

30,000 acres, lying above the Cascade Canal and the West Side Ditch, are partially irrigated from various creeks. The supply of water for the Bureau of Reclamation development is obtained from the natural flow of Yakima River and from storage in Keechelus and Kachess Reservoirs.

1105. The irrigation plan includes the diversion of 1,320 second-feet of water from Yakima River at the Easton Dam (65 feet high and 248 feet long) located about 40 miles northwest of Ellensburg, at elevation 2,200 feet above sea level. The main canal, capacity 1,320 second-feet, follows the south side of the river canyon for 26 miles until it emerges into the Kittitas Valley, where it branches. The North Branch (capacity, 925 second-feet) crosses the river and follows around the north and east sides of the valley for 50 miles, finally reaching the river 6 miles south of Ellensburg. The South Branch (capacity, 250 second-feet) follows along the south rim of the valley for a distance of 14 miles from the end of the main canal. This region is, primarily, one of hay and grain, but fruit, root crops, dairying, and poultry products are important. Farm units are 20 to 160 acres. The diversion duty of water is about 4.28 feet, net duty about 3 feet.

1106. *b. Tieton division.*—Construction of the Tieton division was authorized late in 1905 and work was begun in 1906. It was opened in part for the irrigation season of 1911, and completed the following year. The enlargement of the main canal was completed in 1918.

1107. This division includes about 32,000 acres of irrigable land, the main body of which lies directly west of the city of Yakima, and approaches practically to the city limits. Much of the land in the immediate vicinity has been irrigated from early days by privately owned ditches taking water directly from Naches River and neighboring streams, but these ditches supply water to the lower-lying ground only, the lands included under the Tieton division being at about 200 feet higher elevation.

1108. Storage to the extent of 198,000 acre-feet is provided in the Tieton Reservoir located at elevation 2,750 feet above sea level, on Tieton River, 23 miles above its mouth and 43 miles from Yakima. Diversion from Tieton River into the main supply canal is at a point  $7\frac{1}{2}$  miles below the reservoir at elevation 2,300, and is effected by means of a concrete weir 3 feet high and 110 feet long. The capacity of the canal is about 350 second-feet. From the point of diversion the canal follows down the south side of Tieton River Canyon, passes in a tunnel through Naches Ridge, and enters the valley of the north fork of Cowiche Creek, from which it is diverted at five well-selected points into eight main laterals. From these laterals smaller ones extend to each 40-acre subdivision of the project.

1109. The elevation of the land under this division varies from 1,300 to 2,100 feet above sea level. The winters are mild, with a few inches of snowfall, the temperature seldom dropping as low as  $15^{\circ}$  F. above zero. The soil is volcanic ash and decomposed basalt, underlain with gravel, exceedingly fertile, and particularly adapted to fruit growing, which is a flourishing industry. Potatoes, hops, and sugar beets are valuable crops. Dairying and hog raising are carried on to a considerable extent. The lands in the main valley are mostly in small tracts of less than 20 acres. The duty of water is  $2\frac{1}{2}$  feet. This district is also served by a number of large irrigation systems, mostly

owned by mutual stock companies, water for which is assured by the storage reservoirs of the Bureau of Reclamation.

1110. *c. Moxee division.*—This division comprises 36,750 acres of irrigable land in Wenas, Selah, and Moxee Valleys, all in the vicinity of Yakima. The elevation of the land ranges from 1,150 to 1,700 feet. Not much work has been done by the Government on this division. The plan of irrigation is to divert water from Tieton River, 5 miles above its mouth and about 25 miles from the city of Yakima, and conduct it thence by a gravity canal through the Wenas, East Selah, and Moxee Valleys. The length of the canal, completed to the head of the Moxee Valley, will be about 60 miles. Potatoes are more important as a crop in the Moxee Valley than elsewhere on the Yakima project, with the possible exception of the Wapato unit.

1111. *d. Wapato project.*—The uppermost end of this project which lies about 6 miles southward of the city of Yakima, includes 120,000 acres of Yakima Indian Reservation lands, and is under the supervision and direction of the United States Bureau of Indian Affairs; but since it is dependent upon the Yakima River and Yakima project of the Bureau of Reclamation for its supply of irrigation water, it is treated here as a division of the Yakima project. Elevations of the Wapato project range between 700 and 900 feet. The climate is mild, with occasional cold periods.

1112. A Report on the Condition of the Yakima Indian Reservation, published as House Document No. 1299, Sixty-third Congress, third session, states:

The Indians have been irrigating in a more or less crude manner on this reservation since 1859. At first oxen were used for breaking the land, and in 1862 more than 200 acres were under irrigation, 500 in 1863, and 1,000 to 1,200 in 1865. No work, however, was done by the United States Indian Service until May 20, 1896.

1113. Work on the project, as at present constituted, may be said to have begun in 1903, when the New Reservation Canal was built.

1114. Under this project, which is now substantially completed for the irrigation of 120,000 acres, 106,000 watered by gravity and 14,000 by pumping, water is diverted from the west side of Yakima River at a point a short distance below Union Gap and  $6\frac{1}{4}$  miles, by river, below the city of Yakima. The project includes over 200 miles of main ditches as well as 500 miles of laterals.<sup>67</sup> The New Reservation Canal, the main diversion channel, has a capacity of about 1,425 second-feet.

1115. The Wapato pumping unit no. 1, for the irrigation of 11,000 acres, was completed in 1929. It has a capacity of 150 second-feet, and pumps against a head of 85 feet; the canal is 24 miles in length.

1116. The soil of the Wapato project is volcanic ash, overlying a loose and porous gravelly subsoil at depths of 4 to 8 feet. The inherent porous nature of this subsoil has given rise to a considerable loss by seepage in the canals.

1117. Many acres of land under this project have become water-logged thereby causing alkali to be deposited on the surface, and rendering the land unsuitable for cultivation. This has been due to a combination of causes, among which were the high losses due to seepage, and the objectionable custom of using excessive quantities of irrigating water. Such water-logging of land has led to the con-

<sup>67</sup> U. S. Department of Interior, Bureau of Indian Affairs, Annual Report, 1928.

struction of a system of drainage canals to drain 30,000 acres of land in the southern part of the area.

1118. The Indians have been allotted 80 acres of irrigable land each, 40 acres of which carry a free water right. The other 40 acres are supplied with water from storage reservoirs, and are assessable for the water right in addition to cost of construction, operation and maintenance. Most of the irrigating is being done by whites, either as owners or lessees. According to a survey and report made in 1928 by the United States Department of the Interior, only 6 percent of the irrigated area was being irrigated by Indians. The principal crops are forage, potatoes, hops and fruit. Gross duty of water is 4.3 feet, or 1 second-foot per 100 acres, for the season of 7 months. Net duty is 3 feet.

1119. *e. Sunnyside division.*—This division is an elongated body of land, containing 107,600 acres that are irrigable, extending for a distance of 50 miles from a point about 8 miles southeast of Yakima, to a point about 6 miles east of the town of Prosser. About 10,000 acres are on the south side of Yakima River, east of the Yakima Indian Reservation; the remaining lands are on the north side.

1120. The Northern Pacific Railway Co. originally owned a large part of the land included within the Sunnyside division, and this company was naturally the first to make investigations of the feasibility of irrigating it. Their engineers made several adverse reports, but, in 1889, a subsidiary company was formed for constructing a canal for supplying water to the land. This company, together with its several successors, constructed the main canal on the north side of the river, 57 miles in length, with a capacity of 650 second-feet at the intake, together with some of the main laterals, so that on June 23, 1906, when the Federal Government acquired the system from the Washington Irrigation Co., there were about 30,000 acres under irrigation.

1121. Water for irrigation was first furnished by the Bureau of Reclamation for the season of 1907. Since that time the system has been improved and enlarged to the extent that at the present time water is available for 102,335 acres of the 107,600 acres of irrigable area, about 95 percent of which is in crops. Diversion of water for the Sunnyside division is made from the east side of Yakima River, about 8 miles below the city of Yakima, by means of a concrete diversion dam 8.5 feet high and 500 feet long. The main canal, with a capacity of 1,270 second-feet, roughly parallels Yakima River for a distance of 61 miles, supplying water to hundreds of laterals, including the Snipes Mountain, Rocky Ford, Turner, Mabton Siphon, and Prosser Siphon systems. The soil on about three fourths of the division is sandy loam or volcanic ash, from 10 to 60 feet deep. The remainder is decomposed basalt underlain by gravel, or a combination of this and the above-named soils. All are easily tilled and respond readily to irrigation. The principal products are forage crops, fruits and vegetables, dairy and poultry products. Peaches and similar soft fruits grow phenomenally well in this part of the valley, the climate being ideal for such crops. The duty of water is about 3.5 feet.

1122. *f. Roza division.*—This division, like the Sunnyside division, embodies an elongated body of land containing 58,350 acres that are irrigable, located on the easterly side of Yakima River, mostly in a narrow strip 1 to 3 miles wide and 50 miles long. It lies parallel to

and above the Sunnyside Canal, and extends from about 9 miles southeast of the city of Yakima, near Union Gap, to Benton City, a distance of 50 miles. The elevations range from 1,200 to 800 feet above sea level.

1123. Only a little work has been done on this division. The proposed irrigation plan is to divert water from the easterly side of Yakima River at a point 15 miles above the city of Yakima, near Roza, and conduct it by a gravity canal for a distance of 100 miles to the lower end of the project. Numerous drops on the way will be developed to furnish power for pumping at other points.

1124. *g. Kennewick division.*—Situating on the southerly side of Yakima River near its junction with the Columbia, the Kennewick division comprises an area of 35,000 acres of irrigable land in Benton County extending from Kiona, 56 miles southeastward of the city of Yakima, to a point below Kennewick. Elevations of the lands within the area range from 800 to 450 feet above sea level.

1125. Only a little work has been done on the division. The proposed irrigation plan is to divert water from Yakima River at Prosser, conduct it 10 miles down the southeast side of the river in a concrete-lined canal to a pumping plant, where a part of the water will be used to drive hydraulic turbines, and then returned to the river, while the remainder is raised 110 feet by pumps and conducted to the lands to be irrigated.

## 2. COSTS AND RELATED MATTERS

1126. From the nature of the accounting system used, it is difficult to segregate the costs of individual projects with absolute accuracy. The following tabulations and statistics, tables nos. 194, 195, 196, and 197, compiled from annual reports of the Secretary of the Interior, the Commissioner of Reclamation, and other official sources afford the best information available relating to the Yakima and Okanogan projects, their irrigable acreages, crop productivity, the costs of construction, operation and maintenance of reclamation works, and related matters.

TABLE NO. 194.—*Statistics regarding Yakima project*

Item	Yakima project			Tieton division, 1929	Sunnyside division, 1929
	1927	1928	1929		
Irrigable acreage:					
Project .....	134,540	133,635	133,280	30,800	102,480
Private <sup>1</sup> .....	166,720	166,720	166,720		
Irrigated acreage:					
Project .....	119,900	115,935	114,665	27,100	87,565
Private <sup>1</sup> .....	120,828	124,140	124,390		
Cropped acreage:					
Project .....	102,590	103,140	101,675	22,600	79,075
Private <sup>1</sup> .....	120,828	124,140	124,390		
Crop value:					
Project .....	\$8,283,060	\$8,242,930	\$12,431,020	\$4,484,350	\$7,947,570
Private <sup>1</sup> .....	\$14,853,830	\$13,342,200	\$18,315,030		
Crop value, per acre:					
Project .....	\$60.74	\$79.92	\$122.27	\$198.42	\$100.51
Private <sup>1</sup> .....	\$123.00	\$107.00	\$147.00		
Operating cost, project .....	\$264,484		\$254,770		
Operating returns, project .....	\$261,171		\$271,619		
Operating excess, project .....	\$3,313		\$16,849		
Total operating cost to Dec. 31 .....			\$4,076,086		
Total operating returns to Dec. 31 .....			\$4,002,947		
Total operating excess to Dec. 31 .....			\$73,139		

<sup>1</sup> Lands furnished water under provisions of Warren Act.

TABLE NO. 195.—*Statistics for 1929 regarding population and construction costs, Yakima project*

Item	Yakima project	Tieton division	Sunnyside division	Kittitas division
Towns, number.....		8	10	5
Irrigated farms, number.....		1,360	3,150	355
Population.....		3,921	10,135	1,100
Towns, population.....		28,000	8,315	5,217
Construction cost to June 30, 1930.....	\$14,148,888 <sup>1</sup>			\$6,562,908
Acres possibly susceptible of irrigation.....	341,700 <sup>2</sup>	32,000	107,600	72,000

<sup>1</sup> Does not include costs of Kittitas division or Wapato project.

<sup>2</sup> Includes Moxee division, 36,750 acres; Roza division, 58,350 acres; and Kennewick division, 35,000 acres; but does not include Wapato Indian project, 120,000 acres.

TABLE NO. 196.—*Crop report for 1929 for Yakima project*

Crop	Acreage cropped	Yield	Crop value	
			Total	Per acre
Barley.....	782	27,198 bushels.....	\$20,491	\$26.20
Corn.....	4,788	205,989 bushels.....	175,887	36.75
Oats.....	1,179	60,626 bushels.....	36,079	30.60
Wheat.....	9,816	335,860 bushels.....	367,611	37.50
Alfalfa hay.....	32,541	109,460 tons.....	1,472,811	45.25
Other hay.....	1,487	2,558 tons.....	25,586	17.20
Corn fodder.....	329	1,234 tons.....	7,151	21.70
Other forage.....	612	7,546 tons.....	57,145	93.20
Pasture.....	16,118		311,275	19.30
Beans.....	8,121	860 bushels.....	2,580	51.60
Potatoes.....	2,485	2,006,700 bushels.....	2,107,053	259.50
Truck.....	16,008		821,238	129.30
Apples.....	2,315	213,407,748 pounds.....	4,874,655	304.50
Peaches.....	3,449	19,182,385 pounds.....	460,385	198.90
Pears.....	1,069	41,922,700 pounds.....	1,467,295	269.10
Prunes.....	1,330	9,385,645 pounds.....	89,116	83.40
Small fruits.....	939	9,145,255 pounds.....	338,902	254.50
Miscellaneous fruits.....	1,251	3,362,956 pounds.....	84,074	89.60
Other crops.....			212,606	170.00
Total.....	106,669			
Duplicated.....	4,994			
Total cropped.....	101,675		12,431,920	122.27
Irrigated, no crop.....	12,990			
Total irrigated.....	114,665			

TABLE NO. 197.—*Operation and maintenance cost per acre on the Yakima and Okanogan projects*

Year	Yakima project		Okanogan project <sup>3</sup>	Year	Yakima project		Okanogan project <sup>3</sup>
	Sunnyside division <sup>1</sup>	Tieton division <sup>2</sup>			Sunnyside division <sup>1</sup>	Tieton division <sup>2</sup>	
1909.....	\$1.05		\$2.13	1920.....	\$1.80	\$3.36	<sup>3</sup> \$12.61
1910.....	1.50		2.31	1921.....	1.52	3.19	7.77
1911.....	1.35	\$2.39	2.71	1922.....	1.55	2.94	9.52
1912.....	1.38	2.64	1.87	1923.....	1.62	3.52	8.82
1913.....	1.30	1.23	1.26	1924.....	1.48	3.13	12.61
1914.....	1.13	2.01	1.36	1925.....	1.60	3.33	11.04
1915.....	1.13	1.62	1.47	1926.....	1.55	3.43	11.92
1916.....	1.09	1.08	1.88	1927.....	1.62	3.50	9.81
1917.....	1.37	1.94	2.19	1928.....	1.55	3.76	6.20
1918.....	1.67	2.63	5.04	1929.....	1.46	3.54	
1919.....	1.48	2.96	5.74				

<sup>1</sup> Based on a charge of \$1 per acre vested water rights, and a minimum of \$2 for public notice lands, etc.

<sup>2</sup> Based on a charge of \$1.50 per acre-foot of water delivered between June 1 and August 31, and 60 cents per acre-foot of water delivered at other times during the irrigating season.

<sup>3</sup> Beginning with season of 1920, based on a charge of \$4 per acre of irrigable land, whether water was used thereon or not, which entitled the water user to one acre-foot of water, additional water being furnished at \$1.50 for the first acre-foot, and \$3 per acre-foot for further supply.

1127. On the Sunnyside division, after purchase of improvements by the United States, June 23, 1906, building charges were \$52 to \$64 per acre of irrigable land, which amounts to an average annual payment of \$4.57 per acre over a repayment period of 11 years, as provided for under act of December 5, 1924.

1128. On the Tieton division, building charges, not including the cost of all upstream storage, were \$93 per acre of irrigable land, which amounts to an average annual payment of \$4.08 per acre over a repayment period of 24 years, as provided for under the same act, plus a charge of \$11.63 per acre for supplemental construction.

1129. On the Okanogan project, after charging off \$998,327.20 (\$170.60 per irrigable acre), authorized by act of May 25, 1926, building charges were \$95 per acre of irrigable land, which amounted to an average annual payment of \$7.96 per acre over a repayment period of 12 years, as provided for under act of December 5, 1924.

#### (B) OKANOGAN PROJECT

1130. Okanogan project is a small enterprise fostered by the United States Bureau of Reclamation, situated in the north-central part of the State of Washington, on the west side of Okanogan River, about 50 miles south of the Canadian boundary. It was originally designed to irrigate 10,000 acres by gravity, but the water supply in recent years has not been sufficient for so large a tract; consequently, the irrigable area under the gravity system has been tentatively reduced to 3,700 acres. To supplement the supply during periods of low water, a pumping plant has been provided to lift water from Okanogan River at a point near Omak for the lower-lying portion of the project. In 1929, the cropped acreage was 3,825 acres. The lands under this project lie in three benches at an average elevation of about 1,000 feet above sea level. The temperature range is between 10° below zero, Fahrenheit, and 108° above; the variation of the seasons is marked. The mean annual precipitation is 12 inches.

1131. Transportation is afforded by the Great Northern Railway, a branch line of which passes along the eastern border of the project connecting with the main line at Wenatchee to the south, and with another branch line at Oroville to the north. A State and Federal aid hard-surfaced highway runs through the edge of the district, and hard-surfaced roads penetrate to all parts of the project. Okanogan, population 1,519, the county seat, is located near the southern extremity of the development. Omak, with a population of 2,547, also serves the project.

1132. The lands covered by the Okanogan project were at one time a part of the Colville Indian Reservation. Prior to 1886, at which time these lands were thrown open to settlement, irrigation was practiced only in a very crude and limited way by diversion from Salmon Creek through small ditches to irrigate a few acres of hay, grain, corn, potatoes, and garden truck, but this demonstrated the fertility of the soil and value of irrigation so conclusively that in 1888 the existing ditches were enlarged and still others constructed.

1133. The Okanogan project developed by the United States Bureau of Reclamation beginning with 1903, provided for the storage of 3,200 acre-feet of water in Salmon Lake Reservoir on the north fork of Salmon Creek, and also for 13,000 acre-feet of storage in Con-

conully Reservoir, which was created by a dam at the junction of the north and west forks of Salmon Creek. The Salmon Creek Reservoir has never been used as the water available has not required both reservoirs for its regulation. Water is released from the Conconully Reservoir as needed. The crest elevations of Salmon Lake and Conconully Reservoirs are 2,298 and 2,287 feet, respectively, above sea level. Diversion is made from Salmon Creek at a point 12 miles below the Conconully Reservoir at elevation 1,371, whence water is conducted by a canal with a capacity of 110 second-feet to the bench lands to be irrigated. At two points along the line of the canal advantage is taken of drops of 110 and 58 feet each to develop power that is transmitted to the pumping plant near Omak, at which place water is lifted from Okanogan River to irrigate about 1,070 acres on Robinson Flat.

1134. The soil is volcanic ash combined with varying quantities of sand underlain with sand and gravel on the upper benches, and sand and gravel on the lowlands along the Okanogan River, both of which have excellent underdrainage and preclude the probability of water-logged areas. The major portion of the land irrigated is planted with fruit trees, principally apples. In 1929, the cropped acreage was 3,835 acres having a crop value of \$979,220, an average of \$255 an acre. The maximum farm unit irrigated for any one owner is 40 acres. The length of the irrigation season is from May 1 to September 1—123 days. The duty of water is limited to 3 feet.

1135. Under contract with the United States, dated November 24, 1928, operation of the project was assumed by the Okanogan irrigation district on January 1, 1921.

1136. The following tabulations and statistics, tables nos. 198 and 199, compiled from annual reports of the Secretary of the Interior, Commissioner of Reclamation, and other official sources, afford the best available information relating to the Okanogan project, its irrigable acreage, crop productivity, costs of construction, operation and maintenance of reclamation works, and related matters.

TABLE NO. 198.—*Statistics regarding Okanogan project*

Item	1927	1928	1929
Irrigable acreage.....	17,300	7,150	5,850
Irrigated acreage.....	4,125	4,150	4,255
Cropped acreage.....	3,760	3,600	3,835
Crop value.....	\$1,064,215	\$1,092,725	\$979,220
Crop value, per acre.....	\$282.88	\$303.73	\$255.35
Operating cost, project.....	\$40,451		
Operating returns, project.....	\$30,377		
Operating excess, project.....	\$10,074		
Total operating cost, project to Dec. 31.....			\$649,647
Total operating returns, project to Dec. 31.....			\$649,647
Total operating excess, project to Dec. 31.....			
Towns, number.....		3	3
Irrigated farms, number.....		383	382
Irrigated farms, population.....		991	1,026
Towns, population.....		3,500	4,356

Acreage possibly susceptible of irrigation, 7,300.<sup>5</sup>

Total construction cost to June 30, 1930, \$1,422,526.

<sup>1</sup> Annual Report, Secretary of the Interior, 1928, p. 333.

<sup>2</sup> Annual Report, Secretary of the Interior, 1929, p. 143.

<sup>3</sup> Annual Report, Commissioner of Reclamation, 1930, p. 80.

<sup>4</sup> Deficit.

Annual Report, Commissioner of Reclamation, 1930, p. 69.

TABLE NO. 199.—*Crop report for 1929 for Okanogan project*

Item	Acreage cropped	Yield	Crop value	
			Total	Per acre
		<i>Tons</i>		
Alfalfa hay.....	125	330	\$4, 943	\$39. 50
Other hay.....	1		5	
Corn fodder.....	13	28	305	23. 45
Potatoes.....	5		696	139. 20
Truck.....	55		6, 594	119. 20
		<i>Pounds</i>		
Apples.....	3, 605	800, 380	920, 437	255. 20
Peaches.....	6		2, 711	451. 80
Pears.....	28		10, 249	366. 00
Prunes.....			964	
Smallfruit.....	28		29, 920	
Miscellaneous fruits.....			2, 196	
Other crops.....			200	
Total.....	3, 866			
Duplicated.....	31			
Total cropped.....	3, 835		979, 220	255. 34
Irrigated, no crop.....	420			
Total irrigated.....	4, 255			

For building charges and annual operation and maintenance costs on the Okanogan project from 1911 to 1928 inclusive, attention is invited to par. 1136 and table no. 198.

## (C) FLATHEAD PROJECT

1137. The Flathead project of the United States Bureau of Indian Affairs comprises 124,500 acres of irrigable land of what was the Flathead Indian Reservation in the west central part of the State of Montana, about 100 miles south of the Canadian boundary. The project lies mainly south of Flathead Lake, on the east side of Flathead River, a tributary of Clark Fork of the Columbia. It is in a protected valley between the high Bitterroot Mountain Range on the west, and the Mission Range on the east, both ranges rising to elevations of about 10,000 feet. The average elevation of the irrigable area is 3,000 feet above sea level. Extremes of temperature are 30° below zero, Fahrenheit, and 100° above. Some winters are so mild that a minimum temperature of zero is not reached. Violent winds are rare, and in winter, as a rule, do not accompany the winter storms. The mean annual precipitation at St. Ignatius is 16.15 inches, 60 percent of which falls during the 5 months of the irrigating season, April to August. Snow falls to a depth of 24 inches, or more, occasionally, but is frequently melted within a few days by Chinook winds.

1138. Rail transportation is afforded by the transcontinental main line of the Northern Pacific Railway, which touches the southerly edge of the project, and by a branch line between Dixon and Polson which traverses the major portion of it. A Federal-aid highway also traverses the main body of the project and connects with the Yellowstone Trail at Missoula. The principal towns and their populations are: Polson, 1,453; St. Ignatius, 718; and Ronan, 535. Missoula, population 14,616, outside the project, also serves it.

1139. Irrigation was first practiced, in a crude and limited way, about the year 1855 at St. Ignatius' Mission and has been continued there ever since. Individual Indians built a number of small ditches from various streams in different parts of the reservation, applying

the water to hay, vegetables, and fruit-growing purposes. They undertook no large works, and used only a very small part of the natural water supply. In 1904, Congress passed an act allotting lands to the Indians in severalty, and providing for the sale and disposal of all surplus lands upon their reservation, following which about 60 percent of the project area has passed into the hands of white irrigators.

1140. Under the Federal Government, in 1907, came the first concerted action for developments of any magnitude on the project, although many years before that time the Bureau of Indian Affairs had constructed a canal in the Jocko Valley for about 6 miles, which, however, by 1907 had fallen into a bad state of repair and was of little use. The present irrigation plan of the project provides for the irrigation of about 124,500 acres of the former Flathead Reservation, located in four main valleys entirely separated from one another as to water supply and topography, and lying some distance apart. Water is diverted from creeks and rivers rising in the Mission Mountains, and then conducted by gravity canals directly to the land. The gravity supply will be supplemented when necessary by pumping from Flathead Lake. Storage for flood waters is provided in 16 reservoirs having an aggregate capacity of about 84,000 acre-feet, not including Flathead Lake, from which pumping will be required. Water was first furnished on the Jocko and Mission divisions of the enlarged project in 1910, and the Camas in 1917. The completed project contemplates the construction of about 900 miles of canals, laterals, and sublaterals with capacities of 50 to 300 or more second-feet each.

1141. The soil of the project varies from light sandy to heavy clay. It is very retentive of moisture, except in the Jocko Valley, where it is shallow and underlain with gravel. The crops are largely hay and grain with some vegetables and fruit. Wheat of the best quality is produced. Cattle raising is an industry of some proportions. Farm units are limited to 160 acres; irrigated portions average about 40 acres (based on an unpublished report dated Oct. 29, 1917, by Harold Conkling of the U.S. Reclamation Service). Net duty of water is  $1\frac{1}{4}$  to  $1\frac{1}{2}$  acre-feet per acre, except in the Jocko division, where it is about  $2\frac{1}{2}$  acre-feet, gross  $4\frac{3}{4}$ , owing to the porous nature of the subsoil. The irrigating season is from May 1 to September 30, 153 days.

1142. The following information relative to the Flathead project is from an unpublished report by W. S. Hanna, supervising engineer, United States Indian Irrigation Service, prepared for this Department, April 30, 1931.

The Flathead irrigation project is divided into three primary divisions. These divisions were largely brought about by the geographical location of the various irrigable portions of the Flathead Reservation and all project records as to acreages, and cost-account matters have been kept subdivided on this basis.

The three divisions are the Jocko, Camas, and Mission Valley.

The last-named division is quite large and is subdivided into a number of subdivisions. For the purposes of this report, these subdivisions are disregarded and the Mission Valley division is considered as a single unit for the reason that the water supply, storage reservoirs, supply canals, and distribution systems are so overlapping and interlocking that it is impracticable to consider this division other than as one unit.

The gravity water supply for the Mission Valley division is obtained from a number of streams rising in the Mission Range Mountains and flowing westward to the Flathead River. A feeder canal about 45 miles in length has been constructed along the eastern boundary of this division and along the foothills of

the Mission Range, this feeder canal intercepting and carrying northward the waters discharged by a number of streams. This water is distributed to various storage reservoirs lying below the feeder canal. From this feeder canal and from the various reservoirs, water is distributed to approximately 100,000 acres of land. Since the available supply of gravity-flow water is insufficient for the ultimate needs of this area, additional supply will be provided by pumping from the Flathead River at a point near Polson, Mont.

The Jocko division receives its water supply from the Jocko River in the south part of the Flathead Reservation. No storage reservoirs available for use of the Jocko division lands have as yet been constructed, but a small storage site will probably ultimately be utilized on the headwaters of the Jocko River.

The Camas division lies to the west of the Flathead River and receives its water supply from the Little Bitterroot River, a tributary of the Flathead. There are three constructed storage reservoirs now being utilized in connection with this division.

The area that has been considered ultimately irrigable in the Mission Valley division is 100,000 acres, of which approximately 88,000 acres are now under constructed canals. Work on this division was begun in 1909 and has continued intermittently up to the present time. The average run-off of gravity water available for use on this division is approximately 175,000 acre-feet. At the present time, storage capacity is available for 54,625 acre-feet. There are 716 miles of constructed canals and laterals in the Mission Valley division at the present time. During the season of 1930, a total of 33,874 acres was irrigated on this division.

The estimated cost of the completed Mission Valley division is \$6,057,550, or a total per-acre cost of \$61. The total amount expended to June 30, 1930, for construction on this division was \$4,206,891.86.

Up to June 30, 1930, a total of \$70,136.18 construction cost repayments applicable to the Mission Valley division, had been collected and on the same date, operation and maintenance collections totaled \$422,114.52.

Construction cost assessments for the greater portion of the irrigable land in the Mission Valley division has been fixed by public notice at \$1.12 per acre per annum. This applies to all Indian-owned land and to all white-owned land that is included in the corporate area of irrigation districts in this area. For white-owned land under the Project Irrigation System, but which is not included in the corporate area of the irrigation district, the assessment rate is 5 percent per annum of the estimated completed cost per acre for construction. The estimated amount used for this purpose is \$65.

Operation and maintenance assessments are, in general, made on an acre-foot basis, with a certain minimum charge per acre of irrigable land under constructed works. During the season of 1930, there were several different assessment rates in effect, due, principally, to the varying status of lands in this district. At that time, certain portions of the land were in an irrigation district that had signed a repayment contract and a lump-sum assessment equivalent to the estimated cost of operation and maintenance for the area included in the irrigation district was assessed. The assessment against lands in the same general area but not included in an irrigation district that had executed a repayment contract was fixed at a minimum charge of 82 cents per acre of irrigable land under constructed works which allowed delivery of  $1\frac{1}{2}$  acre-feet of water. For all deliveries above  $1\frac{1}{2}$  acre-feet, an additional charge of 75 cents per acre-foot was made. For that portion of the Mission Valley division south of Post Creek, a minimum charge of 60 cents per acre of irrigable land under constructed works was made, all water being measured and charged for at the rate of \$1 per acre-foot for the first acre-foot received and 50 cents per acre-foot for all additional water.

The average per-acre cost to water users in this area of the project was approximately \$1 per acre for the season.

The Camas division of the Flathead project is considered to cover 11,000 acres as ultimately irrigable, this entire area being considered under constructed works. Construction work was started on this division in 1916. The average run-off available for use on the Camas division is estimated to be 25,000 acre-feet. There are now constructed and available for use, storage reservoirs having a capacity of 32,000 acre-feet. There are 93 miles of constructed canals and laterals in this division. During the season of 1930, a total of 5,388 acres was irrigated. The estimated cost of this completed unit is \$1,101,960, or a per-acre cost of \$100. There has been expended to June 30, 1930, a total of \$1,046,110.80. A total of \$9,720.03 construction repayments, had been received up to June 30, 1930, and operation and maintenance assessments to the same date amounted to \$22,125.35.

Construction cost assessments for lands in the Camas division that were included in the irrigation district that has signed a repayment contract have been fixed at \$1.12 per acre. The same charge applies to Indian lands, but for white-owned lands not included in the irrigation district, the assessment rate is based on 5 percent per annum of the estimated completed per-acre cost. The total per-acre cost to be collected from lands in the Camas division is \$65 per acre as applied to Indian land and to white-owned land included in the irrigation district. Congress has made provision for other means of reimbursement for the cost in excess of \$65 per acre.

Operation and maintenance assessments in this division are made on the same basis as lands in the Mission Valley division.

The Joeko division includes an ultimate irrigable area estimated to be 13,500 acres. Construction work was begun on this division in 1909. The run-off of the streams supplying the Joeko division is approximately 170,000 acre-feet, a large percentage, however, being during the spring flood period, the natural flow becoming quite small during the latter part of the irrigation season. No storage reservoirs have been constructed to date for this division. There are 85 miles of constructed canals and laterals included in the Joeko division. During the season of 1930, a total of 4,613 acres was irrigated. The estimated cost of the completed Joeko division is \$524,900, or a total per-acre cost of \$39. There has been expended to date for construction on this division a total of \$220,222.98.

Construction cost repayments to June 30, 1930 amounted to \$10,240.04. Operation and maintenance payments to the same date amounted to \$27,198.23.

Construction cost assessments on the Joeko division have been fixed at 5 percent per annum of an estimated total construction cost of \$40 per acre.

There is some variation in the operation and maintenance assessment rate under this division but the average rate is a minimum charge of 50 cents per acre of land under constructed works, the final charge being based on an acre-foot basis at a charge of \$1 per acre-foot for the first acre-foot of water delivered and 50 cents per acre-foot for all additional water used. The maximum charge allowable against any individual is \$2 per acre of land under constructed works.<sup>68</sup>

The Flathead irrigation project was constructed by the United States Government from reimbursable congressional appropriations, all expenditures being a lien against project lands.

Approximately 20 percent of the irrigable area of the Flathead project is trust patent Indian allotments, the remainder being lands in white ownership acquired either by homestead entry or by the purchase of Indian lands.

Practically all of the white-owned lands on this project are included in irrigation districts. Three separate districts have been organized; namely, the Joeko Valley irrigation district, including all the irrigable lands in the Joeko Valley, the Flathead irrigation district, including the Camas division and all that portion of the Mission Valley division that lies north of Post Creek and the Mission irrigation district, which includes the white-owned lands in that portion of the Mission Valley division lying south of Post Creek.

Various congressional acts have carried provisions for certain benefits to such of these irrigation districts as have executed repayment contracts with the United States, and, at the present time, the Flathead irrigation district and the Mission irrigation district have executed such contracts. The benefits to accrue to land owners in the irrigation districts that have executed the repayment contract consist principally in much more favorable construction cost repayment terms, in the definite assurance of further necessary construction work being done, and in the securing of certain benefits, financial and otherwise, from the use of electric energy and the sale of electric energy that is available for use or disposition by the Flathead irrigation project.

Until the irrigation districts execute the repayment contract provided for by legislation, no further construction work is permitted within the area of that district, the district lands are subject to much more severe construction cost repayment terms and no benefits can be allowed to such areas from use or distribution of power.

The ultimate irrigable area figures given in this report are those that have been carried in the project records for many years. A classification of project lands has recently been made and when this classification becomes fully effective some changes in ultimate irrigable areas will be made.

<sup>68</sup> For duty of water see par. 1141 above.

## (D) STATE IRRIGATION ACTIVITIES

1143. In common with all Western States having arid lands within their borders, the States in the Columbia River drainage area have always actively encouraged irrigation. Although the States of Oregon, Idaho, and Montana, as well as Washington, have from time to time passed various acts for the purpose of stimulating irrigation development, yet, in the present report, the State of Washington will be given principal consideration because in matters of irrigation that State is the one directly concerned with the Columbia Basin irrigation project.

1144. In 1889, when the citizens of the State of Washington met to draft their State constitution, they provided in article XXI, section 1, that, "The use of waters of the State for irrigation \* \* \* shall be deemed a public use." The State has always been ready, to a limited extent, to aid the promoter of irrigation development, whether individual, corporate, or Federal. Its laws have not always been wise, but this may be attributed to inexperience and the lack of precedents in the development of large scale irrigation enterprises. The year 1898 marks the beginning of a systematic organization of irrigation activities in the State of Washington, and especially the inception of the irrigation district idea. The State laws, originating at that time, with subsequent amendments have developed into the "District Law" of today. Briefly stated, the irrigation district is the result of the legislative application of the public municipal idea to the needs of irrigation. Properly worked out, it removes numerous difficulties which cling to other forms of organization. Yet, in spite of its many advantages, the irrigation district is not a panacea or cure for all irrigation troubles.

1145. During the session of the Washington State Legislature in 1917 there was created the office of State hydraulic engineer, subsequently called supervisor of hydraulics, whose duty is to supervise the appropriation, diversion and use of all public waters within the State. This was followed by the Reclamation Act and Land Settlement Act of 1919, under which was created the State Reclamation Board, subsequently succeeded by the State Department of Conservation and Development, and the Reclamation Bond Certification Act of 1923. A State Reclamation Service was authorized, and a reclamation revolving fund was created to purchase the bonds of properly organized irrigation districts, to supervise the construction of the works, and to resell the bonds whenever they should become salable in the general market. Under the State Reclamation Service, about 40 irrigation, drainage, and diking projects have been investigated. The State has purchased bonds of several of these projects and has advanced funds to various districts for investigation and construction expenses. However, it is admitted that, notwithstanding what may have been accomplished in other ways, financially the State's ventures in reclamation thus far have not been markedly successful.

1146. The State Legislature in 1927 passed a supplemental Reclamation Act, among the other provisions of which were the following:

Reclamation districts including an area of not less than 1,000,000 acres of land may be created and maintained in this State, as herein provided, for the reclamation and improvement of arid and semiarid lands situated in such districts.

Such reclamation districts may be organized and maintained for any or all of the following general purposes:

1. The construction or purchase of works or parts of same for the irrigation of lands within the operation of the district.
2. The reconstruction, repair or improvement of existing irrigation works.
3. The operation or maintenance of existing irrigation works.
4. The construction, reconstruction, repair or maintenance of a system of diverting canals or conduits, from a natural source of water supply to the point of individual distribution for irrigation purposes.
5. The execution and performance of any contract authorized by law with any department of the United States or any State therein for reclamation and irrigation purposes.
6. The performance of all things necessary to enable the district to exercise the powers granted in this act.

1147. As has been previously noted, the projects susceptible of easy and low-cost development have been largely taken up, thus leaving only relatively high-cost undertakings for the future, undertakings which will be of doubtful interest to private capital. It is evident that ultimately the entire agricultural area of Washington will need to be completely developed. Since the probability of interesting private capital in the remaining undeveloped reclamation enterprises is remote, it appears that public agencies, State or Federal, or preferably both cooperating together, must assume the responsibility of carrying the larger projects through their development periods. This undoubtedly will involve much additional legislation, as the inadequacies of the present laws are demonstrated.

1148. While the larger irrigation activities have been centered about projects of the Federal Government, yet numerous smaller ones have developed in conformity with the district organization, or district law, of the State. Notable among these lesser ones are the developments in the Wenatchee district, and in the Okanogan and Methow Valleys.

#### 1. WENATCHEE DISTRICT

1149. The Wenatchee district, in the geographic center of the State of Washington, includes about 28,000 acres of irrigated lands out of a possible 60,000 acres of irrigable area, largely supplied with water from Wenatchee River and its tributaries. The cultivated district is about 35 miles long and 1 to 5 miles wide. Elevations of the irrigated lands range from 600 to 1,500 feet above sea level. The climate is mild. The temperature range is between 0° and 110° F. Annual precipitation is 10 to 15 inches. Snow lasts from 4 to 10 weeks. Rail transportation is afforded by the main transcontinental line of the Great Northern Railway. The Sunset Highway, connecting Spokane with the Puget Sound cities, passes through Wenatchee.

1150. Irrigation was first practiced with the coming of the white men in the year 1870, when a small quantity of water was diverted from Squillchuck Creek. The first nursery stock was set out in 1873. The Great Northern Railway was constructed through the valley in the early nineties. Not much irrigating was done until 1903, when the high-line canal was built.

1151. The soil is deep volcanic ash containing iron, potash, and nitrates; other constituents are disintegrated granite and lava. Apples are the principal crop, of which the average yield of 500 boxes to the acre is said to be higher than in any other part of the world. The best orchards produce as many as 1,000 boxes to the acre. Soft fruits (apricots, peaches, pears), berries, and melons are

produced in considerable quantities. Dairy and poultry products are also important items of commerce.

<i>Crop production, 1928</i>	<i>Value</i>
Apples (20,000 cars)-----	\$20,000,000
Soft fruits-----	2,000,000
Vegetables, berries, and melons-----	2,250,000
Dairy and poultry products-----	2,000,000
Total-----	26,250,000

1152. The orchard units are mainly 5 to 20 acres each. From the best information available the net duty of water averages about 1½ feet. The average frost-free period is April 23 to October 15, 175 days.

#### 2. PRIVATE PROJECTS, OKANOGAN AND METHOW VALLEYS

1153. In Okanogan County, in addition to the Government project, there are private and corporate projects totaling about 41,000 acres of irrigated lands, out of a possible 84,000 acres of irrigable area. The principal ones, organized as irrigation districts, are Methow, Okanogan, Bonaparte, Whitestone, West Okanogan, Pateros, Methow Valley, and West Side Methow. These lands extend northward from the Columbia River to the Canadian boundary in the valleys of the Okanogan and Methow Rivers. For the most part the lands lie in benches high above the river beds at elevations of 800 to 2,000 feet above sea level. The temperature range is between -10° and 108° F. The mean annual precipitation is 12 inches.

1154. But little storage is provided. Diversion is effected by simple structures, some of concrete. Many of the ditches are short and inexpensive. The soil, especially in the Methow Valley, is somewhat heavier than in most other irrigated areas, and ranges from clay to gravel. Fruits, principally apples, pears, peaches, and berries, are the best crop. Dairying is an important industry. The duty of water is variable, but probably averages about 2½ to 2¾ feet.

#### (4) POSSIBLE IRRIGATION DEVELOPMENT--I. EARLIER INVESTIGATIONS

1155. The greater portion of the Columbia Basin is arid in character; a semiarid and relatively small area in the southern and eastern part of Washington is successfully cultivated by dry-farm methods.

1156. In the arid region, the necessity for irrigation has been recognized since the first land settlement. As a result, the first land settlements were made on the lowlands bordering the streams or adjacent to springs which afforded a water supply for irrigation. These early settlements were located in such a manner that the pioneer was able to construct the necessary irrigation works through his own efforts and those of his family. These favorable locations were relatively few in number, and, as the population of the State increased and the value of farm products and lands advanced, more ambitious plans of irrigation were proposed with a view of reclaiming the higher, but just as desirable, lands. These larger projects were at first attempted by a group of farmers pooling their efforts in constructing the necessary ditches leading from the source of water to the lands.

1157. The projects that could be developed in this manner were eventually completed and other plans of financing and developing the larger and more expensive projects were necessary. Irrigation and

canal companies were formed in many sections for the reclamation of desirable areas. These companies were generally financed by eastern people who hoped to be recompensed through the sale of, or annual rental of, water rights. The projects developed along these lines were generally successful as far as the farmer was concerned, but unsuccessful from the investor's standpoint.

1158. This system proved to be inadequate except for relatively small areas where the cost of reclamation was low, and we find it followed by the enactment of Federal and State laws making provision for the reclamation of public and private lands.

1159. The first of these, known as the "Carey Act", was made effective August 18, 1894. This was followed by the law creating what is now known as the United States Bureau of Reclamation, providing for the advancing of funds for the reclamation of the public lands. The Reclamation Act was followed in many Western States by a law permitting the creation of irrigation districts for the purpose of financing and constructing irrigation works under prescribed regulations.

1160. Turning for a moment from the arid region to the area in the southern and eastern part of the State of Washington, where dry farming is successful, we find that the more venturesome farmer had been settling along the border and outskirts of this successful dry-farm area, and, during a cycle of years when the rainfall was above normal, that the entire tillable area extending to the Columbia River on the west and north, including the area known as the "Big Bend", had been settled and that some measure of success had been achieved in the production of wheat. When this wet cycle was followed by the inevitable dry cycle, the fallacy of this movement was discovered and a large portion of the area has been abandoned or farming is done with very unsatisfactory results.

1161. In an effort to extend the irrigable area in the arid regions and to afford relief for lands in the semiarid regions, a great number of projects have been proposed, examined, and studied by various interested agencies, private, corporate, district, State, and Federal.

1162. In preparing the present plan for the reclamation of lands in the Columbia Basin, the fullest possible use has been made of all available previous studies and reports. Some of the reports made on projects within the area in question have been made by individuals or corporations and are not available. Some deal with projects that have been constructed and are in operation and are of interest in this report only to the extent that they have demonstrated the value of irrigation and indicate the way to proper development; but the major portion deals with projects which, for various reasons, are still in the preliminary stages.

1163. The reports listed below have been made in connection with the possibilities of irrigating tracts within the Columbia Basin. A large number of these reports have been available in making the present study, some available in part, and some unavailable.

1. Palouse irrigation project (1904). A report on reservoir plans made by Christian Anderson for the United States Geological Survey. Report published, Fourth Annual Report, United States Reclamation Service.

2. Palouse irrigation project (1904). A general engineering report by H. N. Savage, J. H. Quinton and T. A. Noble for the United States Reclamation Service. Report published, Third Annual Report, United States Reclamation Service.

3. Palouse irrigation project (1905). Soil report made by Thomas H. Means for the United States Department of Agriculture. Report published.

4. Quincy Valley project (1910). A report on general engineering features of Quincy Valley and including water-supply studies of Clark Fork River, Pend Oreille Lake, Spokane River, ground water and artesian supply. This report by Joseph Jacobs for the Quincy Valley Water Users Association. Report unpublished.
5. Quincy Valley project (1911). A soil survey by A. W. Mangum, Cornelius Van Duyne and H. L. Westover for the United States Department of Agriculture. Report published, Thirteenth Report, Bureau of Soils, United States Department of Agriculture.
6. Quincy Valley project (1912). A preliminary report covering various phases of the project; geology by Henry Landes, soil survey by A. W. Mangum, soil analysis by H. K. Benson, climatic studies by E. J. Saunders, irrigation by Joseph Jacobs. Report published in Washington Geological Survey Bulletin No. 14.
7. Palouse project (1914). A soil survey of Franklin County, Wash., by Cornelius Van Duyne for the United States Department of Agriculture and the State of Washington. Report published, Sixteenth Report, Bureau of Soils, United States Department of Agriculture.
8. Quincy Valley project (1915). A preliminary report on engineering features of an area of 400,000 acres in Quincy Valley. Made by L. M. Rice & Co. for the Quincy Valley Water Users Association. Report unpublished.
9. Five Mile project (1916). A preliminary report on power development at Five Mile Rapids and the irrigation of 73,500 acres near Pasco. Report by E. G. Hopson, sponsor unknown. Report unpublished.
10. Palouse irrigation project (1916). A cooperative report on general engineering features by D. C. Henny, Charles. H. Swigart for the United States Reclamation Service, Marvin Chase and J. C. Ralston for the State of Washington. Report unpublished.
11. Palouse irrigation project (1916). A soil survey by H. F. Holtz for United States Department of Agriculture. See Washington State College Bulletin No. 133.
12. Five Mile project (1920). A report on duty of water. A cooperative report. J. H. Lytle for the United States Reclamation Service, Marvin Chase, State hydraulic engineer, for the State of Washington. Report unpublished.
13. Columbia Basin project (1920). General engineering report and estimate of cost of the Columbia Basin irrigation project prepared by the Columbia Basin Survey Commission for the State of Washington under authority of an act of the Legislature of the State of Washington approved March 1, 1919. This report is supplemented by a large number of unpublished detail line topographic sheets, canal profiles, land classification data, etc. Report published by State of Washington.
14. Columbia Basin project (1920). A review of the report of the Columbia Basin Survey Commission by D. C. Henny, James Munn and C. T. Pease for the United States Reclamation Service. Report in manuscript form.
15. Marginal areas (1921). A report by John B. Fiske for the Great Northern Railway Co., outlining small tracts along the Columbia River between Kettle Falls and Chelan. Report unpublished.
16. Columbia Basin project (1921). A document by the Columbia Basin Survey Commission relative to criticism of Report No. 13. Report unpublished.
17. Greater Wenatchee-Quincy irrigation project (1922). A general report on a plan of irrigating the Greater Wenatchee area and 50,000 to 100,000 acres in the Quincy tract. Report by Lars Langloe for the State of Washington. Report unpublished.
18. Greater Wenatchee-Quincy project (1922). A report on plan for irrigating lands in Wenatchee Valley and on Quincy tract. Report unpublished. (Report prepared for State of Washington by Lars Langloe).
19. Columbia River Pumping and Power project (1922). A report by Willis T. Batcheller on the pumping plan of reclaiming the Columbia Basin irrigation project and the development of commercial power. Report prepared for the State of Washington. In manuscript form.
20. Columbia Basin project (1922). A report by George W. Goethals and Co., Inc., relative to the Columbia Basin irrigation project. This report is in published form and was prepared for the State of Washington.
21. Priest Rapids-Highland project (1922). A report by Quinton, Code, and Hill for the Washington Irrigation & Development Co. covering a project of 100,000 acres below Priest Rapids and on the north and east side of Columbia River. This irrigation development was to be made in connection with a proposed power

development at Priest Rapids. This report is not available. A promotion prospectus only was available.

22. Uses of the Columbia River (1924). A report to Federal Power Commission on the best use of the waters of the upper Columbia River by a board consisting of—

J. B. Cavanaugh, colonel, Corps of Engineers, United States Army,

D. C. Henny, consulting engineer,

F. F. Henshaw, district engineer, United States Geological Survey,

C. S. Heidel, State engineer, Montana,

W. G. Swendsen, commissioner, Department of Reclamation, Idaho,

Marvin Chase, supervisor of hydraulics, Washington.

Report published by Federal Power Commission.

23. Columbia Basin project (1924). A general engineering report and estimate on the Columbia Basin irrigation project by Homer J. Gault for the United States Reclamation Service. This report deals with all phases of various plans for irrigating this area and was accompanied with numerous maps, plans, etc., and appendices dealing with the land classification, soil survey, geology, and water supply. Report printed; Senate committee print, Sixty-ninth Congress, second session.

24. Columbia Basin project (1924). A review of the Gault report (No. 23) by A. J. Wiley, James Munn, and J. L. Savage for the United States Reclamation Service. Report printed; Senate committee print, Sixty-ninth Congress, second session.

25. Columbia Basin project (1925). A general engineering report and estimate of various plans of development of the Columbia Basin project, prepared for the United States Bureau of Reclamation by Louis C. Hill, Joseph Jacobs, Charles H. Locker, Richard R. Lyman, Arthur J. Turner, O. L. Waller. Report printed; Senate committee print, Sixty-ninth Congress, second session.

26. Rathdrum Prairie (1927). A report on reconnaissance of various plans for irrigating Rathdrum Prairie, with preliminary estimates. Report by W. G. Sloan for State of Idaho. Report unpublished.

27. Columbia Basin project (1928). A report on soil and economic conditions by B. E. Hayden, reclamation economist, Bureau of Reclamation, and Prof. George Severance, head of department of farm management, State College of Washington. Report published by Department of Interior.

28. Annual Reports of the United States Reclamation Service (later, Bureau of Reclamation). All published reports since that of 1902.

## II. PRESENT INVESTIGATION

1164. Recognizing the generally accepted principle that in the arid regions irrigation has a preferential claim upon the water supply, it is manifest<sup>69</sup> that any comprehensive study of the Columbia River must make provision to reclaim all irrigable land within the basin that would depend, in whole or in part, upon that stream for its water supply. Plans were, therefore, made for the reclamation of such areas, listed below, to determine the ultimate demands that will be made upon the Columbia for water. While irrigation of these lands may or may not be feasible at this time, provision must be made for their reclamation when conditions justify the development. That the waters of the Columbia River, which will eventually be required for irrigation, may not be permanently appropriated to power or other use, it is necessary to determine at this time the ultimate irrigation requirements and points of diversion. Determination of these questions is the objective of the irrigation section of this report.

1165. The areas listed include the irrigable lands within the Columbia Basin, tributary to the river except possibly a few small areas that may eventually be reclaimed through individual effort and which will have an inappreciable effect on the water supply. In the study of those areas where diversion is made by pumping, unless otherwise

<sup>69</sup> Uses of the Columbia River (1924) Cavanaugh report (no. 22 above) p. 24.

specifically treated, the feasibility of the project and the cost of development is determined in the manner set forth under the heading, Economics of pumping, in part III of this report on the Columbia River as prepared by the district engineer, Portland, Oreg., district.

1166. (a) *Tracts considered.*--

- |                          |                    |
|--------------------------|--------------------|
| 1. Rathdrum Prairie      | 7. Pasco           |
| 2. Little Spokane Valley | 8. Palouse         |
| 3. Methow-Okanogan       | 9. Lind            |
| 4. Greater Wenatchee     | 10. Hanford        |
| 5. Quincy                | 11. Marginal areas |
| 6. Priest Rapids         |                    |

(B) IRRIGATION OF INDIVIDUAL AREAS

1. RATHDRUM PRAIRIE

1167. The irrigable area of Rathdrum Prairie is located in Kootenai County, Idaho, and is bounded on the east by the Chilo Mountains, on the south by the Spokane River, on the west by the Idaho-Washington State line and a mountain spur extending north and south and on the north by a line extending approximately east and west through the town of Athol. (See plate no. 3, p. 591.)

1168. The principal city in the area is Coeur d'Alene, the county seat, located in the southeastern corner of the tract. The town of Post Falls is located on the southern border, and the town of Rathdrum in the central portion of the dry-farming area.

1169. The tract is well provided with transportation facilities. The main line of the Northern Pacific Railway bisects the tract, from southwest to northeast; the Spokane International Railroad, a subsidiary of the Canadian Pacific, generally parallels the Northern Pacific; a branch line of the Chicago, Milwaukee, St. Paul & Pacific Railroad, from Spokane to Coeur d'Alene, extends along the south edges of the tract with parallel service by an electric interurban railway between the same points. Another branch line of the Chicago, Milwaukee, St. Paul & Pacific Railroad extends along the western edge of the project from Spokane to Newport and Metaline Falls. The two main State highways cross the project.

1170. Kootenai County has been a lumbering country from its earliest development. As the timber was removed, the land has been cleared and placed under cultivation and the desirable areas were eventually fully settled and efforts were made at farming by the dry-farm method.

1171. The Coeur d'Alene Mountains, which border Kootenai County and the surrounding region on the east, protect the region from the cold easterly winds. The region, however, is subject to quite varied temperatures. The summer months as a rule are dry. The temperature is not oppressive during the day, and the nights are characteristically cool. The mean annual temperature, according to records of the United States Weather Bureau at Coeur d'Alene is 41.1° F. The mean temperature for January, the coldest month, is 26.3° F., and for July, the warmest month, 67.3° F. The records show an absolute annual range of 118°, or from 102° F., in July as a maximum, to -16° F. in January, as a minimum. The cold spells of the winter months are usually of short duration, and are quite commonly followed by warm dry winds, known as "chinooks," which break up the cold weather and melt the snow quickly. The fall

months are characterized by a rainy period lasting for 2 weeks or more, followed by cool to cold weather. Snow lies on the ground for 2 to 6 weeks during midwinter. The spring months are usually rainy.

1172. The average annual precipitation at Coeur d'Alene is 24.90 inches. There is a gradual increase in the precipitation from the west county line to the east, the amount ranging from 20 inches along the west border to more than 24 inches in the more mountainous sections of the eastern part of the county. Most of the precipitation comes during the winter months, the mean precipitation for December, January, and February being 9.51 inches. The summer months are quite dry, the mean precipitation for June, July, and August being 2.74 inches. The distribution of precipitation is favorable for grain and hay harvesting. Although the rainfall during the summer months often is not sufficient for good crop yields, complete crop failures from drought are unknown.

1173. The average date of the last killing frost in the spring is May 5, and that of the first in the fall October 1. This gives an average growing season of 149 days, which is ample for the maturing of the general farm crops grown in this region. Frosts often occur on some of the valley floors earlier than on the adjacent upland slopes.

1174. The dry farms of the prairie are devoted chiefly to the production of grains with a limited effort toward producing alfalfa and clover. Due to the shortage of rainfall during the growing season, the yields have been small, although complete failures due to drought are unknown.

1175. The insufficiency of the rainfall during the growing season has led to efforts on the part of the land owners to supplement the rainfall by irrigation. As a result of these efforts, six districts have been developed along the Spokane River and in the vicinity of Hayden Lake which have placed about 11,000 acres under irrigation, and the results as far as production is concerned have been satisfactory. In most cases, however, the water supply has been limited, and the cost of water for irrigation on purposes has been high. Two of these districts secure their supply through gravity systems diverting from lakes and creeks and four by pumping from Hayden Lake. The demand on these small lakes has been excessive and as most of the distributing systems consist of low-pressure pipe lines the operation and maintenance costs have been high, and power for pumping purposes purchased at the commercial rate has placed the annual cost of operation at a rate that is burdensome to the farmer.

1176. These districts cover but a small portion of Rathdrum Prairie and repeated efforts have been made in past years to reclaim the balance of the project. Water may be supplied for the balance of the area from only four sources.

First. By gravity from Priest River.

Second. By pumping from Pend Oreille Lake.

Third. By pumping from Coeur d'Alene Lake.

Fourth. By pumping from underground supply.

1177. In 1927 an examination and investigation, sponsored by the State of Idaho, was made covering this area. This reconnaissance gave 60,000 acres as the area of irrigable land under a gravity diversion from Priest River. This gravity diversion was considered by

that agency as the only plan worthy of investigation. The investigation lead to no estimate of cost of the proposed system, but outlined the work necessary to prepare such an estimate on the plan suggested as the only one of merit. This report assigned 3.00 acre-feet as the amount of water that would be required at the point of diversion to insure a delivery of 1.8 acre-feet at the land, the amount considered necessary to supplement the natural precipitation.

1178. In connection with the present report consideration was given the reclamation of this area. A reconnaissance was made of the project and a general determination was made of the area which will eventually require a water supply.

1179. As a result of this reconnaissance the net irrigable area was placed at approximately 40,000 acres, and, due to the general gravelly character of the subsoil, 2.5 acre-feet at the land was considered as required even though the irrigation season be a short one.

1180. Any development on this area will be relatively expensive, and, due to the character of the soil, it will doubtless be necessary to concrete line all or practically all of the canal system. With a lined system a gross diversion of 3.00 acre-feet per season for each acre served would be a generous but safe allowance.

1181. The comprehensive development of the water of the Columbia River will provide an abundance of secondary power, the logical use of which would be the pumping of irrigation water, as the demand for the irrigation water existed at the time the power is available.

1182. If the power development on Columbia River is advanced to the point where this secondary power is available for pumping purposes at the time the Rathdrum Prairie is brought under irrigation, tentative estimates have shown that it will be less expensive, both as to first cost and cost of operation, to provide a supply by pumping from Pend Oreille Lake at Solitaire Bay, through a head of 400 feet, to a saddle immediately to the west, from which point the water may be conducted by gravity to the lands of the project rather than resort to a gravity system with a diversion from Priest River. It is not considered feasible to reclaim any large part of the Rathdrum area by pumping from Coeur d'Alene Lake. Coeur d'Alene Lake is located at the southern edge of the area in question, and an expensive side hill canal, many miles in length, would be required to carry the water northward to a point from which the water might be carried by gravity to the lands to be reclaimed.

1183. The plan of providing a water supply by pumping from the underground supply was not considered worthy of further investigation by the State of Idaho in their examination of the project. This conclusion is doubtless a proper one, as any development by that manner would be expensive and the probability of securing an underground supply that could be recovered at a reasonable cost and that would prove adequate is a very remote possibility.

1184. The gravity plan as outlined by the State of Idaho requires a main canal 60 miles in length extending from the point of diversion on Priest River to a point at the head of the project that is practically identical with the point of discharge of the pipe lines leading from a pumping plant in Solitaire Bay. This 60 miles of main canal would be over an area where canal construction would be difficult and expensive. A large proportion of the canal would be along steep side hills and a large percentage of solid rock excavation would be

encountered. Many concrete and steel structures would be required, including a long siphon under high head crossing the Clark Fork.

1185. Whether the final development on this project consists of the gravity plan or the pumping plan is of no importance in reaching the conclusion desired for this report.

1186. Whether the 120,000 acre-feet which will be required for this area, when developed, is diverted from Pend Oreille Lake by pumping at Solitaire Bay or whether it is diverted from Priest River by a gravity system will have the same identical effect on the Clark Fork at Albany Falls, the first possible development on that stream. The water-supply studies in this report make allowance for the ultimate diversion of 120,000 acre-feet from Pend Oreille Lake or from Clark Fork above Albany Falls.

## 2. LITTLE SPOKANE VALLEY

1187. There are about 30,000 acres of land in the Little Spokane River Valley that are susceptible of irrigation that are not considered in the present plans for the reclamation of arid lands. (See pl. no. 3.)

1188. These lands are in private ownership and have been for many years. The soil, climate, rainfall, and other conditions are such that dry farming is practiced with some measure of success, and it is questionable as to whether or not the increased production due to irrigation would be commensurate with the cost involved. It is also very doubtful if the landowners are interested in irrigating these lands.

1189. For the above reason, these lands have not been seriously considered in connection with the irrigation development with which this report is concerned. However, should irrigation be desired for these lands, a relatively small amount of water would be required and they could be served from the irrigation systems planned later in this report for the Lind project, or for the gravity plan for the combined area referred to as the Columbia Basin irrigation project, at per-acre costs as estimated for those projects. If irrigated, the water requirement for this area would be small and is not considered in this report.

## 3. METHOW-OKANOGAN PROJECT

1190. The Methow-Okanogan project comprises an extension of the Okanogan project although the lands to be reclaimed are for the most part widely separated. (See pl. no. 3, p. 591.)

1191. The main body of the irrigable area is located on a series of benches on the west side of Okanogan River and extends northward from the confluence of this stream with the Columbia River for a distance of about 8 miles. Detached and more or less isolated areas of irrigable land extend from there to the southern boundary of the Okanogan project, where the Pogue Flat marks the northern boundary of the proposed project. Extending in a southwesterly direction from the main body, called the "Brewster Flats", are found other desirable, but more or less disconnected benches, the Indian Dam and Tupper Flats, the latter ending just north of Pateros. The Pateros Flats form the southern boundary, ending about 4 miles south of Pateros. In addition, there are a number of isolated small tracts on the benches along the east bank of the Methow River. The aggregate of these

areas is about 18,000 acres. Included within this area is a tract on the Brewster Flats consisting of 1,500 acres that was reclaimed during 1912 and 1913 by a private irrigation company, later formed into the Okeh irrigation district. Water supply for this area was secured from a storage reservoir located on a small creek about 7 miles from the project. The entire area was under cultivation at one time, but a shortage in water supply has caused the abandonment of a large portion of the higher areas, and the lower portion of the tract, consisting of about 500 acres, secures a water supply by pumping from the Columbia River.

1192. Efforts have been made during past years to develop a satisfactory plan of reclaiming the lands in the Methow-Okanogan project. A district organization was perfected and studies and surveys prepared by the State of Washington on behalf of the district.

1193. Due to the fact that this land is located on the higher benches and plateaus, it is impossible to secure a water supply by a gravity diversion from the Columbia River. The low-water supply available from the Okanogan River is fully utilized at present, and suitable sites for storage are not available. The remaining source of a gravity supply is from the Methow River, where sufficient storage may be developed to meet the seasonal requirements of the lands on the project. The plans as developed for the reclamation of this area covered a gravity project with a diversion from the Methow River at a point near Twisp. The details of this plan are not available at the present time and little is known of the details of this proposed plan of development. The present study includes no estimate of the cost of this proposed gravity development but due to the length of the canal system and character of the area crossed, the per-acre cost of the land reclaimed will be high.

1194. This land will doubtless stand a high cost for irrigation water as it is particularly adapted to fruit growing. An economic study of this area prepared in 1926 by A. Weiss and W. W. Johnston for the United States Bureau of Reclamation stressed its importance as an apple-growing district and predicted that the entire area, when reclaimed, would be devoted to the production of apples.

1195. As the plan considered for reclaiming this area proposes a gravity diversion from the Methow River, supplemented by storage that would be accumulated during the flood period, but little effect would be made on the flow of the Columbia River below its confluence with the Methow River.

1196. Included in the marginal areas discussed in paragraph 1321 are certain areas that may be reclaimed by pumping from that stream. Of these areas, about 5,000 acres are included that might be reclaimed by the proposed gravity system from the Methow River.

1197. The cost of the gravity system from the Methow River is of interest at the present time only insofar as it might indicate the source of the water supply for the 5,000 acres in question. The area involved is so small that whether final development incorporates the area in the gravity system or whether it be reclaimed by pumping from the Columbia River will have an insignificant effect on that stream.

#### 4. GREATER WENATCHEE PROJECT

1198. The greater Wenatchee project, as considered in this report, includes certain areas within the Wenatchee Valley above present

irrigation systems, certain lands in the Wenatchee-Malaga, in the east Wenatchee and Moses Coulee districts, aggregating an area of 20,000 acres, and the Quincy tract with an irrigable area of 320,310 acres located in the western part of Grant County. (See pl. no. 3, p. 591.)

1199. The total irrigable area of the project consists of 340,310 acres. The classification of the lands on the Quincy tract was determined in the manner outlined in a general discussion of the Columbia Basin irrigation project following in this report.

1200. The remaining 20,000 acres in the Wenatchee Valley and other districts, as noted above, was not classified for the present report. This irrigable area was fixed from the most reliable data available on the subject. Previous reports on the greater Wenatchee project give the results of certain land classifications of these areas. Reclassifications, made later, have resulted in revisions downward in the irrigable area. No detail information is available on this classification but the 20,000 acres used in this report represents the opinion of those most familiar with the territory. These areas are given only general consideration in this report, the major objective of which is the reclamation of the Quincy, one of the principal areas on the Columbia Basin irrigation project. The main canal leading to the Quincy area secures its water supply from the Wenatchee River and passes in the approximate vicinity of the tracts that constitute the 20,000 acres mentioned. The present estimate makes provision only for a water supply of 3 acre-feet per acre net, for those areas, and capacity in the main canal for carrying that water to points where it may be diverted into canals leading to the areas under consideration.

1201. The Quincy area represents about 95 percent of the area of the greater Wenatchee project and has been given the same consideration and treatment as has the Columbia Basin irrigation project. The irrigable area and water requirements for this area were determined in the manner described in the general discussion of the project which follows later in this report.

1202. The water supply for this project is secured from the Wenatchee River. The present unregulated flow of the Wenatchee River is not fully utilized during the low-water season in providing for the irrigation requirements of the present development in the valley.

1203. To provide an adequate water supply, the present plan includes regulation of the flow of the Wenatchee River by the construction of a dam across that stream about  $1\frac{1}{2}$  miles below Plains or 9 miles below the outlet of Wenatchee Lake. With regulation of Wenatchee Lake to elevation 1,980 by the construction of a dam at the site proposed, water supply would be available for the greater Wenatchee project after allowing 525 second-feet to flow down the river to meet the demand of existing rights.

1204. Two power plants are in operation on the Wenatchee river at the present time. The upper or Chumstick plant has an installed capacity of 525 second-feet while the lower or Dryden plant has an installed capacity not exceeding that of the Chumstick plant. Water by-passed the dam at the Wenatchee Lake reservoir to meet the demands of these power installations, is adequate to meet the irrigation demand on the river below the Dryden plant.

1205. In designing the present system, the same canal losses have been used as determined for the Columbia Basin irrigation project.

1206. No provision has been made for rediverted water on the project as it is believed the rediversions possible on the Quincy area were very limited in extent.

1207. Engineering treatment given this project is the same as that given the Columbia Basin irrigation project. The Quincy area forming the major area of the plan now under discussion is one of the important areas of the Columbia Basin irrigation project. In the comparative estimates for the different plans for that project, plan no. 6-A includes the identical project now under discussion, and forms a very important part. In order to place these various plans of development for the Columbia Basin irrigation project on a comparable basis, the present plan has been given the same consideration and treatment as is outlined more fully in a general discussion of engineering treatment of the Columbia Basin irrigation project, which follows later in this report.

1208. The system required for the development of the greater Wenatchee project consists of a dam for the regulation of Wenatchee Lake to elevation 1,980 and a main canal, consisting of a series of sections of open canal, tunnels and siphons from the Wenatchee Lake dam to a point on the Quincy area about  $3\frac{1}{2}$  miles northwest of Quincy, the end of the main canal.

1209. From the end of the main canal the main east is carried easterly to a point south of Ephrata and the main west is carried south to the Low Gap tunnel, and to the southern slope of the Frenchman hills. From these main laterals, diversions are made into the distributing system which serves the irrigable land within the project.

1210. The main-canal estimate is based upon a projection made on line topographic sheets prepared by the Columbia Basin Survey Commission, while the lateral and distributing systems have been estimated upon projections made on the United States Geological Survey quadrangles.

1211. *a. Main canal.*—Gravity diversions from Wenatchee River.

Area reclaimed by gravity, Quincy area.....	acres..	284, 090
Area reclaimed by supplemental pumping, Quincy area.....	do....	36, 230
Total area reclaimed, Quincy area.....		do.... 320, 310
Area provided main canal delivery only.....	do....	20, 000
Total area greater Wenatchee project.....		do.... 340, 310
Mean irrigation requirement at land.....	acre-feet per acre..	2. 94
Total seasonal requirement at land.....	acre-feet..	1, 001, 137
Capacity of main canal at head.....	second-feet..	3, 400
Diversions to Wenatchee areas.....	do.....	210
Capacity of main canal at bifurcation works.....	do.....	3, 190
Loss in main canal.....	do.....	64
Requirements at bifurcation works.....	do.....	3, 126

1212. Table no. 200 gives the monthly requirement at the land and the monthly requirement at the point of diversion after correcting for canal and reservoir losses. No water is rediverted on this project.

TABLE NO. 200.—*Water requirements for the greater Wenatchee project (acre-feet)*

Place	April	May	June	July	August	September	October	Total
At land.....	102,617	178,202	170,394	192,218	182,708	120,837	54,161	1,001,137
At bifurcation works.....	109,167	189,577	181,270	204,487	194,370	128,550	57,619	1,065,040
At diversion.....	111,402	193,460	184,982	208,676	198,350	131,183	58,799	1,086,852
Diversion requirements.....	111,402	193,460	184,982	208,676	198,350	131,183	58,799	1,086,852

NOTE.—No reservoir loss; no rediverted water.

1213. In designing the main canal no reduction in capacity was due to canal losses. The lower end of the canal will have a slight excess capacity.

1214. Following are the features listed geographically, which constitute the entire main canal and storage system for the greater Wenatchee project.

1215. Feature no. 1. Wenatchee Lake Dam. This structure would be located on the Wenatchee River about  $1\frac{1}{2}$  miles below Plains and about 9 miles below the mouth of Wenatchee Lake and effects the regulation of that lake and serves as a diversion structure from the river. This structure is of the rock-fill type.

1216. In connection with a combined plan of irrigation and power development involving the complete regulation of the Wenatchee River a plan was prepared of this structure with a top elevation of 2,015. For the purpose of the present plan, which is limited to irrigation, the structure was modified in dimensions to meet the requirements for regulation to elevation 1,980. For the purpose of preparing plans for this structure, a topographic survey was made of the dam site during the present investigation. (See pl. no. 22.)<sup>2</sup> No testing or drilling was done to determine foundation conditions, but a geological investigation was made to determine the suitability of the site.

1217. Regarding the geological features the report by Henry Landes is, in part, as follows:

At the dam site there is a sloping outcrop of bedrock on the east side, which reaches a height of about 50 feet above the water level. Beyond this point the rock is covered by a veneer of soil that has but a slight depth. The entire east end of the dam would rest upon rock in place. The formations are mainly conglomerate and sandstone with very little shale. The strata have a strike that is north and south, or in the same direction as the river at this place. The dip or pitch of the beds is about  $40^\circ$  to the west.

The bed of the river at the dam site contains rock similar to that on the east bank. The river has beveled off the strata and made a fairly smooth floor of conglomerate and sandstone over which it flows. There is no overburden at the dam site and at the date this examination was made (Oct. 21, 1930) the water was both low and clear, so that the bottom of the channel could readily be seen. The stream bed is smooth and without potholes or inequalities of any size.

On the west side of the Wenatchee no rock in place outcrops between the river bed and the foot of the mountain, nearly 3,000 feet away. Along the center line of the dam, across the terraces, the distance vertically to bedrock can be determined only by drilling. The rock is probably but a little way below the surface, because the erosion of the Wenatchee Valley in this locality has been done by the river only and not by glaciers. The glaciers which came down the White and the upper Wenatchee Rivers ended at the foot of Wenatchee Lake, where they left terminal moraines that created the lake. The glacier that descended the Chiwawa River came to an end before the mouth of that stream was reached. Since the valley cutting at the dam site was stream work only, the bedrock in the

<sup>2</sup> Not printed.

cross section is not likely to be any lower anywhere else than it is in the present channel. In other words, it is wholly unlikely that on the west side of the valley there is any former river course, once deeply carved in the rock and later filled and abandoned.

In order to determine the actual depth to bedrock it is suggested that a hole be drilled on the line of the dam, at a point about 1,000 feet west of the river bank. If bedrock should be reached at a depth of less than 40 feet, or the approximate level of the river bed, it would be wise to locate a second hole half way between no. 1 and the river, and a third one half way between no. 1 and the west end of the dam. The results from three holes would probably be enough to give the approximate depth to bedrock at the site now under consideration.

The formations which outcrop on the east bank and in the bed of the river would afford good materials for the support of a dam. The rocks have been derived from a disintegrated granite and the sediments have been laid down in a very compact manner. The percentage of voids is low and the soluble material of very limited extent.

1218. The outlet tunnel from the Wenatchee Lake Reservoir discharges directly into the main canal. The main canal extends from the outlet from Wenatchee Lake Reservoir to the bifurcation works at the head of the Quincy tract. It is 63.43 miles in length and for the greater portion of that distance is located over a rough, steep, rocky area where canal construction will be difficult and expensive.

1219. The main canal system consists of a series of canal sections, siphons, and tunnels, including a pressure tunnel of large proportions and high head crossing under Columbia River.

1220. The estimate for the main canal is based upon a projection made on line topographic sheets that were made in connection with the report prepared by the Columbia Basin Survey Commission. The various features, comprising the main canal system, are described in detail in appendix no. 5.

1221. The main canal system consists of 35.27 miles of canal, 7 siphons having a total length of 2.83 miles, 11 tunnels aggregating 23.93 miles and the pressure tunnel under Columbia River 1.40 miles in length.

1222. *b. Distributing system.*—At the bifurcation works the main canal is divided into the main east and the main west.

1223. The main east extends eastward along the north boundary of the Quincy tract to a point north of Moses Lake covering an area of 152,680 acres.

1224. The main west extends along the west boundary of the tract to Frenchman siphon, then easterly to the low gap tunnel. After passing through that tunnel it extends both easterly and westerly to cover the area south of Frenchman Hills. The main west covers an area of 167,630 acres.

1225. The main east and main west are located favorably from a construction standpoint. Except for the Great Northern siphon, Potholes siphon, Frenchman siphon, and low gap tunnel on the main west, no unusual features are involved, and construction would be relatively inexpensive.

1226. The estimates for these portions of the system are based upon projections made on the United States Geological Survey quadrangle sheets. The various features constituting the system are described in detail in appendix no. 5, and the detail estimates are given along with those of the main canal.

1227. *c. General project items.*—Above has been given a brief description of the canal system as proposed for the greater Wenatchee

project. The items following pertain to the general project rather than to any of the subdivisions mentioned above.

1228. *a'. Drainage.*—A blanket estimate is included to cover the item of drainage. The question of drainage is one that will require considerable detail study and one that will not be determined until some years after the land has been put under irrigation. For the purpose of this estimate, a blanket estimate of \$5 per acre has been included to cover this item.

1229. *b'. Wasteways.*—Wasteways along the main canal are included with the feature on which they are located. Wasteways on the project are the same as those used in the Gault report for the Quincy area.

1230. *c'. Supplemental pumping.*—In all the various plans considered later in this report, consideration is given to pumping to certain desirable lands lying above the gravity system. On those plans considered later, locations favorable to power development are available along the canal system, and it is proposed to develop this power to be utilized in pumping to these high areas. In order to put the project, now under consideration, on the same basis for comparative purposes, it is proposed to pump to the desirable lands that can be reclaimed with a lift of not to exceed 100 feet. The project now under consideration offers no opportunity for developing power on the project with water used for irrigation and the power requirements for this supplemental pumping must be secured from an outside source. The power installation required to meet the demand of this supplemental pumping is 3,300 kilowatts.

1231. The total area on the Quincy tract under supplemental pumping is 36,230 acres, the seasonal water requirements of which are 113,200 acre-feet. These areas to be covered by supplemental pumping vary in extent from several thousand acres to areas as small as 20 acres and are scattered throughout the project, as is indicated on plate no. 127. The average lift to cover these areas is 70 feet gross.

1232. Estimates for pumping installations to cover these tracts are taken from graphs. The cost of the installation includes all electrical equipment from the step-down transformers, pumping equipment, valves, pipe lines, etc., and is expressed on an acre-foot-foot basis.

1233. To meet the requirements of supplemental pumping all installations are capable of handling 113,220 acre-feet during the season against a gross head of 70 feet or 7,925,400 acre-feet-foot.

1234. It is apparent that the cost of any pumping installation is dependent upon the size of the unit. The approximate size of the units required will be as follows:

- 50 percent or 3,962,700 acre-feet-foot, 1,000 kilowatts installation.
- 30 percent or 2,377,620 acre-feet-foot, 500 kilowatts installation.
- 10 percent or 792,540 acre-feet-foot, 250 kilowatts installation.
- 5 percent or 396,270 acre-feet-foot, 100 kilowatts installation.
- 5 percent or 396,270 acre-feet-foot, 10-50 kilowatts installation.

1235. The cost of these developments was determined by applying the unit prices as determined from the graph to the unit quantities as given above.

1236. *d'. Telephones.*—An estimate is included to cover the expense of a telephone system adequate to meet the requirements of the system when in operation.

1237. *e'. Wells.*—As explained more fully in discussion of the Columbia Basin Irrigation Project, which follows later in this report, this item is included to meet requirements during the construction period.

1238. *f'. Permanent buildings.*—This item covers the buildings, offices, shops, warehouses, and quarters, etc., required in the operation of the completed system.

1239. *d. Estimates of cost.*—The following tabulation itemizes the cost of all features of the greater Wenatchee project.

Feature no.	<i>Main canal system</i>	
1. Wenatchee Lake Dam (including \$673,300 over flow damages)		\$9, 278, 450
2. Included in feature no. 1.		
3. Canal	-----	721, 520
4. Chumstick Tunnel	-----	670, 320
5. Canal	-----	556, 990
6. Chumstick siphon	-----	562, 030
7. Canal	-----	657, 600
8. Eagle Tunnel	-----	1, 940, 090
9. Open canal	-----	58, 820
10. Eagle siphon	-----	167, 990
11. Derby Tunnel	-----	1, 596, 810
12. Canal	-----	416, 700
13. Nahahum Tunnel	-----	4, 605, 090
14. Canal	-----	532, 350
15. Warm Springs Tunnel	-----	2, 271, 500
16. Canal	-----	453, 540
17. Sunnyslope Tunnel	-----	2, 009, 170
18. Canal	-----	130, 570
19. Columbia River siphon	-----	8, 350, 570
20. East Bank Tunnel	-----	191, 150
21. Canal	-----	780, 000
22. Valley View siphon	-----	102, 510
23. Canal	-----	928, 520
24. Liberty siphon	-----	87, 610
25. Canal	-----	2, 760, 630
26. Rock Island Tunnel	-----	1, 471, 960
27. Rock Island siphon	-----	2, 223, 620
28. Moses Coulee Tunnel	-----	2, 227, 520
29. Canal	-----	232, 300
30. Moses Coulee siphon	-----	3, 434, 060
31. Canal	-----	245, 130
32. Willow Springs Tunnel	-----	939, 670
33. Canal	-----	1, 188, 640
34. Willow Springs siphon	-----	127, 960
35. Canal	-----	257, 870
36. Quincy Tunnel	-----	803, 090
37. Canal	-----	56, 350
38. Bifurcation works	-----	34, 190
Total main canal system	-----	<u>53, 072, 890</u>

	<i>Main east</i>	
1. Main east	-----	2, 670, 920
E-1. Lateral E-1	-----	754, 070
E-1-1. Lateral E-1-1	-----	253, 090
E-2. Lateral E-2	-----	190, 130
E-3. Lateral E-3	-----	216, 590
E-4. Lateral E-4	-----	83, 440
2. Sub-laterals	-----	3, 206, 280
Total main east	-----	<u>7, 374, 520</u>

*Main west*

Feature no.		
1.	Canal	249, 860
2.	Great Northern siphon	135, 640
3.	Canal	824, 000
4.	Potholes siphon	1, 295, 990
5.	Canal	975, 750
6.	Frenchman siphon	880, 750
7.	Canal	1, 211, 620
8.	Low Gap Tunnel	855, 040
9.	Canal	1, 418, 820
W-1.	Lateral W-1	93, 000
W-2.	Lateral W-2	90, 130
W-3.	Lateral W-3	567, 400
W-4.	Lateral W-4	31, 510
10.	Sublaterals	3, 520, 230
Total main west		12, 149, 740

*Project items*

Preliminary surveys	200, 000
Supplemental pumping (less power development and transmission lines)	693, 470
Drainage	1, 601, 550
Wasteways	65, 640
Permanent buildings	350, 000
Wells	55, 000
Telephone system	100, 000
Total project items	3, 065, 660

*Recapitulation*

Main canal (including Wenatchee Lake Dam)	53, 072, 890
Main east	7, 374, 520
Main west	12, 149, 740
Project items	3, 065, 660
Total Quincy area	75, 662, 810

1240. *e. Stage development.*—The necessity and importance of a stage development on a project, the magnitude of the one now under consideration, is set forth in a discussion of plan no. 2-A for the Columbia Basin irrigation project which follows in this report (par. 1452). On the basis as outlined in that discussion, table no. 201, gives the set-up for the stage development in the present plan.

TABLE No. 201.—*Stage development, Greater Wenatchee project*

Year	Stage	Capital expenditure	Area re-claimed	Area colo-nized	Area begin-ning re-payment
1.		\$100, 000			
2.	1	365, 000			
3.		1, 800, 000			
4.		3, 400, 000			
5.	2	5, 700, 000			
6.		10, 500, 000			
7.		30, 852, 530	52, 740		
8.		2, 430, 810		52, 740	
9.	3	3, 147, 510	87, 670	43, 830	
10.	4	6, 962, 400	49, 860	43, 840	52, 740
11.		4, 085, 650		49, 860	43, 830
12.	5	3, 526, 970	93, 820	46, 910	43, 840
13.	6	2, 791, 940	36, 220	46, 910	49, 860
14.				36, 220	46, 910
15.					46, 910
16.					36, 220

1241. Under the plan of development as outlined above the first land would be brought under cultivation in the eighth year and repayments on that area would begin at the end of the tenth year, the last area in the project would be brought under cultivation in the fourteenth year and repayments on that area begin at the end of the sixteenth year. Carrying all capital expenditures to the end of the sixteenth year with interest at the rate of 4 percent and deducting an annual repayment of \$11.85 per acre which also carries interest at the rate of 4 percent to the end of the sixteenth year gives the following:

	<i>Per acre</i>
Capital cost plus interest.....	\$94, 896, 200 = \$296. 26
Capital cost.....	75, 662, 810 = 236. 22
Interest.....	79, 233, 390 = 60. 04
Annual interest charge after completion.....	<u>11. 85</u>
Annual cost of operation and maintenance.....	1. 10
Annual depreciation charge.....	<u>. 80</u>
Total annual charge less power.....	1. 90

#### 5. QUINCY PROJECT

1242. The Quincy area forms a part of and is fully covered in the preceding discussion of the greater Wenatchee project.

#### 6. PRIEST RAPIDS PROJECT

1243. *a. General data.*—The Priest Rapids project consists of the irrigable area within the tract bounded on the west and south by Columbia River, on the east by the steep sidehill slope extending from the Pioneer Ranch opposite the lower end of Savage Island, northeast to a point about 1 mile west of Scootenev Lake, and on the north by the Saddle Mountains. See plate no. 3. This area, if developed as a separate project, would eliminate from plan no. 4 all areas below the Scootenev siphon in that plan. The area so eliminated from plan no. 4 amounts to 165,320 acres. The irrigable area of the Priest Rapids project is 140,520 acres, the difference, 24,800 acres representing high areas that cannot be feasibly reclaimed under the plan now proposed for the Priest Rapids project.

1244. The irrigable area of this project consists of 140,520 acres. The classification of this land and its water requirements were determined in the manner outlined under the discussion following, relating to the Columbia Basin irrigation project of which this Priest Rapids project forms a part. This area includes the Priest Rapids-Highland project, a development proposed and sponsored by the Washington Irrigation & Development Co. during 1920-22. This proposed development, said to reclaim 100,000 acres, has never progressed beyond the preliminary stages and that area is included in the project now under discussion.

1245. The water supply for this project will be secured by a pumping diversion from the Columbia River at a point about 3 miles above Bend or about 10 miles above Priest Rapids. The plan now under consideration is strictly an irrigation project and no power development is included. The comprehensive development of the water resources of the Columbia River includes a power development at Priest Rapids. This development would be the logical source of power for pumping purposes on the irrigation project now being considered,

and the estimate has been based upon securing power from that source. An alternative estimate is also given based upon the securing of power from the development of the Columbia River at Grand Coulee as proposed under plan no. 4 for reclaiming the Columbia Basin irrigation project.

1246. In designing an irrigation system for this Priest Rapids project, the same engineering treatment has been rendered as outlined for the Columbia Basin irrigation project which is discussed later in this report.

1247. The same seasonal distribution of water has been used, the canal losses determined in the same manner, the same general type and character of construction work is proposed for each case.

1248. The irrigation system proposed for this project consists of the pumping plant with collateral works and the canal system necessary to deliver the water to the lands of the project.

1249. The area to be reclaimed amounts to 140,520 acres with a seasonal water requirement of 443,132 acre-feet at the pumping plant.

1250. In order to reduce the pumping head as much as possible the water will be delivered from the pumps to two canals; the high-line canal having a water-surface elevation at 1,005 at the head and the low-line canal having an elevation of 850. The unregulated low-water elevation of Columbia River at the site of the pumping plant is 470. With the high dam at Priest Rapids, as considered in the power section of this report, the elevation of the pool above that development will be at elevation 540.

1251. The high-line canal includes a repumping station about 30 miles downstream from the Bend pumping plant, to serve a desirable area in that section. The high-line canal, with repumping as noted, serves an area of 66,420 acres, requiring a maximum canal capacity of 660 second-feet. The low-line canal serves an area of 74,100 acres with a maximum canal capacity of 730 second-feet.

1252. *b. Bend pumping plant.*—This proposed pumping plant located on the Columbia River about 3 miles above Bend in section 15, township 15 north, range 23 east, Willamette meridian, consists of the following items:

One concrete-steel building, 40 by 60 by 180 feet, with the necessary substructure and intake channel leading to the pumps. For the high-line canal—

Three pumping units, each unit consisting of two single-stage pumps connected in series, capacity of each unit 330 second-feet, total head 545 feet, each unit discharging into a steel discharge pipe, 78 inches in diameter, 860 feet in length leading to the canal. Each pump is actuated by a 15,000-horsepower motor with the necessary electrical equipment. This installation provides for one stand-by unit.

For the low-line canal—

Three pumping units, each unit consisting of two single stage pumps connected in series, capacity 365 second-feet, total head 390 feet, each unit discharging into a discharge pipe 82 inches in diameter, 580 feet in length leading to the canal. Each pump is actuated by a 12,000-horsepower motor with the necessary electrical accessories.

1253. The above description includes pumping heads, motor capacities, etc., that are based upon pumping from the Columbia River in its unregulated condition. With the Priest Rapids power development these data would be modified to meet a river elevation of 540 instead of 470 as used above.

1254. *c. Canal system.*—As described heretofore, the canal system consists of two main canals, the high-line canal and the low-line canal.

1255. *a'. High-line canal.*—The high-line canal extends eastward from the pumping plant, along the south slope of Saddle Mountains for a distance of 34 miles at which point a repumping plant is located to raise the water through a head of 222 feet. The canal then continues in an easterly and southerly direction for a distance of about 16 miles where its capacity reaches 100 second-feet. Because of the few features involved in this project, the detailed description of each is included in the body of this report as a general indication of the feature descriptions for the larger projects, which, for the sake of brevity, have been placed in appendix 5.

Pumping diversion from Columbia River:

Static head.....	feet.....	535
Pumping head.....	do.....	545
Area reclaimed primary pumping.....	acres.....	26, 480
Area reclaimed by repumping.....	do.....	39, 940
Total area under high-line canal.....	do.....	66, 420
Maximum capacity high-line canal.....	second-feet.....	660
Loss in high-line canal.....	do.....	40
Net delivery to land.....	do.....	620
No rediverted water.		

1256. The high-line canal consists of the following features listed geographically.

1257. *Feature no. 1.—Open canal.*—Bend pumping plant to repumping plant. Length, 34.17 miles. This section of canal extends along the south slope of the Saddle Mountains for its entire length. The topography is somewhat broken, especially at the upper end of the section. The first mile of canal will be over steep ground with a large percentage of solid rock excavation. Other than the upper portion of this section the conditions are average from a construction standpoint. No laterals divert from this section of the high-line canal.

1258. *Feature no. 2.—Repumping plant.*—The water is delivered to this pumping plant at elevation 945, and 395 second-feet is repumped to elevation 1,150. This pumping plant consists of the following items: Concrete-steel pump house, 30 by 40 by 60 feet; 3 pumping units, each unit consisting of a single-stage pump, capacity 200 second-feet, total head 222 feet, each pump discharging into a steel pipe line 60 inches in diameter and 2,410 feet in length leading to the canal above, each pump to be actuated by a 7,500-horsepower motor with the necessary electrical accessories. One stand-by unit is provided in the above plan.

1259. *Feature no. 3.—Open canal.*—Repumping plant to Kohler siphon. Length, 12.2 miles. This section of canal extends along the south slope of Saddle Mountains to reach the land west of the drainage leading south from Scootency Lake. No unusual items are found in this section of canal. This section is very favorable from a construction standpoint. A small amount of classified material will be encountered in this section of the canal work.

1260. *Feature no. 4.—Kohler siphon.*—No special drawing. This structure consists of a single steel pipe line, 75 inches in diameter, with the necessary concrete end structures and cradles. Length, 6,019 feet, horizontal distance. One steel pipe line. Maximum head, 148 feet. This structure crosses a low depression located be-

tween the High-line canal and an area of irrigable land located in the vicinity of the Windspear Ranch.

1261. *Feature no. 5—Open canal.*—Kohler siphon to 100 second-feet capacity. Length, 4.90 miles. This section of canal extends from the end of the Kohler siphon to a point where the capacity is reduced to 100 second-feet. Conditions are very favorable for canal construction.

1262. *Feature no. 6—wasteway canal.*—Length, 4.36 miles. This canal is used as a wasteway only. It extends from the repumping plant southward to an area of waste land bordering Columbia River. This canal affords an outlet for the discharge of the high-line canal should the repumping station be put out of commission on short notice. This section of canal is favorable from a construction standpoint. While it will be used only intermittently, it will require a concrete lining because of excessive grades.

1263. *Feature no. H-1—lateral H-1.*—Length, 6.9 miles. This lateral extends from the repumping plant in a southeasterly direction for 6.90 miles and is really an extension of the high-line canal beyond the repumping plant. This section of canal is favorable from a construction standpoint.

1264. *Feature no. 7—sublaterals.*—The system as described above constitutes the entire high-line canal system having a capacity of 100 second-feet or more. The present plan includes a canal system capable of making water delivery to each farm unit, but the laterals having a capacity of less than 100 second-feet are not estimated individually, but are covered by a blanket estimate based upon the area served.

1265. *b'. Low-line canal.*—The low-line canal is eastward of the bend pumping plant, and is approximately parallel to the high-line canal which is located farther up the slope on the south side of Saddle Mountains. This canal, except for the first 2 miles which are located over an area broken in topography and rocky in character, is favorable for canal construction. Three laterals, L-1, L-2, and L-3 are diverted from the low-line canal.

*Pumping diversion from Columbia River*

Pumping head.....	feet..	390
Static head.....	do.	380
Area reclaimed by primary pumping.....	acres..	74, 100
Maximum capacity low-line canal.....	second-feet..	730
Losses in low-line canal.....	do.	44
Net delivery to land.....	do.	686
No diverted water.		

1266. The low-line canal consists of the following features listed geographically.

1267. *Feature no. L-1—lateral L-1—length, 3.3 miles.*—This lateral involves no unusual items. It is located over an area ideal from a construction standpoint.

1268. *Feature no. L-2—lateral L-2—length, 6.9 miles.*—This lateral involves no unusual items and is first class from a construction standpoint.

1269. *Feature no. L-3—lateral L-3—length, 4.0 miles.*—This lateral includes the Haven siphon, consisting of one steel pipe line 42 inches

in diameter, 6,019 feet in length. Other than this siphon the lateral involves no unusual items and is ideal from a construction standpoint.

1270. *Feature no. 2—sublaterals.*—As explained in a similar feature under the high-line canal, the laterals having a capacity of less than 100 second-feet are not treated individually, but are covered by a blanket estimate based upon the area served.

1271. *d. General project items.*—Above has been enumerated the various features that constitute the proposed irrigation works consisting of pumping plants and canal system. The following items, necessary adjuncts to a completed system, pertain to the general project rather than to any of the subdivisions mentioned above.

1272. *a'. Drainage.*—This phase of the problem is discussed fully under plan no. 2, Columbia Basin irrigation project which follows in this report. The matter is given the same consideration in the plan now under discussion. A blanket estimate of \$5 per acre is allowed to cover this item. In the plan of stage development proposed the cost of this development is all placed in the last years of construction.

1273. *b'. Wasteways.*—Wasteways required on this project are covered by an individual estimate under the canal system to which they are appurtenant.

1274. *c'. Supplemental pumping.*—No pumping is considered in the present study except that outlined at the Bend pumping plant on the Columbia River and at the repumping plant on the high-line canal. Supplemental pumping is given consideration only on those projects where opportunity is provided in the canal system for developing power to be used for pumping to higher lands. In the plan now under consideration, no opportunity for developing power exists along the proposed canal system.

1275. *d'. Telephone systems.*—An estimate is included to cover the cost of a telephone system thought to meet the requirements during operation of the proposed system.

1276. *e'. Wells.*—This phase is discussed fully under plan no. 2 of the Columbia Basin irrigation project, and is included in the present plan for the same reasons as outlined in discussions.

1277. *f'. Permanent buildings.*—This item covers the cost of buildings, offices, shops, warehouses, quarters, etc., required in the operation of the completed system.

1278. *g'. Preliminary work.*—This item is included to cover the preliminary work necessary and incidental to the development of the final plan of reclamation of the area.

1279. *h'. Other features.*—The estimate includes an item for fencing all canals and for providing bridges, where required, on existing highways. Where bridges are required, standard types of the Washington Highway Department with an H-15 loading have been used in all cases. The fences, bridges, etc., are included in the estimate for the feature of which they form a part.

1280. *e. Estimates of cost.*—Following are the estimates of the various features that constitute the irrigation system as designed for the Priest Rapids irrigation project. It should be noted that the estimate includes no power development. Power for pumping purposes is to be transmitted from Grand Coulee power plant.