COLUMBIA RIVER AND MINOR TRIBUTARIES

PART 2

REPORT OF THE DISTRICT ENGINEER, SEATTLE, WASH.

SYLLABUS

The district engineer shows potential development of power and irrigation on the upper Columbia to be important and navigation and flood control unimportant.

He submits a comprehensive plan for adoption as a guide for future developments on the river looking toward a complete utilization of the water of the Columbia.

He recommends Federal coordination of all river work involving the comprehensive plan, and Federal participation in navigation improvements where required, but no Federal contribution toward power development on a basis of its aid to navigation.

He believes irrigation by pumping from pools above dams to be feasible when combined with power development, but that recommendation regarding Federal participation involves a matter of policy outside the province of this report.

WAR DEPARTMENT,
UNITED STATES ENGINEER OFFICE,
Seattle, Wash., July 31, 1931.

Subject: Report on Columbia River above mouth of Snake River.
To: The Chief of Engineers, United States Army
(Through the Division Engineer).

CHAPTER I. INTRODUCTION

A. AUTHORITY AND PURPOSE

1. This is part 2 of a report in three parts on Columbia River submitted in accordance with the requirements of section 1 of the River and Harbor Act of January 21, 1927, which directs that surveys be made in accordance with House Document No. 308, Sixty-ninth Congress, first session, and includes certain streams not listed in that document. This act reads, in extract, as follows:

SEC. 1. That the following works of improvement are hereby adopted and authorized, to be prosecuted under the direction of the Secretary of War and supervision of the Chief of Engineers, in accordance with the plans recommended in the reports hereinafter designated: * * * Surveys in accordance with House Document Numbered 308, Sixty-ninth Congress, first session, and * * *

2. House Document No. 308, Sixty-ninth Congress, first session, mentioned in the foregoing citation of authority, listed the streams of the United States considered worthy of investigation under the provisions of section 3, of the River and Harbor Act of March 3, 1925. This section of the act reads as follows:

SEC. 3. The Secretary of War, through the Corps of Engineers of the United States Army, and the Federal Power Commission are jointly hereby authorized and directed to prepare and submit to Congress an estimate of the cost of making

such examinations, surveys, or other investigations as, in their opinion, may be required of those navigable streams of the United States, and their tributaries, whereon power development appears feasible and practicable, with a view to the formulation of general plans for the most effective improvement of such streams for the purposes of navigation and the prosecution of such improvement in combination with the most efficient development of the potential water power, the control of floods, and the needs of irrigation: *Provided*, That no consideration of the Colorado River and its problems shall be included in the consideration or estimate provided herein.

3. This report (part 2 of a report on the entire section of the Columbia River within the United States) deals with the section of the river between the international boundary and the mouth of Snake River. However, the report gives some consideration to Clark Fork of the Columbia, and also to other tributaries.

NOTE.—A companion report, part 3, dealing with the section of the Columbia below the mouth of Snake River has been prepared by the district engineer, Portland, Oreg., district. See general index map, plate no. 2, part 3, page 1410 of this document.

4. Within the limits laid down in the preceding paragraph, the purpose of this report is to formulate plans for the most effective improvement of Columbia River for the purposes of navigation, and for combining such improvement with the most efficient development of the potential water power, the control of floods, and the needs of irrigation.

B. HISTORY OF REPORT

(1) PRELIMINARY INVESTIGATION

5. As a necessary preliminary to a complete survey, a reconnaissance was made of that portion of Columbia River lying within the limits set forth in paragraph 3 above. This was made for the purpose of determining the justifiable extent, scope, and cost of a more detailed investigation. The reconnaissance consisted not only in assembling, reconciling and compiling existing data from all available sources, but also field work to supply information not otherwise obtainable. This work was started in April 1928 and completed on February 11, 1929, at a total cost of $23,146.70.

6. Much valuable assistance was obtained from the United States Geological Survey, the United States Reclamation Service, the United States Forest Service, the division of hydraulics, State of Washington, the University of Washington, the University of Idaho, the State College of Washington, the Seattle Chamber of Commerce, the Columbia Basin Irrigation League, and many individuals and agencies not listed.

(2) DETAILED INVESTIGATION

7. The preliminary studies of the various problems presented, having shown a more detailed investigation of the Columbia to be warranted and more information to be needed before plans could be formulated for the best utilization of the river, authority and funds to make this study were obtained and the formal investigation of the river initiated on June 4, 1929, and completed as of the date of this report. The results of this investigation are embodied herein.

8. *1. General plan of investigation.*—A preliminary investigation of the problems involved in formulating general plans for the improvement of the upper Columbia for the purposes of navigation, and for the prosecution of such improvement in combination with the most

efficient development of potential water power, the control of floods, and the needs of irrigation indicated:

First, that improvement of the upper Columbia for navigation would probably be justified, only when combined with power development;

Second, that the river was well suited to power development if satisfactory dam sites could be found, by reason of its steep slope and comparatively large low-water flow due to the regulating effect of the many lakes on the tributaries;

Third, that control of floods was not a problem for consideration, as the upper river, for most of its course, runs in a deep valley and flood waters are always confined by its banks;

Fourth, that irrigation of the Columbia Basin irrigation project was of particular importance for study not only because it would at times affect power and navigation by requiring the diversion from the river of some 15,000 second-feet of water, but also because irrigation is considered a more beneficial use of water than is power development. The successful execution of this project would be of great benefit to the State and Nation by providing homes for many people and making productive a large area of land which would otherwise be of little use. This irrigation project when developed and settled will require transportation for its products and supplies. It will also greatly increase the demand for power. It will thus aid in justifying power generation and river improvement, and will, if economically feasible, form an essential element in the comprehensive plan for the uses of the waters of Columbia River.

9. When the study on which this report is based was started, there were available the following maps, plans, and reports:

MAPS

United States Geological Survey topographic sheets covering the river valley below Chelan and the greater part of the southern portion of the Columbia Basin irrigation project area, on scales of 1:62,500 and 1:125,000, with 25- and 50-foot contours.

United States Geological Survey maps of Pend Oreille Lake, on a scale of 1:31,680, with 5-foot contours.

United States Geological Survey profile surveys of Clark Fork and lower portion of Spokane River.

Maps of the Columbia from the boundary to Rock Island Rapids, on a scale of 1:24,000 (surveys of 1891 and 1894) showing sketched contours and soundings along the Thalweg; maps of the river from Rock Island Rapids to Snake River, on a scale of 1:12,000, with soundings (survey of 1909-10).

Rough profile of river made from data obtained during the above-mentioned surveys.

Maps showing in a general way the distribution systems for both the gravity and pumping plans of irrigation.

Map of main supply and portions of the main west and main east canals for pumping plan.

Maps and drill records at dam sites on the Columbia at Kettle Falls, Grand Coulee, Rock Island, and Priest Rapids.

Reconnaissance maps of reservoir dam sites in the Grand Coulee.

Map of gravity supply line from Albany Falls to Columbia Basin irrigation project, and also maps and record of borings at dam sites on this line.

Reconnaissance map of Wenatchee Dam and Reservoir sites.

Map of supply line from Wenatchee Reservoir to the land on Quincy Flats.

REPORTS

Various river and harbor preliminary examination and survey reports on the Columbia, Okanogan, Clark Fork (Pend Oreille), St. Joe, and Flathead Rivers.

Reports on the uses of the upper Columbia River, and on the Columbia Basin irrigation project, together with maps, designs, estimates, and water-supply studies by the Columbia Basin Survey Commission of the State of Washington, the United States Bureau of Reclamation, the Federal Power Commission, and others.

Discharge records of the United States Geological Survey, both published and unpublished.

Report with maps, plans, and estimates of cost of irrigating an area of some 100,000 acres in the vicinity of Pasco by diversion of water from the Palouse River.

Reports on the geology of dam and reservoir sites on gravity and pumping supply lines.

Unpublished reports by private engineers on irrigation of various areas within the drainage basin of the Columbia.

10. As it was made plain by preliminary study that improvements for navigation could be economically effected only when combined with power development, and as irrigation is considered a more beneficial use of water than power generation, it was evident that the proper approach to the problem was to fix tentatively the method of irrigating the Columbia Basin irrigation project and make the plans for power development and improvements for navigation conform thereto as far as practicable.

11. This problem was complicated, however, as two methods of irrigating the lands were presented for consideration, viz,

First, the gravity plan, under which it was contemplated to divert water from the Clark Fork at Albany Falls and convey it to the land by gravity through 130 miles of canals, tunnels, and siphons. This plan, which is contingent upon the storing of water in Pend Oreille Lake is further complicated, as it is possible to obtain part of the water from Coeur d'Alene Lake and thus reduce the size and cost of the main supply line between Albany Falls and Spokane.

Second, the pumping plan, under which it was contemplated to construct a dam in the Columbia at the head of Grand Coulee and pump from the pool thus formed into a canal 1¾ miles long, leading to an artificial reservoir 28 miles long in Grand Coulee. From this reservoir the water would flow 10¼ miles in the main supply canal and 15½ miles in the main west or 17 miles in the main east to the borders of the project. The Columbia River dam would serve two purposes—reduce the pumping lift and provide head for the generation of power for pumping the water for irrigation and for commercial purposes.

12. The area to be irrigated, the duty of water, and the best method of irrigating the project were determined by field inspections, surveys, and careful study of all previous investigations, estimates, and reports. The study of the gravity plan included consideration of obtaining part of the required water from Coeur d'Alene Lake.

13. The field work done during the period of the study was, briefly, as follows: The land within the project was inspected and reclassified, and the irrigable areas for both plans—gravity and pumping—were determined; the duty of water, canal losses, and diversion duty were fixed by field inspections and office studies; canal lines were inspected, and in a few places surveys were made and the line relocated; resurveys were made of dam and reservoir sites on the gravity line at Camden, Dry Creek, and Rock Lake; survey was also made of the Spokane Valley and river crossing; field work was done to locate a supply line from Coeur d'Alene Lake to a connection with the main supply line near its crossing of the Spokane River, and

survey was made for a proposed relocation of the Great Northern Railway at the Camden Reservoir site.

14. In connection with the pumping plan, a survey was made of the Grand Coulee reservoir site. Three dam sites at the south end of this reservoir site and one at the north end were surveyed. One dam site at each end of the reservoir site was drilled. This reservoir site was inspected and its watertightness reported on by three outstanding geologists. The suitability of the dam site was also reported on by them after inspections. The main supply canal, main east, and part of the main west pumping plan, were surveyed and located. The lands marginal to Pend Oreille and Coeur d'Alene Lakes were inspected and county records examined to obtain an estimate of overflow damages due to storage of water in these lakes. Designs and estimates of cost were made for all dams, tunnels, siphons, and all other elements of both the gravity and pumping plans. A topographic map of the most important parts of the Grand Coulee was made in four sheets on a scale of 1: 31,680 by the United States Geological Survey for this office. (See appendix no. 7.)[1]

15. The Columbia Basin irrigation project involves such a vast area (about 1,500,000 acres) that its irrigation must be effected by stages extending over a long period of years. Study was therefore given to the possibilities of irrigating the area by steps, but in such manner as not to interfere with the ultimate full development. The units chosen and the method of irrigating each should, as nearly as possible, fit the comprehensive plan for irrigating the entire area.

16. Consideration was given to irrigating an area of some 360,000 acres in the vicinity of Quincy by water from the Wenatchee River. This would require storage of water within the Wenatchee Basin. Surveys were made of dam sites on the Wenatchee River and on its tributary, the Chiwawa, and estimates of cost were prepared.

17. A second unit studied was in the vicinity of Lind, which involves some 750,000 acres to be irrigated from Clark Fork and Coeur d'Alene Lake.

18. A third unit was an area near Pasco to be irrigated by diversion from Palouse River. An area of 100,000 acres near Priest Rapids and an area of 10,000 acres near Pasco were considered, both obtaining water from the Columbia by pumping. No additional field work was necessary in connection with these studies except a survey of the supply line at Priest Rapids.

19. The economic feasibility of the Columbia Basin irrigation project is dependent not only on the cost of irrigating its land but also on the nature and amount of produce that can be grown; also, on the markets for that produce, and on transportation facilities, and the rate at which settlement would take place. Data were collected on precipitation, temperature, growth in population, industries, and markets. Water and rail transportation were given attention. All this was done as a basis for the economic study which was made with reference to irrigation in general and the Columbia Basin irrigation project in particular.

20. Lands marginal to the river and suitable for irrigation were inspected, areas estimated, and pumping lifts determined. Study was made of the feasibility, method, cost, and amount of water required to irrigate these areas, as it was believed that such work forms a part of the comprehensive improvement of the river.

[1] Not printed.

21. To develop fully the potential water power of the Columbia above the Snake and provide for complete canalization, it would be necessary to so locate and construct dams that the backwater from each would extend to the next one upstream.

22. To aid in determining the best locations of these dams for both navigation and power interests, a survey was made by the United States Geological Survey at the request of, and with funds allotted by, the United States Engineer Department. This survey covered the stretch from the international boundary to the mouth of Snake River, 425.3 miles in length, and maps drawn on a scale of 1:31,680, or 2 inches equals 1 mile, with 20-foot contours. (See appendix 7.) This survey included the establishment of a line of bench marks from which water-surface elevations were taken at various river stages. This provided data for the drafting of river profiles.

23. Detail surveys were made of possible dam sites at Little Dalles, Foster Creek, Wells, Chelan, Rocky Reach, and Vantage. The State's survey of the Grand Coulee dam site was extended.

24. Core drilling was done at Grand Coulee, Foster Creek, Wells, Chelan, Rocky Reach, and Vantage dam sites to determine foundation conditions.

25. Based on discharge records, profiles, and data determined during backwater studies made by power companies at Rock Island and Kettle Falls, computations were made of the extent of backwater. By this means the proper heights of dams were determined.

26. To provide additional discharge records, gages were established and maintained during the period of study. These gages were established and maintained by the United States Geological Survey at the request of and with funds furnished by the War Department.

27. On the Spokane and Clark Fork and its tributaries are a number of large lakes (Flathead, Pend Oreille, Priest, and Coeur d'Alene), in which regulation of storage of water is possible. Studies were made of the effect on power and irrigation by regulation of storage in the above-mentioned lakes. These studies included consideration of the proposed Hungry Horse Reservoir on the south fork of Flathead River. An effort was made to work out the best regulation for both the gravity and pumping plans of irrigation. To be successful, the gravity plan requires regulation of Pend Oreille Lake in the interest of that plan. If the pumping plan be chosen, storage in Pend Oreille could be regulated for the benefit of power. The many possible combinations of regulation made this study long and difficult. It included 17 years' records at 25 stations with 9 reservoirs (Hungry Horse, Flathead, Pend Oreille, Priest, Coeur d'Alene, Kootenay, Chelan, Wenatchee, and Chiwawa) for two purposes: irrigation and power.

28. In these studies allowance was made for future irrigation requirements in Idaho and Montana, and for areas in the valley of the Columbia. This was done so that ultimately the fullest use would be made of Columbia River water. The State of Washington made available to this office a study of the effect on the river slopes and power at Albany Falls of channel enlargement above Albany Falls. This study was based on a field survey made by the State.

29. At each of the dam sites on the Columbia, studies were made of the power possibilities. Dams and power houses were designed

and estimates of cost computed. The problems of design were difficult not only because at most of the sites suitable foundations were to be found only at great depths, but also on account of the relatively narrow valley and large volumes of water to be passed during floods, as high as 1,000,000 second-feet.

30. Particular attention was given to the problems of power development and irrigation pumping at the Grand Coulee site. Under the pumping plan of irrigating the Columbia Basin irrigation project, part of the power generated at this site would be used to pump water for irrigation, and the remaining power sold. Should the gravity plan be adopted, all the power would be for sale. Two dams were studied: one of just sufficient height to back the water to the foot of Kettle Falls and the other high enough to inundate Kettle Falls and back the water to the international boundary.

31. The feasibility of this and other power plants on the Columbia depends on the market for electrical power.

32. The amount of power that any of these plants will produce is large; the low dam at Grand Coulee would provide head for generating 602,000 kilowatts for 90 percent of the time. Records of the amount of power generated in the northwest each month, extending back for varying periods, were collected and compiled. Changes in industrial conditions, growth in population, and related matters were studied, all with a view to predicting probable future power demand. As Columbia power would be obliged to compete with possible steam plants on Puget Sound, the work was extended to include a study of the cost of steam power and the cost of transmitting large amounts of power from the plants on the river to points on salt water.

33. In connection with power generation, the possibilities and cost of complete canalization of the river were given consideration. Partial canalization was also studied. Improvement by open-river methods was considered sufficiently to demonstrate its infeasibility.

34. Improving this river in the interest of navigation is difficult owing to the steep slope, 2.31 feet per mile. Improvement in connection with power generation involves passing boats over high dams (at Priest Rapids, either 90 or 130 feet; at Foster Creek, 160 feet; and at Grand Coulee, either 220 or 330 feet), a very difficult problem. It was much aggravated by the lack of room afforded in the narrow river valley in which to locate dams, power houses, and navigation structures.

35. After all data had been collected and designs and estimates of the various possibilities completed, an effort was made to combine the different features into a harmonious plan for the fullest possible use of the natural resources of the region; a plan which, if followed, would insure the ultimate complete use of those resources for the most beneficial purposes and without unnecessary waste. It is not to be expected that the plan suggested will be adhered to in all respects. Its full consummation is too far distant to permit of refinement as to details. However, it is confidently expected that the plan suggested will be a safe guide, and that it will indicate the possibilities as well as the limitations of a comprehensive development to use the waters of the Columbia.

36. The total cost of the investigation up to July 1, 1931, was as follows:

Stream gaging, construction, operation, and maintenance	$35, 114. 59
Water-supply studies	11, 117. 14
Surveys	62, 533. 51
Exploratory work (drilling foundations)	60, 873. 93
Geological explorations and reports	6, 575. 00
Land classification	3, 270. 52
Study of markets for power and farm products	14, 275. 20
Office studies, drafting, writing report	122, 681. 56
	316, 441. 45

CHAPTER II. DATA

A. Columbia River Basin

A. GENERAL

37. The Columbia River is approximately 1,210 miles in length, of which the upper 465 miles lies wholly in Canada. Of the portion in the United States, 425.3 miles lies above the mouth of Snake River, and that is the portion with which this section, part 2 of a report in three parts on Columbia River, is particularly concerned. The portion of the river below the mouth of the Snake, 323.5 miles in length, is described in a companion report, part 3, prepared by the district engineer, Portland, Oreg., district.

38. The drainage area of the Columbia above the mouth of Snake River is 103,000 square miles, of which 39,000 square miles are in Canada, and 64,000 square miles are in the United States. The drainage area above the mouth of Snake River is divided between the Province of British Columbia and the three States of Montana, Idaho, and Washington, and comprises about 40 percent of the total drainage area of the Columbia River.

39. Data relating to the main river and its principal tributaries above the Snake are included in tables nos. 1 and 2, with more detailed descriptions following.

Table No. 1.—*Data relating to Columbia River*

Distance above mouth of Snake	Place	Drainage area	Estimated flood discharge of 1894	Average discharge	Elevation of low water above sea level	Distance below British Columbia boundary
Miles		*Square miles*	*Second-feet*	*Second-feet*	*Feet*	*Miles*
0.0	Snake River, mouth:					
	Below	212,000	1,100,000	183,000	312	425.3
	Above	103,000	750,000	126,000		
3.5	Pasco, N. P. Ry. bridge		750,000	126,000	314	421.8
3.9	Kennewick, highway bridge		750,000	126,000	315	421.4
10	Yakima River, mouth:					
	Below	102,000	750,000	126,000	319	415
	Above	96,200	740,000	121,000		
66	Vernita (Richmond ferry)	95,500	740,000	121,000	389	359
	Priest Rapids:					
72	Foot	95,400	740,000	121,000	400	353
81	Head				469	344
87.7	Beverly, C. M. St. P. & Pac. R.R. bridge	90,300	740,000	121,000	471	337.6
96.9	Vantage, bridge	89,700	740,000	121,000	487	328.4
98	Vantage dam site	89,700	740,000	121,000	488	327
129	Rock Island dam:					
	Below	88,700	740,000	121,000	544	296
	Above				560	
132.3	Great Northern Ry. bridge		740,000	121,000	563	293
140.5	Wenatchee, highway bridge	88,500	740,000	121,000	588	284.8
	Rocky Reach:					
150	Power-house site	87,200	735,000	117,000	604	275
151.5	Dam					273.5