based on the existing rate of increase and the assumed rate at some future time, based on a study of the trend in rates as above outlined. The general trend of growth shows not only that the rate decreases but that the rate of this decrease becomes slower with time. A straight line connecting two points on logarithmic paper, one point representing the present rate of growth and the other the rate of growth at some future time, gives a gradual increasing rate of decrease in the rate of increase which expresses the most probable measure of the changing rate of population growth during the period under consideration. Such a curve corresponds to a curve representing biological growth and to that degree is compared to the curve of growth developed by Pearl.[23]

303. An equation which will give the population at any time on the curve developed by this logarithmic plotting has been developed by this office and is used in making the population forecasts.

5. FORECAST OF POPULATION GROWTH FOR EASTERN WASHINGTON, EASTERN OREGON, AND IDAHO

304. A forecast of population growth for eastern Washington, eastern Oregon, and Idaho can be made by using the above formula and assuming the rate of increase as predicted above—that is, 0.26 percent for 1960. The resulting population figure for 1960 is 1,233,200. This forecast is based on the assumption that the rate of growth after 1930 will follow the trend in growth for Iowa and Missouri combined, as shown in plate no. 27.[2] It would not be reasonable to assume a more rapid rate (except as credit is given to new development) in view of the remarkable growth and development of the Middle West during the past 100 years. Neither would it be logical to assume a lower rate in view of the correlation in trends of growth, the similarity of fundamental conditions governing

[2] Not printed.
[23] Proceedings of American Academy of Science, Oct. 17, 1930. LXXII, pp. 399-401.

growth, and the fact that the rate of growth is now below the rate of berths over deaths.

305. The above estimate of population growth is based on the extension of the trend, and does not take into account the new lands that will be brought under irrigation as a result of irrigation development. If the Columbia Basin irrigation project, or an equal area elsewhere, is developed and settled during the next 30 years, the population increase due to this direct development should be added to the estimated increase based on the trend in population growth.

306. Assuming that 1,500,000 acres will represent the total area brought under irrigation and settled between 1930 and 1960, and assuming further that there will be 1 person to every 8 acres of irrigated land, the increase in population due to this development will be 187,500. The addition of 187,500 to the estimated increase in population based on the trend practically doubles the rate of increase for the three decades.

307. The assumed number of acres per individual is based on comparative figures. There are 8.75 acres per individual in Twin Falls County, Idaho; 8.6 acres per individual in Imperial Valley, Calif.; 3.3 acres per individual in Yakima County, and approximately 8.9 acres per individual in the State of Iowa. In each of these areas general farming predominates. If the development of the land to be brought under cultivation were to represent as intensive production as in the Yakima Valley, where apples form the main product, the increase in population would be based on the rate of 1 person to every 2.9 acres. It is assumed, however, that general agriculture will predominate on the Columbia Basin irrigation project or other areas which may be developed.

308. Adding the estimated population to the general increase, as indicated by the trend, to the estimated population increase due directly to possible irrigation development, a total population of 1,374,000 is secured as the forecast for the population of eastern Washington, eastern Oregon, and Idaho for 1960. Table no. 80 gives the estimated increase in population by decades to 1970.

309. This population for 1960, as estimated, represents an increase of 29.1 percent over the census figure for 1930 for eastern Washington, eastern Oregon, and Idaho. The development of 1,500,000 acres of irrigated land represents an increase of 41.7 percent in the area of irrigated land in 1930. The difference in these percentages is probably due to the fact that the figure for population growth compares an average density of population of 9 acres per person in the newly developed territory to a more than average density represented by intensive agricultural development in sections such as the Yakima Valley, which can be expected in a general agricultural community.

6. FORECAST OF POPULATION GROWTH FOR WESTERN WASHINGTON AND WESTERN OREGON

310. A forecast of population growth for western Washington and western Oregon is made by the use of the formula when the rate of increase for western Washington and western Oregon for 1930 (1.99 percent), and the assumed rate of 1.46 percent for 1960, is based on a comparison of the trend in rates of increase for New York and New England combined, with the trend in rates for western Washington and western Oregon combined. The physical conditions in these

two general areas are not dissimilar; both are affected by ocean commerce and by industrial development, and while New York and New England had Europe as a source of immigration, western Washington and western Oregon have the great Middle West to draw from. With the declining opportunities for expansion in the Middle West, as indicated by the fact that emigration is now more important than immigration in many areas, the undeveloped resources of the West will draw upon this surplus population. The result of this computation gives a figure of 3,021,000 as the probable population of western Washington and western Oregon for 1960.

311. In view of the remarkable growth of New York and New England during the past 100 years, it would appear unreasonable to assume a more rapid rate of growth for the area west of the Cascades than the historical rate of increase for New York and New England. It might be reasonable to assume a lower rate in view of the fact that New York and New England had the tremendous expansion in the Middle West and West as a foundation for commercial and industrial growth, while no similar expansion can possibly take place in the Northwest. Such argument would be valid from a long-time viewpoint, but for the next 30 years the expansion in the Northwest itself, as represented by developments such as the Columbia Basin irrigation project, should maintain the rate of growth assumed. Growth beyond that period depends in part, at least, upon the growth of foreign trade. The close correlation in rates of growth in these two general areas, as shown in plate no. 27 [2] and table no. 80, gives the estimated increase in population by decades to 1970.

312. No special gain in rate is given as a direct effect of the development of the Columbia Basin irrigation project, or other similar area, as it is assumed that the increase from this cause will be a part of the general increase as predicted by the trend in population growth. In other words, the development of the back country will be a part of the general forward movement. The results depend in part upon the activity of the people of the Northwest in pushing the general development of the resources available.

7. POSSIBLE INFLUENCE OF POWER DEVELOPMENT ON POPULATION GROWTH

313. The development of power on a large scale is a factor which will tend to support the trend in population growth. It is not unreasonable to assume that industrial development may create as dense a population in western Washington and Oregon as now exists in Rhode Island (560 per square mile), New York (217 per square mile), or Massachusetts (470 per square mile). The possibility of such an increase depends in part upon the demand for products of industry, because a highly industrialized section must depend on outside markets. The intrinsic possibilities of commerce in the counties west of the Cascades are enormous.

314. If the rate of increase of urban families in the Northwest is as great as the industrial possibilities might warrant, the agricultural land in the Northwest would be heavily taxed to feed the industrial population.

315. If the present rate of increase of urban over rural families in the Northwest continues, there will be a great increase in that portion

[2] Not printed.

of the population dependent upon industry and commerce other than agricultural production. This increase would be employed in part, at least, by the industries dependent upon power development.

316. The trend in rural and urban growth is indicated by the following figures, which give the proportion of rural population for each decade since 1900 for Washington, Oregon, and Idaho.

	1930	1910	1900
Washington	44.8	47	59.2
Oregon	50.1	54.4	67.8
Idaho	72.4	78.5	93.8

8. OTHER FACTORS INFLUENCING THE POSSIBLE INCREASE IN POPULATION

317. Other factors also tend to influence the possible increase in population. The climatic conditions of the sections west of the Cascades are particularly favorable for human health and efficiency. This fact has already proved to be an attraction which has increased the population in the past. The possible economics due to the greater efficiency of labor may be an increasing factor in attracting industries, to this favored section.

318. Absence of tornadoes, earthquakes, and severe floods also reacts favorably on population growth, since the danger of loss from these natural catastrophies necessarily forms a burden on industry in sections where damage may occur, and has a retarding influence on settlement and industrial development.

319. The large and valuable acreage of timber in the Northwest, estimated to equal one half of the supply of saw timber in the United States, is a natural resource which will have a direct influence on employment of labor in industry and commerce, which will in turn influence the increase in population. The influence of this factor on population is indicated by the fact that the slump in lumbering operations during the last half of the past decade was a factor in a decrease in the rate of growth for Washington, Oregon, and Idaho below that of the United States. With the present per capita consumption of lumber and paper, and with the population of the United States in 1960 estimated at 165,000,000, it will be necessary to greatly increase the area in forest if the present per capita rate of consumption is maintained.[24]

320. If the population forecast is correct, the development of the Columbia Basin irrigation project, or of any similar project, and the development of power, as outlined in the power study, will be required to meet needs of the increased population. The problem of developing markets for products of the Northwest and of creating opportunity for settlement and industrial development to support and employ the estimated increase in population is, therefore, as important as the problem of securing people to occupy the land to be developed or to work in industries dependent upon power development. Increase in population will follow the development of opportunity. In other words, irrigation and power development will be necessary to maintain the predicted rate of population growth between 1930 and 1960.

[24] W. Russell Taylor in National Increase in Contemporary Peoples, U.S.D.A. Year Book 1923, p. 451.

TABLE No. 80.—*Forecast of population growth for Washington, Oregon, Idaho, and California by decades to 1970*

Year	Western Washington and Oregon	Normal for eastern Washington and Oregon and Idaho	Increase due to Columbia Basin irrigation project	Total	California
1930	1,871,615	1,085,499		2,957,000	5,677,000
1940	2,232,900	1,137,100		3,370,000	6,842,000
1950	2,603,450	1,192,800	46,875	3,843,000	8,417,000
1960	3,021,000	1,233,200	140,625	4,395,000	10,237,000
1970	3,487,400	1,260,630	187,500	4,935,000	12,270,000

9. COMBINED POPULATION GROWTH FOR WASHINGTON, OREGON, AND IDAHO

321. Table no. 80 gives the present forecast of population growth for Washington, Oregon, and Idaho by decades from 1930 to 1970. Table no. 78 gives a comparison between the figures secured by the methods of forecast adopted in this report with the figures secured in other studies.

10. FORECAST OF POPULATION GROWTH FOR CALIFORNIA

322. The growth of population in California does not follow the trend of growth in any other section of the United States. The rate of growth in California during the past decade (65 percent) is greater than for any other time since 1860. It is not as great, however, as the rate of increase of Washington, Oregon, and Idaho during the boom of the Northwest in the decade from 1900 to 1910. Following the very rapid rate of increase in the decade from 1900 to 1910, the rate of increase for the Northwest dropped to 20 percent for the decade from 1910 to 1920, and to 15 percent for 1920 to 1930, which is approximately equal to the variation in the rates of increase for New York and New England over the past 100 years. Favorable climatic conditions, agricultural expansion, oil development, power development, the moving-picture industry, and the general industrial and commercial opportunities in a rapidly growing community, coupled with a prolonged period of general prosperity combined to give California a much greater increase in population than any other section of the United States. Fifty-six percent of the increase in population in California during the past decade was in Los Angeles County. It is not unreasonable to assume, therefore, that the very rapid rate of increase in California during the present decade will approach the rate of increase for the Northwest following the boom of 1900 to 1910 which is, as already stated, approximately equal to the historical trends of rates of growth in New York. If California continues to grow as predicted in this report, the increased population will offer an important market for agricultural products of the Northwest.

323. Table no. 79 shows the historical rate of growth in California compared to the rates of growth for the Northwest, New York, and New England, and for the United States. Table no. 80 gives the present forecast of population for California for each decade up to 1970 based on the trend of rates of growth for New York State from 1850 to 1880, which show the closest correlation with the trend in growth for California based on a comparison of trends plotted on

logarithmic paper. A comparison of this forecast for California with other forecasts is shown in table no. 78.

II. FORECAST OF POPULATION GROWTH FOR THE UNITED STATES

324. Using the same formula as used in determining the future population of California and the Northwest, and assuming the rate of increase for 1960 to be 0.68, the population of the United States will be as shown in table no. 78 for each decade between 1930 and 1970.

325. Table no. 78 gives a comparison between the figure secured in this study of population growth with other estimates.

(H) TRANSPORTATION ROUTES

1. WATERWAYS

326. The only navigable waterways usable in commerce are the river itself and the lakes on the tributaries. The river is navigable to Grand Rapids, and from Kettle Falls to Arrow Lakes, in Canada. Commercial navigation has been carried on in three stretches: From below the Snake to the foot of Priest Rapids, from Wenatchee to Bridgeport, and from Kettle Falls into Canada. Other stretches have been navigated to a very limited extent. Steamboats cannot compete with rail transportation, owing to the excessive cost of navigating upstream against the swift currents.

327. Flathead, Pend Oreille, Priest, and Coeur d'Alene Lakes are generally deep and well suited to navigation and are being used for commercial transportation.

328. Canalization would make navigation feasible, but during high water it would still be difficult to ascend the river against the strong currents. The steep grade in the river will make the cost of locks and dams high. The slope is about five times that of the Ohio river.

The following summary of conditions affecting the improvement of the upper Columbia, taken from report in Executive Document No. 39, Fifty-second Congress, second session, is believed to be thoroughly sound:

"A pretty thorough knowledge of the river, and a careful study of all transportation and economic questions connected with it, convince me that this river cannot, at least in the near future, become a through highway of commerce upon which will be transported the products from and supplies to the region drained by it. There are too many things against its ever occupying this high position in the world of commerce. These may be summarized as the obstructions, such as rapids and falls of greater or less magnitude, which can only be passed by expensive canals and locks, boat railways, or portage roads; the many lesser rapids, where auxiliary power or lining would be necessary; the generally swift currents, requiring a large amount of fuel to surmount combined with a lack of fuel and high cost of the same; the economic character of the country in the immediate vicinity of the river, which is of such a nature as to furnish or promise but little local business; the topographical character of the river and its immediate vicinity, which render it difficult to get to and from the fertile regions above it, for it must be remembered that the Columbia flows through a great canyon or depression from 2,000 to 3,000 feet and more below the general level of the country drained by it, and the dangers which boats must ever take in navigating many portions of its course. The function of the Columbia in this upper portion of its course in the commercial world is and will be, at any rate for many years, that certain portions of it will be navigated as feeders to railroads. As such, certain portions will be of great value, and can well receive the attention of the general government." (H.D. 1112/63/2, p. 6.)

329. Present conditions are described and possible improvements discussed in the section of this report devoted to navigation.

2. RAILROADS

330. The open country lying between the Columbia and Snake Rivers and the Bitterroot Mountains is well served by rail facilities, with Spokane the main junction point. North and west of the Columbia and east of the Bitterroots, however, the rugged topography restricts railroads and towns to the stream valleys. (See plate no. 28.[2])

331. Three transcontinental lines traverse this area: The Great Northern; the Northern Pacific; and the Chicago, Milwaukee, St. Paul & Pacific, with a branch of a fourth, the Union Pacific, along the southern edge.

332. The Great Northern crosses the Rockies near Glacier National Park, Mont., and follows a northerly route, utilizing valleys and tributaries of the Flathead, Kootenai, and Clark Fork Rivers to cross the intervening mountain ranges, and enters Spokane from the north. Going west out of Spokane, it crosses Columbia River in the vicinity of Wenatchee, and by following up Wenatchee Valley and tunneling the Cascades near Bern, effects entrance into the drainage basins of Puget Sound.

333. The Northern Pacific Railway passes the Continental Divide near Butte, Mont., and follows the Clark Fork down to Pend Oreille Lake, crossing that lake at Sandpoint, Idaho, to enter Spokane from the north. From Spokane this line swings southwest across the plains bridging the Columbia at Pasco; thence, after following the Yakima to Stampede Tunnel, it passes through the Cascade Range.

334. The Chicago, Milwaukee, St. Paul & Pacific Railroad, entering the basin of the Columbia near Butte, follows the valley of the Clark Fork and the tributary St. Regis River to cross the Bitterroot Mountains, swinging around the south end of Coeur d'Alene Lake and into Spokane from the south. Leaving Spokane, this road, after traversing the Big Bend country, crosses Columbia River at Beverly, enters the Yakima Valley near Ellensburg, and follows up that valley and crosses the Cascades through Snoqualmie Tunnel.

335. The Spokane, Portland & Seattle Railway connects Spokane with Portland, as does the Oregon-Washington Railway & Navigation Co., which enters Spokane over the Chicago, Milwaukee, St. Paul & Pacific tracks.

336. A branch of the Great Northern leaves the main line at Wenatchee, ascends the Columbia to Brewster, and follows the Okanogan and Similkameen into Canada. Another branch connects with this line at Oroville, crosses over into the valley of Kettle River and, crossing the Columbia at Marcus, passes through Colville Valley to enter Spokane from the northwest.

337. Various branches of the Northern Pacific traverse the open prairie lands in the central portion of this basin, and one follows the Snake up to Lewiston, Idaho. A branch of the Chicago, Milwaukee, St. Paul & Pacific leaves Spokane for the north, following down the Clark Fork from Newport to Metaline Falls.

338. Several important local roads augment the rail facilities of the area lying along the Columbia River between Pasco and Portland, Oreg., and the open country between Pasco and Spokane. Most of these lines connect with the three transcontinental railways in the vicinity of Spokane.

[2] Not printed.

3. HIGHWAYS

339. The history of this region shows that after the first settlers and the Army had blazed wagon trails across the country, the railroads followed. Settlements arose along the railroads, and gradually a highway system developed, more or less parallel to the rail system. (See plate no. 29).[2] The railroads utilized the easiest grades in crossing the successive barrier ranges and river gorges; so it is but natural that the highway engineers followed the lines of railway steel as nearly as possible. It is characteristic, therefore, of this region to find railroads and highways together.

340. The Cascade Mountains in Washington are traversed at present by practicable highways in but four places: Stevens Pass, Snoqualmie Pass, Chinook Pass (designated Naches Pass Highway), and the water gap of the Columbia itself. Bridges across the Columbia at Wenatchee, Vantage, and Pasco permit these highways to cross the river and ascend to the level of the Columbia Plateau, which they traverse to Spokane. From Spokane, main roads cross the States of Idaho and Montana, utilizing the valleys of the Kootenai, the Clark Fork, the Flathead, the Bitterroot, and the Coeur d'Alene Rivers. State highways also parallel the Columbia above Wenatchee and below Beverly, with occasional ferries across the river. Roads follow up the Okanogan, San Poil, and Colville Rivers, and down Clark Fork below Newport. In addition to these, wherever topography and local finances permit, county roads follow along the township lines, thus affording a net of intersecting roads in the prairie country. In general, the valley of the Columbia is well served by highways.

4. AIRWAYS

341. East of the Cascades, Pasco is the most important junction point on the airways lying within the drainage basin of the Columbia River. One of the three airways radiating from this town at the mouth of the Snake extends down the water gap of the Columbia to Portland, Oreg., where it joins the main north and south coastal route of aerial travel. A second airway connects Pasco and Spokane, terminating at the latter city, while a third leads in a southeasterly direction through Boise, Idaho, to Salt Lake City, where juncture is effected with the principal transcontinental airway. The easternmost portion of the catchment basin of Columbia River is traversed in part by another airway which extends from Salt Lake City to Great Falls, Mont., by way of Ogden, Pocatello, Butte, and Helena. All of these airways are lighted and partially provided with emergency landing fields. Radio beacons and teletype station connections are likewise partially completed or in process of installation.

342. Traffic over these airways consists of scheduled planes carrying express, mails, and passengers. In general, one plane a day in each direction is scheduled by the operating companies. The Varney Air Line, Inc., operates two 4-passenger planes between Seattle and Salt Lake City, by way of Portland and Pasco, with a short feeder line over the airway from Pasco to Spokane. The National Parks Airways, Inc., operates planes on the Great Falls-Salt Lake City route. The Mamer Air Transport Co., operates a trimotored Ford plane over an unlighted route from Seattle to Spokane, by way of Wenatchee.

[2] Not printed.

(J) INDUSTRIES

1. AGRICULTURE

343. *Historical.*—Agriculture is fundamental to all other industries. The permanent colonization of any region must be accompanied by agriculture or must have this industry near enough to furnish the basic necessities. The first settlers in the upper Columbia Basin came, not for agriculture, but rather for gold; however, these settlers soon discovered that agriculture was necessary in the vicinity in order to promote their mining industry.

344. The first attempt at agriculture in the area lying west of the Rocky Mountains and north of San Francisco Bay was at Colville, Wash., in 1826.[25] It was at Colville some years later that gold was discovered; this caused the first extensive immigration into the upper Columbia Basin.[26] Men with pack trains came into the region from Canada, from California, and from east of the Rocky Mountains just as they had gone to the Fraser River and to California a few years before. Many of these mining camps developed rapidly into towns; oftentimes their disappearance was just as rapid.

345. Paralleling the development of the mining towns, there grew the outfitting and distributing centers. Trails radiating in all directions from these outfitting towns were traversed by long lines of horses and mules carrying supplies and equipment into the interior. In the winter these towns became headquarters for the miners. Most of the supplies and feed demanded in these outfitting and distributing centers was necessarily shipped in from other regions. The resulting high prices were sufficient incentive to inaugurate the home production of many commodities. The high prices, furthermore, stimulated the migration of many people who came to engage in agriculture and stock raising. Soon the mining population diminished, while the herder and the farmer continued their migration into the territory. Cheap lands, rich soil, and the gratifying results secured from the first attempts at irrigation offered an attraction, which, when made easily available through the construction of the transcontinental railways, greatly stimulated settlement of the Northwest.

346. The settlers found congenial conditions in the highlands of eastern Washington, Oregon, and northern Idaho where the rainfall was sufficient to mature wheat satisfactorily and where the soil possessed virgin fertility which resulted in high yields per acre. As a result, Walla Walla became the metropolis of the Northwest during the early days and was not surpassed in population by any of the coast cities until 1883, about the time that the railroads had penetrated to the coast.

347. The area in wheat rapidly expanded onto marginal areas where the rainfall was not sufficiently dependable to justify dry farming. The recent cycle of dry years has resulted in the abandonment of these marginal areas, which have since been taken by Russian thistle, as the clearing and plowing left a fertile field for such infestation. The yields, prices, and returns secured in eastern Washington are compared in table no. 81 to the yields, prices, and returns secured in other wheat-growing sections of the United States.

[25] W. S. Lewis and P. C. Phillips, "The Journal of John Work", 1923.

[26] The term "upper Columbia Basin" as referred to here and in succeeding paragraphs refers to the following 19 counties in the States of Washington and Idaho: Washington: Adams, Ferry, Lincoln, Yakima, Grant, Douglas, Spokane, Benton, Franklin, Okanogan, Chelan, Pend Oreille, Kittitas, Stevens; Idaho: Benewah, Bonner, Boundary, Shoshone, Kootenai.

TABLE NO. 81.—*Wheat yields, prices, and returns in various States, 1918–29*

[Source: U.S. Dept. of Agriculture Yearbook, 1930, p. 600]

State	Yields, bushels per acre	Price per bushel received by producer	Gross returns per acre
		Cents	
North Dakota	10.9	106	$11.55
South Dakota	11.3	105	11.86
Iowa	18.8	114	13.45
Kansas	13.2	114	15.04
Nebraska	15.0	109	16.35
Upper Columbia Basin	15.3	111	16.99
Washington	18.8	111	20.86
Oregon	20.3	114	23.14
United States	14.1	114	16.07

348. Plate no. 30 [2] shows the distribution of the wheat-growing area in Washington at the present time. The wheat shipped from eastern Washington moves to Tacoma, Seattle, and Portland; the larger percentage going to Portland. Much of the wheat is exported to Japan, China, the Philippine Islands, England, the Netherlands, and Italy. Table no. 82 shows the foreign distribution of wheat shipped from the upper Columbia Basin.

TABLE NO. 82.—*Foreign distribution of grain and grain products shipped from selected counties, 1924–29 average*

[Data from U.S. Department of Commerce]

Countries	Percent of total to each country	Countries	Percent of total to each country
Japan	15.5	Italy	5.0
Ireland	14.8	China	3.7
England	14.7	Belgium	2.5
Philippines	6.2	France	2.1
Netherlands	5.3	Peru	2.0

349. The bunch grass in the higher elevations in eastern Washington formed the foundation for a profitable cattle industry. At first the cattle were raised for eastern consumption and were shipped as feeders to the Middle West where they were fattened on corn. During recent years the population of the coast has increased to a point where the flow of cattle has been west rather than east. The demand in western Washington, Oregon, and California has taken all of the local supply together with some importations from Montana and other intermountain points.

350. The development of the cattle industry soon led to the diversion of water from streams for the irrigation of bottom lands for the production of grass and hay which could be used to feed cattle coming in from the open range during the winter. The necessity for producing a wider range of crops than was permitted by the scanty rainfall of eastern Washington, even including the wheat belt, also stimulated interest in the irrigation of easily available bottom lands. These early projects were developed by individuals or by small groups of

[2] Not printed.

individuals and involved the expenditure of comparatively small sums of money, as the work of digging ditches was usually done by the farmers themselves. This activity formed the first stage in the irrigation development in the Columbia Basin.

351. The satisfactory results secured from these early efforts led to the development of larger projects. These later developments required high line canals carrying water to bench lands. Expensive diversion works and storage reservoirs were necessary, all of which involved the expenditure of large sums of money and necessitated financing the projects on a scale hitherto unnecessary. The difficulties involved in the financing of these and other irrigation enterprises, on a basis which was satisfactory to investors in irrigation bonds, resulted in the adoption of a reclamation policy by the Federal Government and the organization of the Reclamation Service, which since 1903 has been an active force in the development of irrigation projects in the West. This activity formed the second stage in the irrigation history of eastern Washington.

352. The discovery of the adaptability of the soil and climate of eastern Washington to the production of fruit permitted the expenditure of considerable sums of money per acre for the development of water supply, as the high per-acre returns justified a charge for water which would repay construction costs not permitted by the returns from general profits. The first orchards to be planted in the upper Columbia basin came as a result of apple seeds planted by the Jesuit missionaries. These early orchards were planted in the Okanogan Valley and Kettle Falls in Stevens County. The seed had been brought from eastern United States, and in some cases directly from Europe.[27] Plate no. 31 [2] shows the distribution of the fruit-growing areas of the upper Columbia Basin.

353. A third stage of the development of irrigation in the upper Columbia Basin has been reached with the more or less complete development of the areas which can be developed at a cost which is justified by the returns which the farmer secures from the sale of crops. There remain large areas of undeveloped land lying at elevations from 300 to 500 feet above the level of the river, which may be irrigated economically by the combined development of irrigation and power, where returns from the sale of water and power are sufficient to repay construction costs with interest.

354. The feasibility of agricultural development on these higher plateaus depends not only upon the yields which can be secured, but upon the markets for the produce which would be raised. It is necessary, therefore, to consider the adaptability of the area for crops and the probable demand which will develop for these crops within the period covered by the possible development of dams and canals necessary to deliver water to these higher areas.

355. Small grains and corn form, by far, the most important agricultural crop of the Northwest. Wheat alone has a value of almost twice that of apples and is approximately equal to the value of hay, which occupies the second place among the agricultural crops in the Northwest. The value of hay is, of course, reflected in the value of

[2] Not printed.

[27] The first fruit trees grown on the banks of the Columbia River sprang from the seed of an apple eaten at a dinner in London, England. The dinner had been given to Captain Simpson. Apples were served for dessert and the seeds placed in Captain Simpson's pocket. Upon his arrival at Fort Vancouver in 1827 he discovered the forgotten seeds and gave them to the gardener to plant.

livestock products, which, when totaled, have a value considerably in excess of both hay and grain. Fruit products are next to hay in value and occupy a peculiar place in the agricultural field, since a large portion of fruit produced is exported and is, therefore, a source of outside revenue. Other crops including potatoes, sugar beets, beans, hops, various seed crops and vegetables have a total value of about two thirds that of fruit. A considerable portion of these general crops are also shipped to points outside of the Northwest and form a portion of the credit items in the balance of trade. Tables nos. 83 to 86 give a record of the acreages, production, and value of the various crops raised in Washington, Oregon, and Idaho for the years 1914, 1919, 1924, and 1929.

TABLE No. 83.—*Field crops—acreage, production, and value, Washington, Oregon, and Idaho, 1914, 1919, 1924, and 1929*

[Compiled from statistics reported by U.S. Department of Agriculture]

Product	Year	Acreage	Production	Value
			Tons	
Hay, all kinds	1914	2,359,000	5,335,000	$48,684,000
	1919	2,765,000	5,766,000	122,689,000
	1924	3,243,000	5,715,000	76,993,000
	1929	3,335,000	7,003,000	94,163,000
			Bushels	
Wheat	1914	3,128,000	72,806,000	71,271,000
	1919	4,606,000	79,188,000	167,330,000
	1924	3,567,000	57,132,000	74,285,000
	1929	4,571,000	93,539,000	97,809,000
Oats	1914	993,000	41,307,000	17,147,000
	1919	852,000	30,263,000	28,413,000
	1924	610,000	20,158,000	11,993,000
	1929	646,000	27,481,000	15,175,000
Barley	1914	489,000	17,788,000	9,439,000
	1919	242,000	6,438,000	9,040,000
	1924	253,000	6,670,000	5,775,000
	1929	326,000	12,167,000	8,760,000
Rye	1914	32,000	554,000	510,000
	1919	94,000	1,050,000	1,975,000
	1924	28,000	259,000	346,000
	1929	23,000	298,000	302,000
Corn	1914	77,000	2,221,000	1,675,000
	1919	158,000	5,203,000	9,030,000
	1924	168,000	5,116,000	5,912,000
	1929	188,000	6,778,000	6,656,000
Potatoes, white	1914	142,000	17,575,000	9,536,000
	1919	142,000	17,525,000	25,985,000
	1924	156,000	22,540,000	16,117,000
	1929	200,000	29,596,000	38,441,000
			Tons	
Sugar beets [1]	1914			
	1919	30,331	203,168	2,235,000
	1924	39,000	267,000	1,920,000
	1929	48,000	492,000	3,530,000
			Bushels	
Beans, dry edible	1914			
	1919	36,000	396,000	1,663,000
	1924	65,000	1,268,000	5,199,000
	1929	99,000	2,151,000	5,994,000
			Pounds	
Hops	1914			
	1919	12,600	9,884,000	7,733,000
	1924	14,350	18,070,000	1,807,000
	1929	19,900	23,520,000	2,721,000
			Bushels	
Clover seed (red and alsike)	1914			
	1919	19,000	96,000	2,517,000
	1924	18,000	48,000	576,000
	1929	37,000	142,800	1,363,000
Alfalfa seed	1914			
	1919			
	1924		90,000	1,089,000
	1929	26,000	103,400	983,000

[1] Idaho data only. No data separately reported for Oregon or Washington, as would disclose individual factory operations.

TABLE NO. 84.—*Tree fruits and nuts, number of trees, production, and value, Washington, Oregon, and Idaho, 1914, 1919, 1924, and 1929*

[Compiled from statistics reported by U.S. Department of Agriculture and U.S. Bureau of the Census]

Product	Year	Number of trees	Production	Value
			Bushels	
Apples	1914		[1] 13,602,000	[2] $9,494,000
	1919	15,060,091	35,227,000	[3] 54,840,000
	1924	12,735,955	30,678,000	[3] 40,694,000
	1929		39,000,000	[3] 48,800,000
Pears	1914		1,142,000	977,500
	1919	2,087,938	3,949,000	6,606,200
	1924	2,861,401	3,035,000	5,069,000
	1929		6,203,000	8,530,000
			Tons	
Prunes	1914			
	1919	6,148,759	[4] 102,693	
	1924	7,887,925	[5] 101,900	3,876,000
	1929		[5] 248,440	9,785,000
			Bushels	
Peaches	1914		993,000	1,013,000
	1919	1,347,268	3,173,000	5,275,000
	1924	1,162,106	711,000	1,496,000
	1929		1,770,000	2,471,000
			Tons	
Cherries	1914			
	1919	1,030,181	[4] 18,009	
	1924		15,900	2,544,000
	1929		24,800	4,628,000
Walnuts [6]	1914			
	1919	181,909	231	
	1924		400	192,000
	1929		1,050	315,000
Filberts [6]	1914			
	1919			
	1924			
	1929		200	56,000

[1] Converted to bushels from barrels, basis 3 bushels per barrel. See Year Book of Agriculture, 1930, p. 723, note 1.
[2] Basis, average between price Nov. 15, and Dec. 15.
[3] Basis, price Dec. 1.
[4] Converted to tons from bushels, basis 60 pounds per bushel for prunes and 56 pounds per bushel for cherries, as recommended by Mr. Kent, Assistant Statistician, Bureau of Agricultural Economics, Portland, Oreg.
[5] Dried prunes converted to fresh weight on basis of 3 pounds fresh to 1 pound dried, as recommended by Mr. Kent, Bureau of Agricultural Economics.
[6] Oregon data only. Data for Washington and Idaho not reported separately.

TABLE NO. 85.—*Small fruits and vegetables, acreage, production, and value, Washington, Oregon, and Idaho, 1919, 1924, and 1929*

[Compiled from statistics reported by U.S. Department of Agriculture, U.S. Bureau of the Census, and by Oregon State College Agricultural Experiment Station]

Product	Year	Acreage	Production	Value
			Quarts	
Strawberries	1919	6,368	11,031,386	[1] $2,909,000
	1924	7,580	12,916,000	[2] 1,595,000
	1929	18,400	27,983,000	[2] 3,206,000
Other berries [3]	1919	10,769	25,937,389	
	1924	[2] 21,272		
	1929	[2] 18,537		
Truck crops [4]	1919	6,871		2,170,000
	1924	23,650		5,011,000
	1929	34,180		5,492,000

[1] Computed by multiplying production by unit price as shown in Year Book of Agriculture, 1925, p. 887.
[2] Data for Oregon and Washington only. Idaho data not separately reported.
[3] Includes raspberries, blackberries, loganberries, gooseberries, currents, cranberries, and huckleberries.
[4] Not including strawberries, potatoes, or dried beans.

TABLE NO. 86.—*Livestock and livestock products, quantity and value, Washington, Oregon, and Idaho, 1914, 1919, 1924, and 1929*

[Compiled from statistics reported by U.S. Department of Agriculture and U.S. Bureau of the Census]

Livestock	Year	Quantity			Value		
		On farms at end of year indicated	For slaughter (live weight)	Other products	On farms at end of year indicated	For slaughter	Other products
		Number	*Pounds*	*Pounds*			
Milk cows	1914	[1] 583,000			$40,697,000		
	1919	563,000		[2] 2,144,924,547	48,190,000		$53,337,286
	1924	669,000		[2] 3,211,000,000	39,960,000		60,622,000
	1929	708,000		[2 3] 3,768,000,000	60,252,000		77,431,000
Beef cattle	1914	[1] 1,097,000			[1] 41,605,000		
	1919	1,656,000			71,962,000		
	1924	1,363,000	427,635,000		33,296,000	$24,848,000	
	1929	1,198,000	403,245,000		50,462,000	36,627,000	
Sheep	1914	6,150,000			28,448,000		
	1919	6,161,000		[4] 32,620,912	66,023,000		[4] 16,092,087
	1924	4,852,000	222,652,000	[4] 34,655,000	51,269,000	20,030,000	[4] 12,532,000
	1929	5,493,000	237,600,000	[4] 41,232,000	51,670,000	23,859,000	[5] 12,370,000
Goats	1914						
	1919	142,030		[6] 380,675	678,567		[6] 211,378
	1924	[7] 101,000		[6] 414,000			[6] 265,000
	1929	[7] 120,000		[6] 468,000			[6] 220,000
Hogs	1914	1,015,000			10,330,000		
	1919	792,000			16,261,000		
	1924	746,000	211,705,000		8,439,000	16,279,000	
	1929	632,000	173,540,000		7,572,000	17,325,000	
Horses and mules	1914	887,000			82,432,000		
	1919	875,000			74,776,000		
	1924	756,000			44,336,000		
	1929	598,000			35,329,000		
			Number	*Number*			
Chickens	1914						
	1919	7,702,498	8,053,903	[8] 496,844,400		([9])	[8 10] 24,862,304
	1924	10,993,000	14,281,000	[8] 970,000,000	8,498,000	8,122,000	[8] 21,198,000
	1929	14,480,000	18,527,000	[8] 1,439,000,000	13,936,000	12,683,000	[8] 36,366,000
				Pounds			
Bees	1914						
	1919	[11] 137,970		[12] 3,778,510	898,083		[12] 997,592
	1924			[12] 5,230,000			[12] 781,000
	1929						

[1] Not comparable with later figures.
[2] Milk.
[3] Idaho data estimated on basis of 1928 production per cow.
[4] Wool.
[5] Estimated, using farm value, Oregon as basis.
[6] Mohair.
[7] Goats clipped only, Oregon data only.
[8] Eggs.
[9] Included with eggs, value.
[10] Includes both chickens for slaughter and eggs.
[11] Hives.
[12] Honey and wax.

356. The live-stock industry centers about the irrigated sections of eastern Washington, Oregon, and Idaho, and the grass sections of western Washington and Oregon. Cattle and sheep are ranged over the drier lands but are fed hay raised on irrigated land during the winter time. The dairy industry is divided on the basis of the demand for dairy products. The whole-milk producers are concentrated around the large consuming centers on the coast. The areas producing butter and cheese are more largely located in the irrigated areas, because whole milk cannot be shipped from the irrigated sections to large consuming centers conveniently.

357. Production of dairy products is somewhat in excess of the local demand although the net amount shipped out is comparatively

small. California forms the best market for the surplus dairy products in the Northwest at present.

358. The supply of meat products in the three States of Washington, Oregon, and Idaho is not sufficient to meet the local demand and as a result, hogs are shipped in from Rocky Mountain and Middle Western points and cattle are also imported from outside the area. Sheep are raised in excess of the demand of the Northwest and lambs are therefore shipped east, where the per-capita consumption of both mutton and lamb is greater than it is in the Northwest. The wool is shipped to coast centers where the textile industry is developing.

359. At the present time a considerable portion of the wheat produced in the Northwest is shipped out. As the population increases, the demand for livestock products becomes greater and more of the grain will be used in feeding hogs, cattle, sheep, dairy stock, and chickens, and the export of grain will be gradually reduced. In other words, the development of irrigated land will increase the production of grain, but in all probability most of this grain will be fed to livestock on the irrigated farms so that the production of grain will not add to the exportable surplus. Corn will probably increase in greater proportion than other grains as it offers better opportunity for profit when fed to livestock than do other grains.

360. Washington, at the present time, produces 25 percent of the apples consumed in the United States. Any great increase in production of apples would, therefore, flood the market. A normal increase in acreage is justified on the basis of the probable increase in population in those areas which are supplied at the present time with apples from the Northwest. The production of other fruits in the Northwest is also limited by the demand. This demand will increase with the increase in population, and the production of fruit and apples should, therefore, increase gradually. The high yields per acre secured from fruit products permit a comparatively few acres to supply a large increase in demand. The economic feasibility of irrigation projects cannot be based on an expectation of the high returns which can be secured where a considerable portion of the land may be devoted to the production of fruit. Small fruits are somewhat better adapted to the humid sections of the coast regions, although blackberries and strawberries can be produced very satisfactorily in the Columbia Basin area.

361. The production of general crops, including potatoes, beans, and various vegetables, will be limited by the market conditions in much the same way as the production of fruit is limited, although not to the same degree as the increased population in the Northwest itself will serve to consume a larger proportion of vegetables produced than will be the case with fruit.

362. Table no. 87 shows the distribution of the 1930 truck crops produced in the Yakima Valley [28] which gives some idea of the importance of the coast markets as compared to the markets in the East.

[28] Data furnished by the Northern Pacific Ry.

TABLE NO. 87.—*Distribution of truck crops, Pasco, Wash., area for 1930 (tons)*

[Statement does not include local traffic between Kennewick and Cle Elum]

Commodity	Eastbound	Westbound	Total
Wheat	37	34,045	34,082
Other grain	25	2,281	2,306
Grain products	218	8,223	8,441
Alfalfa meal	454	5,731	6,185
Hay, straw, and alfalfa	4,987	106,234	111,221
Apples	104,017	74,180	178,197
Other fresh fruits	35,646	44,722	80,368
Dried fruits	2,782	47	2,829
Potatoes	8,845	97,398	106,243
Other vegetables	6,313	13,348	19,661
Hops	1,619	17	1,636
Livestock	6,178	5,691	11,869
Dairy products	453	122	575
Wool		137	137
Canned fruits and vegetables	1,687	12,950	14,637
Vinegar	5,769	20	5,789
Total	179,030	405,146	584,176

363. Production of all crops on irrigated land has been satisfactory where soil and water conditions are favorable. Fruit yields from 5 to 15 tons per acre; alfalfa will yield from 3 to 6 or 7 tons to the acre; grain will yield from 25 to 50 or 60 bushels under varying conditions. The production of crops in the upper Columbia Basin is discussed more in detail in the section on "Irrigation" in chapter III.

2. MINING

364. The metal production of Washington has been derived in a very large measure from the counties of the northeastern part of the State. All of these counties, except Pend Oreille, lie adjacent to the Columbia River. In all the mining districts extensive prospecting is carried on continuously, and large reserves of ore have been found. The annual yield of the mines shows a considerable range in value, and it will always vary with the changes in the selling prices of the metals.

365. From 1860 to 1928, inclusive, the output of metals from Washington amounted to $46,563,027. This production was distributed as follows:

Gold		$30,258,099
Silver	fine ounces	9,204,682
Copper	pounds	24,248,161
Lead	do	61,042,141
Zinc	do	12,860,408

366. There are listed below, in table no. 88, the principal mining districts of the several counties along the Columbia River, the chief metals produced, and a statement of the output wherever reliable statistics are available.

TABLE No. 88.—*Mining districts of counties along the Columbia River*

County	Active mining districts	Minerals mined	Output per annum
Chelan	Red Mountain	Copper	
Ferry	Republic	Gold, silver	$376,932 (1927).
	Keller	Gold, silver, copper, lead	
Kittitas	Swauk	Gold	$27,762 (1926).
Okanogan	Meyers Creek	Gold	
	Nespelem	Silver, lead	
	Twisp	Gold	
	Palmer Mountain	Silver, lead	
	Methow	Copper	
Pend Oreille	Metaline	Gold, silver, copper, lead, zinc	$80,285 (1927).
	Newport	Copper, lead	
Stevens	Bossburg	Silver, lead	
	Chewelah	Silver, copper, lead	
	Colville	Gold, silver, copper, lead, zinc	
	Loon Lake	Copper	
	Northport	Gold, silver, copper, lead, zinc	$468,646 (1926).
	Orient	Gold, iron	
	Springdale	Gold, silver, copper, lead	
	Summit	Silver, lead, zinc, arsenic	
	Valley	Copper	

3. MANUFACTURES

367. (*a*) *Wood products*—(*a'*) *Lumber—Historical.*—The Western States and the upper Columbia Basin are still in the infancy of development in manufacturing. The only manufacturing industries to be developed are the extractive industries, and these have developed because of the vastness of the natural resources. Of all of these natural resources, timber holds first place, and as a result lumbering has become an industry of very large proportions.

368. The lumbering industry did not develop in the upper Columbia Basin until after 1880, when the forests of the States of Michigan and Wisconsin began to be depleted; prior to that time the forests of those Eastern States were thought to be inexhaustible. The lumber industry in the Western States has developed because of, and with, the decreased production in the Lake States.

369. For over a century the lumber industry has been in the process of migration from one forested region to the next. The first lumbering in the United States took place along the Atlantic coast from Maine southward to the Royal Colonies in Virginia and the Carolinas. But lumbering as we know it today did not begin until about 1850; this came with the introduction of improved machinery and large merchant mills. As the first cut of pine in the more thickly settled coast regions drew near its end, the exploitation of the white-pine forests of the Lake States began, and the hardwood regions of Central Appalachia were opened to the market. As the cut of the Lake States drew to its close many lumber producers of that region removed their operations to the south and began the attack upon the great belt of long-leaf pine which stretched from Virginia to Texas. Each of these moves increased the distance between the centers of production and the centers of consumption. Then came the migration from the Southern States to the Pacific Coast States, the last forested region in the United States.

370. In other parts of the United States the forests were cut in order to provide room for agriculture; but agriculture could not replace the lumbering industry in the upper Columbia Basin since the forests

were located on the steep and rough lands. Since there was no competition for the same land, agriculture and lumbering developed simultaneously; agriculture developed on the more level land, and lumbering developed on the steeper, rougher land located along the rim of the upper Columbia Basin. Thus the three great primary sources of wealth (agricultural, forest, and mineral) have developed nonconflictingly and simultaneously in the upper Columbia Basin.

371. *Areal location of forest.*—The location of the timber areas in the upper Columbia Basin are shown on plate no. 32.[2]

372. *Lumber production.*—The relationship which exists in lumber production between the Western States, the upper Columbia Basin and particular States, is shown in tables nos. 89 and 90. The first table, no. 89, shows the production in the 10 leading States in the United States from 1926 to 1929; the second table, no. 90, gives a comparison between lumber production in the upper Columbia Basin, the Western States, and the United States.

TABLE No. 89.—*Lumber production in the 10 leading States, 1929–26*

[Source: U.S. Department of Agriculture Year Book, 1930, p. 1048]

State	Lumber cut (M ft. b.m.)			
	1929	1928	1927	1926
Washington	7,302,063	7,305,277	7,325,862	7,546,239
Oregon	4,784,009	4,371,924	3,992,852	4,456,735
Mississippi	2,669,496	2,524,319	2,556,612	2,894,994
Louisiana	2,232,360	2,278,422	2,385,724	2,889,530
California	2,060,000	1,952,659	2,070,811	2,189,959
Alabama	2,058,964	1,980,082	2,171,687	2,105,122
Texas	1,451,640	1,446,686	1,446,460	1,456,121
Arkansas	1,348,318	1,129,731	1,229,481	1,441,018
Georgia	1,386,250	1,039,475	1,201,008	1,145,489
North Carolina	1,202,377	1,020,893	1,055,222	970,965

TABLE No. 90.—*Lumber production in upper Columbia Basin, Western States, and United States, 1929–26*

[Source: U.S. Department of Agriculture Year Book, 1930, p. 1048]

Geographic division	Lumber cut (M ft. b.m.)			
	1929	1928	1927	1926
Upper Columbia Basin [1]	1,027,000	833,263	1,025,000	1,020,980
Western States	15,563,574	14,994,000	14,710,000	15,514,000
United States	36,872,132	34,142,000	34,532,000	36,936,000

[1] Data from West Coast Lumberman.

373. The source of this lumber produced in the upper Columbia Basin is shown in table no. 91, which gives the acreage for each county which has timber, according to ownership.

[2] Not printed.

TABLE NO. 91.—*Standing timber according to ownership in each county*

County	Acres	Ownership	Source of data	Estimated standing timber
				(*M ft. b.m.*)
Yakima	75,000	Private	County auditor	
	519,430	National forest	Forest Service	
	768,000	Indian	Indian Service	
	98,000	State	State forester	
Total	1,460,430			14,600
Kittitas	234,000	Private	County auditor	
	534,000	National forest	Forest Service	
	96,000	State	State forester	
Total	864,000			8,645
Chelan	50,000	Private	County auditor	
	1,427,000	National forest	Forest Service	
	26,000	State	State forester	
Total	1,503,000			15,000
Okanogan	128,000	Private	County auditor	
	1,500,000	National forest	Forest Service	
	700,000	Indian	Indian Service	
	160,000	State	State forester	
Total	2,488,000			20,000
Ferry	54,000	Private	County auditor	
	510,000	National forest	Forest Service	
	300,000	Indian	Indian Service	
	16,000	State	State forester	
Total	880,000			8,800
Stevens	56,170	Private	County auditor	
	64,700	National forest	Forest Service	
	115,000	Indian	Indian Service	
	31,000	State	State forester	
Total	266,970			1,335
Pend Oreille	70,930	Private	County auditor	
	376,000	National forest	Forest Service	
	4,000	Indian	Indian Service	
	18,000	State	State forester	
Total	468,930			2,345
Spokane	34,450	Private	County auditor	
	13,000	State	State forester	
Total	47,450			240
Boundary	66,500	Private	County auditor	
	550,000	National forest	Forest Service	
	114,900	State	State forester	
Total	731,400			2,952
Bonner	87,600	Private	County auditor	
	504,000	National forest	Forest Service	
	126,100	State	State forester	
Total	717,700			3,992
Kootenai	48,300	Private	County auditor	
	252,000	National forest	Forest Service	
	8,000	Indian	Indian Service	
	30,300	State	State forester	
Total	339,600			2,464
Benewah	88,340	Private	County auditor	
	80,000	National forest	Forest Service	
	28,160	State	State forester	
Total	196,500			3,068
Shoshone	131,250	Private	County auditor	
	1,208,000	National forest	Forest Service	
	55,730	State	State forester	
Total	1,394,980			7,330

374. *Kinds of timber.*—As is shown in table no. 92, yellow pine, red fir, and white fir are the leading varieties of timber in the upper Columbia Basin.

TABLE No. 92.—*Varieties of timber in the upper Columbia Basin (percent)*

[Data from Idaho Timber Handbook and conference with George C. Joy, Washington State Forester]

Geographic division	Varieties								
	Spruce	Cedar	Hemlock	White pine	Yellow pine	Tamarack	Red fir	White fir	Miscellaneous
Eastern Washington	1	3	8	7	35	8	28	9	1
Northern Idaho	14	10	6	18	11	8	16	17	
Upper Columbia Basin	7	7	7	13	23	8	22	13	

375. *Disposition.*—The Nation-wide distribution of lumber produced in the upper Columbia Basin is shown in table no. 93.

TABLE No. 93.—*Distribution of lumber by States from upper Columbia Basin*

[1. The data were secured in conference from each of the mills in the upper Columbia Basin. While the data apply directly to 1929 shipments, yet according to the mills, the 1924–29 average is approximately the same as for 1929]

State	Percentage of total to that State	State	Percentage of total to that State
California	0.41	New Hampshire	0.15
Colorado	1.24	New Jersey	2.58
Connecticut	1.16	New York	6.23
Delaware	.15	North Dakota	1.26
District of Columbia	.06	Ohio	3.62
Idaho	.97	Oklahoma	.25
Illinois	5.69	Oregon	.03
Indiana	.67	Pennsylvania	4.52
Iowa	2.82	Rhode Island	.24
Kansas	1.09	South Dakota	1.97
Kentucky	.13	Texas	.09
Maine	.18	Utah	.18
Maryland	.22	Vermont	.14
Massachusetts	1.43	Virginia	.03
Michigan	3.42	Washington	46.79
Minnesota	3.23	West Virginia	.22
Missouri	1.36	Wisconsin	4.00
Montana	1.18	Wyoming	.24
Nebraska	1.71	Exports	.11

376. Table no. 93, shows that 46 percent of the timber cut goes to the State of Washington. Most of this timber is used locally; approximately one half of the local consumption is used in box and barrel production. The boxes and barrels are then shipped as containers of fruit and vegetables. The industrial east of the United States is the next greatest recipient of timber produced in the upper Columbia Basin.

377. *Future.*—The progress of civilization has been called a struggle between human wants and natural resources. One of the greatest of these struggles is, and has been, man's effort to satisfy his demand for wood.

378. In the United States some attention is now being given to the problem of reforestation, or man-grown timber; at the same time slight attention is being given to the conservation of our present supply of nature-grown timber. The industries of the United States are now realizing that the end of the virgin supply is in sight and that they must either find a new source of timber in foreign

countries, or else they must grow timber on American soil. This change in viewpoint with respect to timber conservation and reforestation is coming not as an evolutionary process, but rather as an economic revolution.

379. The per capita consumption of lumber is increasing continually in spite of the many substitutes that are being found continually for it. In 1840 the per capita annual consumption of lumber was somewhat less than 100 board-feet; today, it is approximately 550 board-feet.[29] The increased use of wood in the paper mills has done much to increase the per capita annual consumption and the production of wood-pulp paper is increasing rather than decreasing. The increased per capita consumption has been accompanied by a like increase in the cost of lumber. Today it takes about $550 to buy as much lumber—and poorer lumber at that—as $100 bought 80 years ago.[30]

380. There is approximately one third of the land in the upper Columbia Basin unsuited for agricultural purposes, either because it is too stony, too rough, too steep, or a combination of these factors. To utilize this large proportion of land and to meet the wood needs of an increasing population, the upper Columbia Basin is forced to consider seriously the problem of reforestation and of conservation. Keeping that land which is unsuited for agriculture productive, means increased pay-rolls, greater population, tax-paying land, greater prosperity, and better economic conditions in general.

381. The probable duration of the present supply of timber in the upper Columbia Basin is somewhat less than 50 years; this estimate is secured by dividing the present stand of timber by the average annual rate of depleting that supply. In order to prolong the supply until a program of reforestation can be brought into complete production, a policy of conservation will have to be adopted.

382. *b'. Paper production.*—Paper is now considered an economic necessity. The first paper was made from wood pulp in 1867 in Massachusetts; prior to that time all paper was made from rags, grasses, and other fibrous materials. Since 1890 [31] wood has been the chief source of cellulose; at the present time wood pulp furnishes over 90 percent of the raw material for paper made in the United States, and the remaining 10 percent is largely made from waste paper which, originally, was made from wood pulp.[32] Wood pulp became the raw material supply for paper because of the shortage of rags and other fibers. The paper mills in the United States again face the shortage of raw materials to the extent that large quantities of pulpwood must be imported.

383. The locative factors in a wood pulp paper mill are an adequate supply of pulpwood and a stream to furnish a large supply of water, power, and sometimes, transportation for the logs. The varieties of woods best suited for pulp production are spruce, hemlock, fir, and poplar. The other raw materials needed by these paper mills are limestone, sulphur, rosin, alum, and dye.

384. It thus becomes apparent that raw materials are factors which favor the industry in the upper Columbia Basin. There is an abundance of land where the kinds of wood can be and are produced, and

[29] U.S. Department of Agriculture, Dept. Circular No. 112.
[30] U.S. Department of Agriculture, Bulletin No. 1119.
[31] U.S. Department of Agriculture, Dept. Bulletin No. 1241, 1924, p. 9.
[32] *Ibid*, p. 6.

there are many streams large enough to furnish a water supply and also power. The present supply of pulpwood can be increased by using slashings and by reforestation. The chief limitation to establishing wood pulp paper industries in the upper Columbia Basin is the lack of an adequate market. At the present time the only pulp paper mill in the upper Columbia Basin ships paper to every State west of the Mississippi River. Freight rates prohibit shipments to greater distances; freight rates will limit the areal distribution in the future. In addition the larger eastern market will prevent any extensive westward migration. The new wood pulp paper mills that do establish in the Western States will be located on the littoral of those Western States rather than inland. The factors which favor the location along the coast are the ease of handling imported pulpwood especially from Alaska, the ease of shipping by water, and the greater population for labor and for market in the littoral section of the Western States.

385. No comparative statistics are available for the one paper mill of eastern Washington; its annual capacity, however, is 28,000 tons of newsprint, 26,000 tons of ground wood pulp, and 10,000 tons of sulphite pulp. Since the pulp and the paper mills cannot operate intermittently at a profit, it is safe to assume that the above listed capacity is the approximate annual output.

386. *b. Packing products—a′ Meats.*—The meat-packing industry in the upper Columbia Basin is a local affair in that the plants are comparatively small and the distribution of meat from these plants is practically confined to the upper Columbia Basin. The industry has shown a very gradual growth;[33] the number of plants will probably not increase in the near future because the immediate locative factor in slaughterhouses is a large supply of labor. The increased demand instead of being supplied by an increase in the number of slaughterhouses will be supplied by an increased production of the already existing plants. In all probability the lack of abundant labor, will keep the upper Columbia Basin from being a large producer of meat in the next three decades.

387. *b′. Dairy.*—Table no. 94, gives comparative data on milk production in the upper Columbia Basin, the Western States, and the United States.

TABLE NO. 94.—*Milk production in upper Columbia Basin, Western States, and United States, 1900–30 (gallons)*

[Source: U.S. Census]

Milk production	Geographic division		
	Upper Columbia Basin	Western States	United States
1900:			
Quantity	10,633,000	283,269,000	7,266,392,000
Per capita	71.8	100.1	95.6
1910:			
Quantity	16,024,000	451,016,000	7,466,406,000
Per capita	43.6	99.9	81.1
1920:			
Quantity	31,943,000	577,410,000	7,805,144,000
Per capita	78.7	88.2	73.8
1925:			
Quantity	46,951,000	774,063,000	9,198,304,000
Per capita	93.8	96.8	81.4

[33] In 1900, there was 1 slaughterhouse in Spokane; in 1910, there was still 1; in 1920, there were 2; in 1930 there were 5. Based on census reports of the various decades.

388. This table, table no. 94, shows a considerable increase in milk production in the upper Columbia Basin from 1900 to the present time. The increased per capita production as is shown in the table has taken place in spite of the fact that the number of cows per capita has not changed; in 1881 there were 25 milk cows per 100 population in the upper Columbia Basin and in 1925 there were 20 milk cows per 100 population. The increased per capita consumption is made possible through an increased production per animal.

389. The milk produced in the upper Columbia Basin is marketed chiefly as butter and cheese, the less perishable dairy products; as the population in the Puget Sound lowland increases, the tendency will be to sell whole raw milk to those population centers.

390. The United States Department of Agriculture has predicted that the per capita consumption of milk and milk products will be no greater in 1960 than at the present time. That being the case, the increased total milk consumption must come from an increase in population. The demand for raw milk is supplied largely from dairy farms near the population centers; the result is that the dairy farms located some distance from these population centers must satisfy the demand for dairy products such as cheese and butter. This condition will be more true in the future. This insures a market for dairy products for regions so located that they cannot sell raw milk. As a result of this, dairying can be one of the chief agricultural activities in the upper Columbia Basin since this will be a means of marketing the bulky and cheaper products such as alfalfa and small grains.

391. *c'. Fruit and vegetable canning.*—The rapid development of the fruit and vegetable canning industry in the United States has been made possible by the great improvement in methods of preserving foods, the development of automatic machinery, and the broadening of the market for canned foods. The growth of the industry has been greatly stimulated by the shifting of food processing and preserving from the family kitchen to the factory. This shift has taken place partly because of the greater purchasing power of the average family, and partly because of an improvement in the quality of the factory product.

392. The growth and development of this industry in the upper Columbia Basin has paralleled the industry in the United States as a whole.

393. *c. Textiles.*—From the standpoint of power and raw materials the woolen industry could be a large industry in the upper Columbia Basin. Raw-silk imports could be stopped in the upper Columbia Basin instead of passing through that region to the eastern part of the United States. But it is not raw materials or power that locate the textile industries; labor is the locative factor in this industry. There is no large amount of labor available in the upper Columbia Basin and there is little possibility of the upper Columbia Basin becoming an urban center in the next three decades. Until labor becomes available in large quantity, the wool produced must continue to be shipped from the upper Columbia Basin to the East. At the present time about 80 percent of the wool produced in the upper Columbia Basin is shipped to the Atlantic seaboard, while the rest is used either locally or in the woolen mills of Oregon.

394. *d. Milling.*—Milling is one of the older industries in the upper Columbia Basin; the first mill was established near Colville, Wash., about 1836. However, it is not a large industry and the possibilities are extremely limited. At the present time such flour as is produced

is distributed to the Western States. Transportation is the chief limitation faced by this industry in the upper Columbia Basin, as the mills must bring in the various varieties of wheat needed and later ship by rail the flour produced. Flour mills located on water routes can ship in the necessary grain, receive a milling in transit rate, and ship out the flour by the cheaper-rate water routes. This gives the mills located on the coast a decided advantage over the interior mills. While at the present time sufficient hard wheat is grown in the upper Columbia Basin or the immediate vicinity, to satisfy the milling demands, the future does not appear so bright. The tendency is to reduce the amount of hard wheat grown in favor of the larger yielding soft wheat. This will compel the millers of the upper Columbia Basin to ship in from other regions larger proportions and larger quantities of wheat to balance the soft-wheat varieties.

(K) MARKETS (AREAL IMPORTS)

395. The upper Columbia Basin not only supplies the Western States, the United States, and some foreign countries foodstuffs, but also consumes commodities produced in the Western States and other parts of the United States. Thus the upper Columbia Basin must be examined not only as a source of commodities but also as a region having great trade possibilities for goods produced elsewhere. In considering the present trade possibilities with the upper Columbia Basin two facts stand out as of prime importance; first, that this region is largely undeveloped, and, second, that the great bulk of articles shipped in are manufactured or finished products. This region will increase its purchases as it becomes more densely populated and as it becomes a greater producer of raw materials.

396. The proposed irrigation projects, hydroelectric plants, and cheaper transportation facilities carry with them a promising market for the manufacturers of the Nation, since the upper Columbia Basin itself provides few of its needs except in raw materials. In return for the output of forests, soil, and mines, this region takes and will continue to take manufactured articles of all description. At the present time the upper Columbia Basin ships out more tons of products than it ships into the region; the ratio is from 5 to 10 tons of exports to 1 ton of imports. The reason for the greater export tonnage is that the shipments out of the region consist of bulky raw materials, while the shipments into the region consist of less bulky manufactured products. However, the value of the products shipped in is approximately the same as the value of the products shipped out, the value of the exports being a trifle more than the value of the imports.[34]

397. Since the upper Columbia Basin does not have any large industries other than those engaged in primary production, no large amount of raw materials are shipped into the region. The shipments consist of such products as are consumed in the region. The leading products shipped in are agricultural implements, automobiles, coal and coke, fresh fruits and vegetables, furniture, grain, groceries, iron and steel, and petroleum. Many of these products come into the region from the Puget Sound lowland cities; the original source of

[34] The data in this section of the report are based on information secured for approximately one half of the towns in the upper Columbia Basin. The data were given with the understanding that the report would make it impossible for anyone to determine the origin of this information. This report will comply with the agreement. The general statements, as a result, must be presented without the substantiating detailed data.

these products cannot be determined in most cases, since the products have been stopped while en route to the consuming centers—in this case the upper Columbia Basin—either to be carried along in the manufacturing process or to be stored for an indeterminate period. Spokane, Wenatchee, and Yakima are the only wholesaling centers, and even at these centers the chief marketing function is the redistribution of these products into smaller lots.

398. On the basis of the data collected, the present per capita imports into the region amount to 13.61 tons per year. That can be considered a fair average since the data collected are for the year 1929, in which year business in general was at a low level. This figure represents goods shipped into the region to be consumed; they are not materials which will be used for further manufacturing or production.

399. The above per capita annual tonnage calculation serves as a basis for determining the future consumption in the upper Columbia Basin. Applying the per capita figures to the estimated population in 1960, the total imports for the upper Columbia Basin would be approximately 8,000,000 tons. The population figure implies a minimum rather than a maximum population; the total tonnage imports also assume that economic conditions will not be changed. Thus, with a change from dry farming methods to irrigation practice, and, with the installation of hydro-electric plants, there will be changes in the commodity imports into the region. To cite an example, the mere change from one type of agriculture to another will make for added demands in that particular community. To make the necessary changes from dry farming to irrigation, Dr. Elwood Mead, Commissioner of Reclamation, has estimated that from $5,000 to $10,000 must be spent to provide the permanent improvements and equipment of an 80-acre farm.[35] This figure does not include the cost of constructing the ditches, canals, or reservoirs; this figure does, however, include the labor costs as well as the material costs. The materials will include such items as fences, buildings, and similar improvements. As financial conditions improve in the upper Columbia Basin—and this will result since the returns will be greatly increased with the completion of irrigation—more commodities will be demanded. Human interests tend to become more varied, and human beings tend to live more complex lives as their earning power increases. Then, as the per capita incomes increase, and as the population increases beyond the minimum estimate, there will be a corresponding increase in the total tonnage imports of 8,000,000 tons.

400. The future imports for the next two or three decades will continue to be of such commodities as will be consumed immediately, rather than those products which will be used for further production, or, processed with some other commodity and then the resulting product shipped to other regions.

B. Navigation

(A) GENERAL

1. HISTORY

401. Commercial navigation of the upper Columbia and its tributaries was first attempted by fur traders in the early years of the nineteenth century; French Canadian voyagers and Indians in the

[35] Proceedings of the American Society of Civil Engineers, May 1929, p. 1208.

employ of Hudson Bay Co. in the course of their trading found their way with their bateaux from the headwaters of the Mackenzie, Athabasca, and Fraser Rivers into Canoe River and thence into the upper Columbia and its tributaries. French names upon the maps of today are evidence of the vast extent of country penetrated by them and bear witness to the prowess and skill of those early voyagers.

402. Following Lewis and Clark, who first navigated and explored the Snake and lower Columbia Rivers in 1804–5, the fur traders employed by Astor, and later those employed by the Northwest Fur Co., navigated the waters of the Columbia, advancing up the river.

403. The discovery of gold on the upper waters of the Columbia and Fraser Rivers in 1848 added impetus to travel and exploration. The natural avenues open to the early gold seekers and settlers were the waterways.

404. Following the fur traders and miners came settlers, who, taking their choice of fertile flats for farming or points of vantage for trading, formed nuclei from which some of the present cities and towns in the Columbia Basin have developed.

405. With the advent of railroads, the Northern Pacific in 1883; the Great Northern in 1892; and the Chicago, Milwaukee, St. Paul & Pacific in 1908, dependence upon the river grew less and less and commercial navigation, once important on some stretches of the upper Columbia, gradually dwindled and has now practically ceased.

406. The treaty of 1846 with Great Britain safeguards to British subjects the right to use the Columbia in navigation, to the same extent as applies to citizens of the United States. Article II of the treaty is:

> ART. II. From the point at which the forty-ninth parallel of north latitude shall be found to intersect the great northern branch of the Columbia River, the navigation of the said branch shall be free and open to the Hudson's Bay Company, and to all British subjects trading with same, to the point where the said branch meets the main stream of the Columbia, and thence down the said main stream to the ocean, with free access into and through the said river or rivers, it being understood that all the usual portages along the line thus described shall, in like manner be free and open.
>
> In navigating the said river or rivers, British subjects, with their goods and produce, shall be treated on the same footing as citizens of the United States; it being, however, always understood that nothing in this article shall be construed as preventing, or intended to prevent, the Government of the United States from making any regulations respecting the navigation of the said river or rivers not inconsistent with the present treaty.

2. PREVIOUS INVESTIGATIONS AND REPORTS

407. An examination of Columbia River from the international boundary to Snake River, to determine its navigability and the advisability of its use for the transportation of troops, stores, and supplies by steamboat, was made in 1881 by Thomas W. Symons, then first lieutenant, Corps of Engineers. This report was published as Executive Document No. 186, Senate, Forty-seventh Congress, first session. In this report, Lieutenant Symons "sought to show the economical relations of the Columbia to the surrounding country, and the importance of making that portion of it lying within the territory of the United States navigable as far as practicable," and suggested a plan for so doing.

408. Reports on examinations and surveys with a view to improvements for navigation have been made as shown in table no. 95.

TABLE NO. 95.—*Reports on examinations and surveys*

Date of report	Congressional Document no. and/or reference to Annual Report, Chief of Engineers	Preliminary examination or survey	Improvement considered	Estimated cost	Recommendation
Nov. 12, 1884	S/114/49/1 1885, p. 2445	Preliminary	Columbia River above Snake River. Removal of obstructions		Favorable.
Oct. 15, 1888, Dec. 31, 1889.	H/238/51/1	Preliminary survey	Wallula to British line. Assisting navigation over rapids by means of boats with auxiliary power, and removal of rock.	$151,000 138,000	Favorable by district engineer only.
Oct. 12, 1892, Mar. 15, 1893.	H/39/52/2 1893, p. 3381	do	International boundary to Rock Island Rapids. Removal of obstructions and canalization by locks and dams.	980,000 18,025,000	
May 22, 1895	1895, p. 3534	Survey	Rock Island Rapids to the Okanogan R. Removal of rock from Methow Rapids and Rocky Reach; construction of boom at Entiat Rapids and removal of gravel.	19,987	Favorable.
June 26, 1905, Nov. 16, 1905.	H/440/59/2	Preliminary survey	Removal of rock and boulders and construction of dikes and wing dams between Wenatchee and Bridgeport.	42,000	Do.
Mar. 31, 1908	H/Com/16/60/2	Survey	Removal of rock and obstructions between Bridgeport and Kettle Falls.	175,000	
June 9, 1909, July 11, 1911.	H/693/62/2	Preliminary survey	Snake River to Wenatchee. Canalization, with locks at Rock Island Rapids and Priest Rapids.	7,025,000 1,925,000 5,100,000	Unfavorable.
May 14, 1914	H/1112/63/2	Preliminary	Columbia River, Wash., from Rickey (or Grand) Rapids to the international boundary line. Canalization and boat railways. Removal of rock.		Do.
Mar. 29, 1917	H/742/65/2	do	Columbia River, from mouth of the Snake River to Priest Rapids. Channel of same depth as may be recommended up to the Snake.		Do.

3. EARLY PROJECTS AND WORKS OF IMPROVEMENT

409. The following acts made provision for improving Columbia River above mouth of Snake River:

Act of September 19, 1890:

Improving Columbia River from the head of Rock Island Rapids to the foot of Priest Rapids, Washington, seventy thousand dollars, of which ten thousand dollars, or so much thereof as may be necessary, may be used in the survey of the Columbia River from the international boundary to Rock Island Rapids.

Act of August 18, 1894:

Improving Columbia River from Rock Island Rapids to Foster Creek Rapids: The Secretary of War may, in his discretion, expend the unexpended balance, eight thousand two hundred and ten dollars and ninety-two cents, of the appropriation heretofore made for the improvement of the Columbia River between the head of Rock Island Rapids and the foot of Priest Rapids, Washington, for the building of a snag boat for use on the Columbia River between Rock Island Rapids and Foster Creek Rapids, and for such other work as may be necessary for the improvement of navigation of said river within the above-named limits.

Act of March 2, 1907:

Improving the Columbia River and tributaries above Celilo Falls to the mouth of Snake River, Oregon and Washington: Continuing improvement, in accordance with the report submitted in House Document Numbered Four hundred and forty, Fifty-ninth Congress, second session. * * *

This document provides $42,000 for improvement of Columbia River between Wenatchee and Bridgeport, a distance of about 80 miles.

Act of March 2, 1907:

Improving Columbia River, between Wenatchee and Bridgeport, Washington: Continuing improvement in accordance with the report submitted in House Document Numbered Four hundred and forty, Fifty-ninth Congress, second session, forty-two thousand dollars.

Act of June 25, 1910:

Improving Columbia River between Bridgeport and Kettle Falls, Washington: Completing improvement in accordance with the report of the Board of Engineers for Rivers and Harbors dated March thirty-first, nineteen hundred and eight, and printed in Rivers and Harbors Committee Document Numbered Sixteen, Sixtieth Congress, second session, one hundred thousand dollars: *Provided*, That the State of Washington shall furnish for the execution of the work the plant owned and employed by it on this section of the river.

Act of July 25, 1912:

Improving Columbia River between Bridgeport and Kettle Falls, Washington: Continuing improvement, twenty-five thousand dollars.

Act of March 4, 1913:

Improving Columbia River between Bridgeport and Kettle Falls, Washington: Completing improvement, $40,000.

410. The total appropriated for improvement of Columbia River above Snake River is $352,098.76. The last expenditure for work was made in 1917.

411. The work done under the projects listed above consisted of removing rocks from Priest, Cabinet, and Rock Island Rapids; placing iron posts and ringbolts to enable boats to ascend these rapids by means of lines. Above Wenatchee, work of removing boulders and reefs was done at mouth of Wenatchee River, Rocky Reach, Chelan, Methow Rapids, Foster Creek Rapids, Box Canyon,

Long Rapids, Whitecap Rapids, Parson Rapids, Hell Gate, Spokane Rapids, Rogers Bar, Gifford Rapids, and Three Rock Bend. A new channel was also dredged at Entiat Rapids. The work done has made navigation of the river above Wenatchee easier and less dangerous. With properly equipped boats of high power it is possible at medium stages to navigate the Columbia from its mouth to the foot of Grand Rapids, a distance of 700 miles.

4. RIVER CRAFT

412. At the present time only launches operate on the Columbia River above the Snake. Vessels which previously operated on this section of the river were of the usual type of stern-wheel flat-bottom river steamers, which is the only type that has been developed to operate on this river in its present condition, except for small craft.

413. On improved rivers where freight in large quantities is transported, it has been found more economical to handle this freight by barges and towboats than by packet boats or self-propelled barges. For instance, on the Ohio River 98 percent of the freight tonnage is carried on barges. Packet boats are used where stops are frequent and commodities are received and delivered in less than boatload lots. Barges used on the Ohio and Mississippi Rivers vary from 26 feet in width and 100 feet in length to 50 feet in width and 200 feet in length. The Board on Experimental Towboats for the Mississippi River and Tributaries found that for speedy service of high-class package freight, the self-propelled barge was well adapted, as it has sufficient power to progress against swift currents where towboats would be obliged to split their tows. The self-propelled barge can also maintain higher speeds at river bends. Self-propelled barges of the screw-propeller type, 280 feet long by 49 feet wide, with a depth of 7 feet and a capacity of 1,700 tons, are being successfully operated on the Mississippi. A summary of the Board's conclusions is that:

> Barges to be towed singly should be of easy shape. Barges to be towed in fleets should be of simple shape. Barges should be as large as the trade, river, and structural conditions will permit. The ratio of length to beam should be as large as possible; structural practice usually limits this ratio to 1 to 7. Fleets should be arranged in long, narrow formations wherever possible. For upstream towing the ratio of length to beam of tow of 9 is desirable. For downstream towing this ratio is determined by ability to maneuver—the greater the draft the greater the economy of power for a given fleet. Barges should be loaded to within 1 foot of the controlling depth of the channel. The maximum draft of towboat fully loaded, with fuel and supplies, should be as little as possible and should always be at least 1 foot less than the draft of its barges as ordinarily loaded at low water. River improvement works should be so constructed that no undue interference is offered to the passage of the economical tow.

414. The Columbia above the Snake has a fall of about five times that of the Ohio, and even after the river has been canalized, current velocities as high as 5 to 7 miles an hour will frequently obtain during the higher stages of the river. Powerful boats will therefore be required, and the size of tows will be smaller than those used on the Ohio. It is believed that, in general, freight on the Columbia above the Snake will be transported in self-propelled barges or packet boats rather than by barges with towboats, but that lock dimensions should be such that a reasonable tow could be accommodated.

(B) DESCRIPTION

1. ORIGINAL CONDITION

415. The Columbia above the Snake has a very stable channel, being generally confined by rock banks and having a bed composed of material not easily transported by even the high-current velocities obtaining in this river. It is a river with a steep slope, high velocities, numerous rapids, and is navigable with great difficulty. At a medium stage navigation is least difficult, as at some rapids navigation is made more difficult by higher water, while at other rapids the reverse is true. Lining is frequently necessary at all stages to enable boats to ascend the river. See plate no. 33,[2] which lists the more important rapids and describes the difficulties of navigation by rapids and sections of river. The three following photographs[2] serve to illustrate the type of river and give an impression of some of the difficulties of navigation. A profile is described in paragraph 119, and is shown on plate no. 2, page 590.

416. However, with properly equipped boats of high power, it is possible to navigate the Columbia from its mouth to the foot of Grand Rapids, a distance of 700 miles. In that portion of the river between the mouth of Snake River and the international boundary line the fall is about 980 feet, the distance being 425.3 miles. The river has an average slope of 2.3 feet per mile. This slope, however, is not uniform, as the greater part of the drop is concentrated in the rapids and falls. A brief description of the navigable condition of the river is as follows:

First section. Mouth of Snake to foot of Priest Rapids; distance 73 miles, fall 88 feet. The river in this section is favorable for navigation. It is obstructed by a few gravel shoals over which there is a controlling depth of about 3½ feet at extreme low water. But as this stage only obtains during the winter and when the river is often blocked by ice, this lack of depth is not important.

Second section. Priest Rapids. These rapids are 9 miles long and consist of seven separate rapids. The fall is about 72 feet. These rapids are a serious obstruction to navigation at all stages and are impassable at low water. They are caused by rock reefs and large boulders.

Third section. Head of Priest Rapids to foot of Cabinet Rapids; distance 42 miles, fall 70 feet. There are in this section four rapids: Cohasset, Island, Quillamine, and Lodged Pole. These rapids offer no serious obstruction to navigation, although at low water the currents are swift, making upstream navigation difficult.

Fourth section. Cabinet Rapids to Rock Island Rapids; distance 6 miles, fall 20 feet. Cabinet Rapids are very difficult to navigate at low water, becoming easier with increased river stages. At Rock Island Rapids there is in the left channel a fall of 12 feet at low water in a distance of 2,700 feet; 6.5 feet at average high water, and 4 feet or less at extreme high water. In the right channel this fall is distributed over a distance of 5,100 feet.

Fifth section. Rock Island Rapids to Wenatchee; distance 12 miles. This stretch is obstructed by boulders and reefs, and at a point just upstream from the Great Northern Railway bridge the river passes

[2] Not printed.

through a narrow section which is difficult to navigate at high water, due to the swift current.

Sixth section. Wenatchee to the foot of Foster Creek Rapids; distance 80 miles. This stretch was regularly navigated for a number of years by daily boats. It may be considered good, although it contains several rapids, the most difficult being Entiat and Methow—Entiat difficult at low water, and Methow at high water.

Seventh section. Foster Creek Rapids to Mahkin Rapids; distance 27 miles. This section is known as Nespelem Canyon. In this 27-mile stretch the river falls about 125 feet. The more important rapids in this section are: Foster Creek, with a fall of 5.9 feet in a distance of 1,400 feet at low water; Coyote Rapids, with a fall of 4.9 feet in 700; Box Canyon and Long Rapids, where the fall is 22 feet in 3 miles at low water, and 24 feet at high water in the same distance (the water runs through this canyon with a velocity of 10 miles per hour); Parsons Rapids, where the channel is obstructed by boulders; Mahkin Rapids, where the water is very swift.

Eighth section. Mahkin Rapids to Grand Rapids; distance 125 miles. This section may be considered fair for navigation. It includes the following rapids: Hell Gate, where the river is obstructed by three high islands, making a bad turn in the channel; Spokane Rapids, where the channel is straight but the current is very swift. The remaining distance is not very difficult to navigate.

Ninth section Grand Rapids to head of Kettle Falls; distance 7 miles. These rapids and falls form a complete bar to navigation at all stages. The drop in Grand Rapids is 20 feet in a distance of 3,000 feet. At Kettle Falls the drop at both low and high water is 33 feet.

Tenth section. Kettle Falls to boundary; distance 41 miles. This section is navigable at low water; but at high water the Little Dalles are not navigable owing to the high velocities in the narrow channel.

2. NAVIGATION SEASON AND ICE CONDITIONS

417. The river is navigable throughout the year except when obstructed by ice. This ice period is generally limited to 2 or 3 weeks in January. Some years there is no closed season due to ice conditions, while during other years the period is extended to 6 weeks.

418. As previously stated, both high- and low-water stages are more difficult in which to navigate than a medium stage.

3. CURRENT VELOCITIES—EXISTING; MAXIMUM DESIRABLE

419. Surface velocities vary from less than 2 to more than 15 miles per hour. There are many places where the velocity is more than 10 miles per hour. These higher velocities do not in general extend over any great distance, but are limited to confined portions of rapids. Upriver navigation without lining is limited to places where velocities do not exceed 7 or 8 miles per hour. If scows are to be towed the velocities should not exceed 5 miles per hour. Results of measurement of current velocities are given on profile in chapter IV.

420. Current velocities are not a true measure of the difficulties of upstream navigation, as these velocities are frequently increased, due to contraction of opening, when the boat enters the rapids. Between rapids, boats follow the shore and avoid the swifter currents which obtain in the center of the river.