79th Congress, 2d Session - - - - - House Document No. 693

COLUMBIA RIVER AT FOSTER CREEK, WASH.

LETTER

FROM

THE SECRETARY OF WAR

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, UNITED STATES ARMY, DATED APRIL 9, 1946, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A REVIEW OF REPORTS ON THE COLUMBIA RIVER AND TRIBUTARIES, OREGON AND WASHINGTON, FOR IMPROVEMENT AT AND IN THE VICINITY OF FOSTER CREEK, REQUESTED BY A RESOLUTION OF THE COMMITTEE ON RIVERS AND HARBORS, HOUSE OF REPRESENTATIVES, ADOPTED ON MARCH 24, 1942

JULY 3, 1946.—Referred to the Committee on Rivers and Harbors and ordered to be printed, with three illustrations

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LETTER OF TRANSMITTAL

WAR DEPARTMENT
Washington, June 28, 1946.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am transmitting herewith a report dated April 9, 1946, from the Chief of Engineers, United States Army, together with accompanying papers and illustrations, on a review of reports on the Columbia River and tributaries, Oregon and Washington, for improvements at and in the vicinity of Foster Creek. This report was requested by a resolution of the Committee on Rivers and Harbors, House of Representatives, adopted on March 24, 1942.

In accordance with section 1 of Public Law 534, Seventy-eighth Congress, and section 1 of Public Law 14, Seventy-ninth Congress, copies of the proposed report of the Chief of Engineers were furnished the Governors of the States of Oregon, Washington, Idaho, Montana, and Wyoming, and the Secretary of the Interior. A copy of the report was also furnished the Federal Power Commission for comment. The views of these States and of the Department of the Interior and of the Federal Power Commission are enclosed, together with a copy of the reply to the letter from the Governor of Idaho.

The Bureau of the Budget advises that there is no objection to the submission of this report. It requests that it be clearly pointed out that (*a*) construction of the proposed project would result in no flood control or navigation benefits, (*b*) the project could be developed so as to provide irrigation benefits, and (*c*) the agency of government normally charged with construction of multiple-purpose projects having irrigation benefits and no value for flood control or navigation is the Bureau of Reclamation of the Department of the Interior.

Sincerely yours,

ROBERT P. PATTERSON,
Secretary of War.

COMMENTS OF GOVERNOR OF OREGON

STATE OF OREGON,
EXECUTIVE DEPARTMENT,
Salem, February 28, 1946.

Lt. Gen. R. A. WHEELER,
Chief of Engineers, United States Army,
Washington, D. C.

DEAR GENERAL WHEELER: I am enclosing a copy of a letter of the State engineer for Oregon, Mr. Charles E. Stricklin, relative to the proposed report on the Foster Creek project on the Columbia River.

I approve the engineer's statement.

Very truly yours,

EARL SNELL, *Governor.*

STATE OF OREGON,
OFFICE OF THE STATE ENGINEER,
Salem, February 25, 1946.

Hon. EARL SNELL,
Governor of Oregon, Salem, Oreg.

DEAR GOVERNOR SNELL: This is to advise you that I have examined the reports of the United States Engineers of the United States Army of the Foster Creek project on the Columbia River, and it is my opinion, since little or no consumptive use of the water is contemplated in the construction of this property, its being a power project, that Oregon's interest will not be adversely affected.

Yours very truly,

CHAS. E. STRICKLIN, *State Engineer.*

COMMENTS OF GOVERNOR OF WASHINGTON

[Telegram]

OLYMPIA, WASH., *March 4, 1946.*

UNITED STATES ARMY ENGINEERS:

The State of Washington believes that the Foster Creek project as recommended in your report is important to the program for development of the Northwest and gives its unqualified support on behalf of the people of the State. I urge that the project be authorized and constructed as soon as possible in accordance with your recommendations. Provisions should be made of course for the irrigation of certain arid lands through the use of summer seasonal power as brought out in your public hearings.

MON C. WALLGREN, *Governor.*

COMMENTS OF GOVERNOR OF IDAHO

STATE OF IDAHO,
OFFICE OF THE GOVERNOR,
Boise, February 20, 1946.

Lt. Gen. R. A. WHEELER,
Chief of Engineers, War Department,
Washington, D. C.

DEAR GENERAL WHEELER: A copy of your proposed report on a review of reports on the Columbia River and tributaries, Oregon and Washington, for improvements at and in the vicinity of Foster Creek, together with the reports of the Board of Engineers for Rivers and Harbors and of the district and division engineers, has been received.

I heartily endorse the report for improvements in the vicinity of Foster Creek on the Columbia River, generally, but do vigorously oppose and protest any future storing of waters in Lake Pend Oreille to the amount of 3,200,000 acre-feet which would require a lake level of about 2,080. Estimates made by former State Reclamation Engineer, James Spofford, set the storage level of 2,062.5 as the point beyond which more injury than benefits, would accrue to the citizens of Bonner County (Columbia River and its tributaries hearings under H. Res. 262, pt. 2, Sandpoint, Idaho, August 28, 1943, p. 531).

Storage of 3,200,000 feet of water in Lake Pend Oreille would seriously affect agricultural production in Bonner County, Idaho, and, as I have been advised, would inundate a large part of the best agricultural land in Bonner County, Idaho, and also a portion of the city of Sandpoint.

I am in favor of the development of the project on the Columbia River in the vicinity of Foster Creek if such developments do not require the storing of water as above indicated.

Yours very truly,

ARNOLD WILLIAMS,
Governor of Idaho.

LETTER TO GOVERNOR OF IDAHO

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, March 14, 1946.

Hon. ARNOLD WILLIAMS,
Governor of Idaho, Boise, Idaho.

DEAR GOVERNOR WILLIAMS: I am in receipt of your letter dated February 20, 1946, which contains your comments on my proposed report on a review of the Columbia River and tributaries, Oregon and Washington, for improvements at and in the vicinity of Foster Creek.

I am pleased to inform you that the Foster Creek project does not require the storage of water in Lake Pend Oreille for its justification. The Foster Creek project was designed for satisfactory operation with only the existing storage in the Columbia River Basin and with suitable provision for expansion when and if any additional storage is found advisable in the Columbia River and tributaries above the Foster Creek. The discussion in the report of increased prime power resulting from additional storage in the Clark Fork Basin of approximately 3,200,000 acre-feet was included not as a specific requirement for the Foster Creek project but merely to illustrate the effect of additional stream-flow regulation on the project. The possibilities for additional storage in all sections of the Columbia Basin above Foster Creek, including Clark Fork, are being studied in connection with a comprehensive report on the entire Columbia River Basin. Recommendations as to specific sites for additional storage are, therefore, not involved at this time but will be made in connection with the comprehensive report. The Department appreciates receiving your views on its proposed report on Foster Creek and you may be assured that the Department's proposed reports on the Columbia River and other streams affecting the State of Idaho will be submitted to you for your comments prior to their submission to Congress.

As provided under the law, the views of the State of Idaho will accompany the Department's report to Congress. I shall be pleased to notify you when the report is transmitted to Congress by the Secretary of War and furnish you a copy of the letter of transmittal for your information.

Sincerely yours,

R. A. WHEELER,
Lieutenant General,
Chief of Engineers.

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COMMENTS OF GOVERNOR OF MONTANA

[Telegram]

HELENA, MONT., *March 15, 1946.*

Lt. Gen. R. A. WHEELER,
Chief of Engineers, Corps of Army Engineers, Washington, D. C.:

Reurtel 14 on February 16 advised district engineer, Seattle, that Montana has no objections, construction Foster Creek project, and no recommendations.

SAM C. FORD,
Governor of Montana.

COMMENTS OF GOVERNOR OF WYOMING

STATE OF WYOMING,
EXECUTIVE DEPARTMENT,
Cheyenne, December 12, 1945.

R. A. WHEELER,
Lieutenant General, Chief of Engineers,
United States Army, Washington, D. C.

MY DEAR GENERAL WHEELER: Receipt is acknowledged of your letter of November 29 with the copy of your proposed report on a review of the reports on Columbia River and its tributaries, Oregon and Washington, for improvements at and in the vicinity of Foster Creek. I am returning your enclosures today, without comment, as the report does not include any proposed development in the State of Wyoming.

Sincerely yours,

LESTER HUNT, *Governor.*

COMMENTS OF DEPARTMENT OF THE INTERIOR

DEPARTMENT OF THE INTERIOR,
Washington 25, D. C., March 4, 1946.

Lt. Gen. RAYMOND A. WHEELER,
Chief of Engineers, War Department.

MY DEAR GENERAL WHEELER: On December 4, 1945, your proposed report on a review of reports on Columbia River and tributaries, Oregon and Washington, for improvements at and in the vicinity of Foster Creek, was received, together with certain reports of the Board of Engineers for Rivers and Harbors and of the district and division engineers, respectively. These reports are bound in a volume entitled "Columbia River and Tributaries, Oregon and Washington, Vicinity of Foster Creek," which was transmitted to me under date of November 29, 1945. The documents were transmitted in compliance with the requirements of section 1 of the act of December 22, 1944 (58 Stat. 887).

Your proposed report recommends authorization by the Congress of construction of Foster Creek Dam and power plant as a part of the comprehensive plan for improvement of the Columbia River. You conclude that the proposed Foster Creek project is essentially a power development, well situated and capable of producing at low cost a large amount of electrical energy for the needs of the Northwest

area. You conclude that its value for irrigation is small and it is of no value for navigation or flood control. And you also conclude that the Foster Creek project is * * * unique among the potential developments below Grand Coulee Dam in that immediate construction will not affect the migratory fish problem in the Columbia River Basin.

I am in substantial agreement with a number of your findings. The navigation or flood-control values of the Foster Creek project are not impressive.

The Foster Creek Dam is assuredly unique among the potential developments below Grand Coulee Dam in that immediate construction will not affect the migratory fish problem in the Columbia River Basin. Additional power facilities will be needed to meet prospective demands for power in the area. It is my hope that these needs may first be met by the Foster Creek Dam, thereby affording additional essential time to provide safeguards for the valuable fishery resource which would be impaired by the premature construction of downstream dams, such as Umatilla. Both the Fish and Wildlife Service and the Office of Indian Affairs, as a result of their studies, urge that in scheduling construction of new major dams in the Columbia Basin, the initial requirements be met through Foster Creek.

I do not agree with your statement that the value of the Foster Creek project for irrigation is small. The report of your own district engineer together with the report on the comprehensive plan now being prepared by the Department of the Interior, both indicate the possibility of direct irrigation of some 15,000 acres in the lower Okanogan River and Columbia River Valleys. In addition, the Bureau of Reclamation is already making plans for numerous other irrigation units which require large amounts of power, such as the 29,000-acre Greater Wenatchee project. Such areas can be served only by pumping against lifts of considerable magnitude. Low summer pumping power rates appear practicable because of the natural distribution of the annual run-off of the Columbia River and the irrigation demands required to be discharged from upstream storage, which permits the generation of large blocks of otherwise secondary summer power that can be used for irrigation pumping purposes. Thus it is evident that the irrigation aspects of the Foster Creek project when considered with power are of primary importance.

In the plan for the development of the resources of the Columbia River Basin, the economic feasibility of the works of which the plan is composed would be aided materially by financial coordination. Coordination in the physical operation of the works comprised in the plan is also a highly desirable objective. Irrigated agriculture and other related land-use developments receive benefits from their financial association with the power generating aspects of other units in the plan for total development. It is essential, in order to safeguard the development of the Northwest, that the Foster Creek project be not excluded from the financial plan for the development of the entire area. If it were set up separately, without financial relationship to the irrigation developments, the benefits of financial assistance to irrigated agriculture would be denied. It is essential that this project be considered as one unit in a complete plan which would integrate

irrigation and power and would give due consideration to power rates within the basin as a whole.

Furthermore, coordination in operation of the Foster Creek project with that of Grand Coulee and Bonneville projects, prior to the eventual completion of the basin development, is highly desirable. Similarly, coordination in time of construction and of installation of generation with basin-wide power needs is important to the realization of maximum benefits from power and irrigation. In this respect, it is desirable to reexamine the number and size of the generating units and to base them on the probable regional load factor, as experienced by the Bonneville Power Administration of the Department of the Interior in marketing power from Bonneville and Grand Coulee Dams.

Your report, in paragraph 147, page 92, under the heading "Effects on local interests," states "No objection to land acquisition at reasonable compensation is anticipated from owners either on the left bank or in the Colville Indian Reservation." I wish to point out that the acquisition and direct payment for Indian-owned lands which are located in the reservoir area may not meet fully the obligations of the United States with respect to our responsibility to the Indians themselves. The productive capabilities of the lands, in the Foster Creek Reservoir area, whether by grazing, crop raising, or by other means, should be suitably replaced to insure the continued economic welfare of the displaced Indians. The solving of such problems is the responsibility of this department through the Office of Indian Affairs.

In my opinion the Foster Creek Dam project should be authorized at the present time, but it should be authorized for construction by the Bureau of Reclamation, Department of the Interior. In this connection, you will recall that the Commissioner of Reclamation advised your Board of Engineers for Rivers and Harbors by letter of October 30, 1945, when that Board was having a hearing on the proposed project, that inasmuch as the project would serve primarily the purposes of power production and irrigation, it was his opinion that, when economically justified, the project should be constructed and operated under the direction of the Secretary of the Interior and supervision of the Bureau of Reclamation, pursuant to the Federal reclamation laws. I concur fully with the statement of the Commissioner of Reclamation, and in his reasons for making that statement.

It will be possible for the authorization of the project, under those laws, to be handled by a report and findings by the Secretary of the Interior submitted to the Congress pursuant to section 9 of the Reclamation Project Act of 1939 (53 Stat. 1187), and in the ordinary handling of the matter that would be the course which this Department would follow. It may be deemed desirable, however, to proceed in this case by means of special legislation. Such special legislation, as I see it, should do these things: (1) Authorize, under the Federal reclamation laws, the construction and operation of a dam and power plant in the general location and of the same general characteristics as that described in your proposed report, (2) authorize the construction of transmission lines for the interconnection of the power plant with other Federal transmission systems in the area, (3) provide for an allocation of costs through a report to the Congress that would recognize, among other things, the benefits to be realized at this project from the construction and operation of Grand Coulee Dam and other upstream storage reservoirs, and (4) authorize, upon

compliance with the provisions of the Federal reclamation laws, the construction of such irrigation works as the Secretary of the Interior found to be feasible as a part of the total development.

Sincerely yours,

OSCAR L. CHAPMAN,
Acting Secretary of the Interior.

COMMENTS OF FEDERAL POWER COMMISSION

FEDERAL POWER COMMISSION,
Washington 25, March 18, 1946.

Lt. Gen. R. A. WHEELER,
Chief of Engineers, War Department,
Washington 25, D. C.

DEAR GENERAL WHEELER: The comments of the Commission herein with respect to your proposed report on a review of reports on Columbia River and tributaries, Oregon and Washington, for improvements at and in the vicinity of Foster Creek, are transmitted in response to the request in your letter of January 16, 1946. Your letter also transmitted the reports thereon of the Board of Engineers for Rivers and Harbors and of the division and district engineers.

These reports recommend authorization, as a part of the comprehensive plan for improvement of the Columbia River, of the construction of a dam and power plant at the Foster Creek site on the Columbia River, 51 river-miles downstream from Grand Coulee Dam. The project is essentially a power development and would have but little value for irrigation and no value for navigation or flood control. The installed capacity would consist ultimately of fifteen 64,000-kilowatt units, aggregating 960,000 kilowatts. These generating units would be installed in five stages, three with the initial construction of the dam and the remainder in four succeeding stages of three units each. The estimated cost of the completed project is $104,000,000 not including transmission.

A dam and power plant at Foster Creek has long been considered an essential unit in plans for the comprehensive development of the water resources of the Columbia River which includes the constructed Grand Coulee, Rock Island, and Bonneville Dams, the authorized Umatilla project, and Chelan, Rocky Reach, Priest Rapids, John Day, and The Dalles projects. The recent investigations by your Department and the studies by the Commission staff, including review of the subject reports, serve to confirm previous opinions in this regard.

With respect to the choice of dam site it appears that all of the sites investigated are located in a restricted reach of the river upstream from the mouth of Foster Creek where the canyon width is inadequate for both a spillway and powerhouse on approximately the same axis. The staff reports that this condition necessitates extensive excavation and other costs, not generally attendant on the construction of such a project, which may amount to as much as $7,700,000. Inspection of available topographic maps indicates a possibility of finding a dam site downstream from the one chosen where some part of these unusual expenses might be avoided. If this possibility has not been investigated, and the reports do not indicate that it has, it would be desirable to explore the situation at the time that this project may reach the definite project stage.

Careful consideration has been given to the market for the power that would be developed at Foster Creek as a result of which it is concluded, on the basis of load estimates supplied by Bonneville Power Administration, that if this power is available by about 1955 it will be absorbed as rapidly as it can be developed under the schedule proposed in the reports of your Department. This conclusion has been reached having due regard to the reduction in war loads within the region, and taking cognizance of the enlargement of existing plants, and proposals for the construction of the Detroit project in the Willamette Basin, Hungry Horse on the Flathead River, Umatilla on the Columbia, and projects authorized on the Snake River. The rate at which these projects will be developed to their ultimate capacities is indeterminate at this time and will depend in part upon the rate at which additional upstream storage, not now authorized, is provided. These are problems concerning which the interested Federal agencies, including the Federal Power Commission, should continue their cooperative investigations with State participation with the view to developing a well-coordinated plan and a schedule of construction that is based upon thorough studies of future power markets.

The primary power at Foster Creek, with existing upstream regulation and with operation of the project coordinated with Grand Coulee, is estimated at 526,000 kilowatts. The estimate in the reports of the installed capacity required has been based upon the development of this power at 67 percent load factor, or 785,000 kilowatts. The proposed installation of 960,000 kilowatts would have a capability under flood flow of 500,000 cubic feet per second of about 795,000 kilowatts and it appears, therefore, that the installation proposed is adequate for the load factor assumed. While this load factor is less than that at which it may be possible to market the power under present conditions of stream-flow regulation it is reasonable to assume that substantially greater regulation will obtain in the future. On this basis the provisions for ultimate installation are considered adequate and serve as a basis for measuring the economic soundness of the project.

The cost of production of energy at the site of the Foster Creek project is estimated in the reports at 1.63 mills per kilowatt-hour of firm energy which, it is stated, would permit the sale of energy under the existing rates of the Bonneville Power Administration, with ample margin for transmission and administrative expense. Based upon its own estimates of the economics of the project the staff reports that, on the assumption that 90 percent of the total firm energy plus 10 percent of the secondary energy is salable at prevailing Bonneville Power Administration rates and that transmission annual cost is $6.25 per installed kilowatt, the at-plant returns from the 15-unit installation would exceed annual charges by $1,253,000 if financing is based upon 2½-percent interest.

Based upon the reports of your Department and upon its own staff studies the Commission concurs in the recommendation of the Board of Engineers for Rivers and Harbors that the construction of the Foster Creek Dam and powerhouse be authorized in accordance with those reports as a part of the comprehensive plan for the improvement of the Columbia River.

Sincerely yours,

LELAND OLDS, *Chairman.*

COLUMBIA RIVER AT FOSTER CREEK, WASH.

REPORT OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, April 9, 1946.

The CHAIRMAN, COMMITTEE ON RIVERS AND HARBORS,
House of Representatives, Washington, D. C.

MY DEAR MR. CHAIRMAN: 1. The Committee on Rivers and Harbors of the House of Representatives, by resolution adopted March 24, 1942, requested the Board of Engineers for Rivers and Harbors to review the reports on Columbia River and tributaries, Oregon and Washington, submitted in House Document No. 103, Seventy-third Congress, first session, and previous reports, with a view to determining if improvements at and in the vicinity of Foster Creek are advisable at the present time. I enclose the report of the Board in response thereto.

2. After full consideration of the reports secured from the district and division engineers, the Board recommends authorization, as a part of the comprehensive plan for improvement of the Columbia River, of the construction of Foster Creek Dam and powerhouse in accordance with the plans in the report of the district engineer and with modification thereof as in the discretion of the Secretary of War and the Chief of Engineers may be advisable at an estimated cost of $71,000,000 for the construction of the first three units, and $33,000,000 additional for a total of 15 units, and with annual maintenance and operation ranging from $650,000 for the first three units to $1,200,000 for the 15 units.

3. After due consideration of these reports, I concur in the views and recommendations of the Board.

Very truly yours,

R. A. WHEELER,
Lieutenant General,
Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

WAR DEPARTMENT,
THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, November 16, 1945.

Subject: Columbia River in the vicinity of Foster Creek.
To: The Chief of Engineers, United States Army.

1. This report is in response to the following resolution adopted March 24, 1942:

Resolved by the Committee on Rivers and Harbors of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors created under section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby,

requested to review the reports on Columbia River and tributaries, Oregon and Washington, submitted in House Document Numbered 103, Seventy-third Congress, first session, and previous reports, with a view to determining if improvements at and in the vicinity of Foster Creek are advisable at the present time.

2. Foster Creek flows into the Columbia River near Bridgeport, Wash., 545 miles above the mouth and 200 miles downstream from the international border. The improvement previously considered in the vicinity consisted of power dam which was 1 of 10 dams included in a comprehensive plan of improvement for the Columbia River. The project as contemplated consisted of a concrete gravity structure 225 feet high and 2,000 feet long and a power plant with an installation of 691,000 kilowatts. The pool formed by the dam would extend upstream to the foot of Grand Coulee Dam, a distance of 51 river-miles.

3. At a hearing held by the district engineer representatives of local, State, and national interests urged immediate authorization of Foster Creek project for early postwar construction. Lumbermen and miners cited the expansion of pulp and mineral production that will follow further low-cost power development. Agriculturists spoke at length of the fertile lands that can be irrigated in the vicinity, and others pointed out that the project will result in increased agricultural and industrial development.

4. After further investigation of the sites in the vicinity of Foster Creek the district engineer proposes construction of the project with minor modifications. He selects a site about 1 mile downstream for the construction of a concrete gravity dam with maximum height of 220 feet and a power plant with a rated capacity of 960,000 kilowatts in 15 units. An initial installation of 192,000 kilowatts is estimated to cost $71,000,000 for construction and $650,000 annually for maintenance and operation, and corresponding costs for the ultimate installation of 960,000 kilowatts are $104,050,000 and $1,202,000. Marketable firm energy is estimated as 4,146 million kilowatt-hours per year and the cost of production at the site is estimated as 1.63 mills per kilowatt-hour on a conservative basis.

5. The district engineer reports that energy generated in the States of Washington, Oregon, Idaho, Montana, and Utah, and served by existing interconnected transmission systems, amounted to 19,201 million kilowatt-hours in 1944. After discounting the present abnormal power production and making an allowance for postwar readjustment, he estimates that additional installations will be required by 1954 if the load should grow at a rate of 10 percent per annum, and by 1960 if the rate should be 5 percent per annum. He points out that frequently the load has doubled within a 7-year period or less, equivalent to average growth at the rate of 10 percent per annum. He concludes that generating capacity, additional to that planned for the authorized Federal projects and all prospective private and municipal power plants will be required in a few years, and that Foster Creek project, an element in the comprehensive plan of improvement for the Columbia River, is one of the best remaining undeveloped power sites on the Columbia River.

6. The district and division engineers concur in recommending authorization of the Foster Creek Dam and powerhouse as the next step in accomplishment of the comprehensive plan for improvement of the Columbia River.

7. Interested parties were advised of the nature of the report of the division engineer and invited to present additional information to the Board. Careful consideration was given to the communications received.

VIEWS AND RECOMMENDATIONS OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

8. The Board concurs generally in the views of the reporting officers. The proposed Foster Creek project is essentially a power development, well situated and capable of producing at low cost a large amount of electrical energy for the needs of the northwest area. Its value for irrigation is small and it is of no value for navigation or flood control. Authorization of the Foster Creek project at this time is considered advisable in order that plans can be made in advance and construction undertaken at the proper time to meet the regional needs for hydroelectric power. In no event should construction of the Foster Creek project take precedence over that of the more important multiple-purpose projects on the Columbia and Snake Rivers already authorized by Congress.

9. The Board recommends authorization, as a part of the comprehensive plan for improvement of the Columbia River, of construction of Foster Creek Dam and powerhouse in accordance with the plans in the report of the district engineer and with modification thereof as in the discretion of the Secretary of War and the Chief of Engineers may be advisable at an estimated cost of $71,000,000 for the construction of the first three units, and $33,000,000 additional for a total of 15 units, and with annual maintenance and operation ranging from $650,000 for the first three units to $1,200,000 for the 15 units.

For the Board:

THOMAS M. ROBINS,
Major General, Senior Member.

REVIEW REPORT ON COLUMBIA RIVER AT FOSTER CREEK, WASH.

SYLLABUS

The district engineer finds that construction of a dam for the improvement of Columbia River at Foster Creek is practicable and that it is favorable in cost and in the power rate required to carry the investment.

He submits a plan for a straight gravity overflow dam with normal pool at elevation 937.5, a powerhouse of 960,000-kilowatt capacity, and an intake with provision for increased capacity as required to utilize future upstream storage.

He believes the growth of power load in the region will absorb the output of the Foster Creek project, in addition to that of all other generating capacity definitely planned for other locations within a few years.

He recommends adoption of the project as the next step in the comprehensive development of the Columbia River Basin.

TABLE 1.—*Pertinent data*

1. Location of dam site, Okanogan and Douglas Counties, Wash., sec. 24, T. 29 N., R. 25 E., Willamette meridian:		
Above mouth of Columbia River	river-miles	545
Above mouth of Snake River	do	221
Above mouth of Okanogan River	do	12
Below origin of Columbia River	do	660
Below international boundary	do	200
Below Grand Coulee Dam	do	51

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TABLE 1.—*Pertinent data*—Continued

1. Location of dam site—Continued		
From Seattle, Wash. (principal city west, population, 368,000)	road-miles	235
From Spokane, Wash. (principal city east, population, 122,000)	do	143
From Brewster, Wash. (nearest railroad, population, 447)	do	14
From Bridgeport, Wash. (post office, population 320)	do	1½
2. Stream flow:		
Drainage area above dam site	square miles	75,000
Run-off, mean annual, 1913–42	acre-feet	77,540,000
Run-off, mean annual, 1913–42	inches	19.62
Discharge (Grand Coulee gage):		
Minimum daily, unregulated January–February 1937	cubic feet per second	15,300
Mean, usual minimum month (February), 1913–42	do	36,300
Mean, usual maximum month (June), 1913–42	do	295,200
Mean, annual, 1913–42	do	107,100
Maximum flood, June 1894, USGS estimate	do	725,000
Spillway design flood	do	1,250,000
Slope, average low-water, international boundary-Snake River	feet/mile	2.3
Slope, average low-water, Grand Coulee-Foster Creek	do	3.3
Slope, maximum low-water, Grand Coulee-Foster Creek	do	14.0
3. Hydraulics:		
Pool elevation, normal	feet mean sea level	937.5
Pool elevation, minimum probable	do	935.0
Pool elevation, maximum known flood (1894)	do	943.1
Pool elevation, spillway design flood	do	957.4
Draw-down, usual maximum below tops of gates	feet	5
Tail-water elevation, normal low (45,000 cubic feet per second)	feet mean sea level	765.3
Tail-water elevation, at spillway design flood	do	840
Tail-water elevation, maximum known flood (1894)	do	817
Reservoir contents, normal pool	acre-feet	480,000
Reservoir pondage, maximum (5 feet) drawn-down	do	36,000
4. Dam, straight concrete gravity over-flow type.		
Spillway section:		
Height, foundation to roadway	feet	220
Length, net opening	do	1,000
Crest elevation	feet mean sea level	908
Tops of gates, elevation	do	940
Top of roadway, elevation	do	960
Tainter gates (25), length	feet	40
Sluices (12), dimensions	do	5.67 x 10
Sluices, capacity at design flood, total	cubic feet per second	55,000
Spillway capacity at design flood	do	1,250,000
Nonoverflow sections:		
Length, right (north) side	feet	390
Length, left (south) side	do	94
Top elevation	feet mean sea level	960
Freeboard	feet	2.6
5. Intake:		
Wall, concrete gravity, length	feet	1,642
Wall height	do	130
Canal, floor elevation	feet mean sea level	850
Penstocks, (15), steel plate, diameter	feet	23
6. Powerhouse:		
Building dimensions, over-all	do	166 x 1,162
Installation:		
Main generators	units	15
Main generators rated capacity each	kilowatts	64,000
Main generators spacing	feet	67
House generators	units	3
Main turbines, Francis, rating each	horsepower	87,000
Plant, installed capacity	kilowatts	960,000
Transformers, 8 banks of 3, rating per bank	kilovolt-amperes	150,000
Power characteristics, critical period:		
Study 6. Uniform flows from Flathead and Kootenay Lakes; Grand Coulee operation coordinated with Foster Creek:		
Prime power	megawatts	526
Firm capability, 67 percent load factor	do	785
Annual firm energy, 67 percent load factor	million kilowatt-hours	4,607
Hydraulic characteristics:		
Plant discharge, full gate, rated head	cubic feet per second	83,800
Head, maximum gross at 15,000 cubic feet per second	feet	183.1
Head, minimum gross at 500,000 cubic feet per second	do	148.6
Head, rated net	do	162.0
7. Land and relocations:		
Reservoir:		
Area within meanders	acres	6,687
Area above meanders, Government-owned	do	2,115
Area above meanders, to be acquired	do	13,043
Area over-all	do	21,845
Relocations, roads	miles	4.6
Access and construction:		
Areas, construction zone	acres	5,946
Areas, construction right-of-way (including transmission line)	do	547
Railroad construction (including sidings)	miles	12.5
Highway construction	do	13.0
Highway relocations	do	2.2
Bridges, major construction	units	3
Transmission-line construction	miles	30

TABLE 1.—*Pertinent data*—Continued

8. Cost estimates, 15-unit installation:	
Construction (1940 prices)	$104,050,000
Interest during construction (3 percent on average time)	6,380,000
Investment, total	110,430,000
Investment, per kilowatt installed capacity	115
Annual, uniform after completion of 15-unit installation:	
Interest on investment, 3 percent	3,313,000
Amortization and replacements, 50-year items	624,000
Amortization and replacements, 35-year items	699,000
Payments in lieu of taxes	2,000
Contingency reserve, 0.10 percent	110,000
Operation and maintenance	1,202,000
Total annual charges	5,950,000

WAR DEPARTMENT,
OFFICE OF THE DISTRICT ENGINEER,
Seattle, Wash., August 15, 1945.

Subject: Review of report on Columbia River in the vicinity of Foster Creek.

To: The Division Engineer, Pacific Division, San Francisco, Calif.

CHAPTER I—INTRODUCTION

1. *Authority.*—This report is submitted pursuant to the following resolution adopted March 24, 1942:

Resolved by the Committee on Rivers and Harbors of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors created under section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby, requested to review the reports on the Columbia River and tributaries, Oregon and Washington, submitted in House Document Numbered 103, Seventy-third Congress, first session, and previous reports, with a view to determining if improvements at and in the vicinity of Foster Creek are advisable at the present time.

2. *Report under review.*—The report contained in House Document No. 103 referred to in the committee resolution and reviewed herein, was made under the provisions of House Document No. 308, Sixty-ninth Congress, first session, which was enacted into law with modifications, in section 1 of the River and Harbor Act approved January 21, 1927. As defined in House Document No. 308 and in the River and Harbor Act of March 3, 1925, the primary purpose of House Document No. 103 was—

the formulation of general plans for the most effective improvement of the river for the purpose 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.

3. The report outlined a general plan for 10 dams on the main stream at the following sites between the international boundary and tidewater: Grand Coulee, Foster Creek, Chelan, Rocky Reach, Rock Island Rapids, and Priest Rapids in Washington; Umatilla Rapids, John Day Rapids, The Dalles, and Warrendale (now Bonneville) in both Oregon and Washington. In his report on the general plan, the Chief of Engineers concluded that coordinated power development on Columbia River was feasible and economical; that power for future irrigation should be supplied at the cost of production; that flood control was a minor interest, susceptible of easy solution by local

interests. As to navigation, the Chief of Engineers found it to be difficult and costly in the upper Columbia above Wenatchee and without prospect of water-borne commerce under those conditions.

4. The dams at Grand Coulee and Bonneville have been built by Federal agencies. The Rock Island Rapids site has been developed for power by private interests. Umatilla Dam was authorized by the River and Harbor Act of March 2, 1945. The Foster Creek Dam, as contemplated in House Document No. 103, was a straight, concrete, gravity type structure 225 feet high and 2,000 feet long. It was proposed primarily for hydroelectric power production, with installed capacity of 691,200 kilowatts, a hydraulic capacity of 77,000 cubic feet per second, and average head of 154.9 feet. It would back the river up to the foot of Grand Coulee Dam, a distance of 51 river miles.

5. *Scope.*—This report is limited by the authorizing resolution to a consideration of improvements at and in the vicinity of Foster Creek. In accordance with the comprehensive plan, it considers development of the site primarily for the production of power, presents plans and cost estimates therefor, and discusses the benefits that would result.

6. *Geographical names.*—Certain terms and place names used in this report are defined or clarified as follows:

(*a*) *Coulee Dam.*—The town situated on both banks of Columbia River, including the former Mason City, just below Grand Coulee Dam.
(*b*) *Grand Coulee Dam.*—The dam structure across Columbia River near the Grand Coulee, a prehistoric, dry channel from which the dam takes its name.
(*c*) *Grand Coulee.*—Used briefly for the Grand Coulee project, which includes the dam, reservoir, and power development. In connection with hydrology, it refers to the gage just below the dam.
(*d*) *Columbia River Reservoir.*—The reservoir formed by Grand Coulee Dam, extending to the international boundary.
(*e*) *Clark Fork.*—Clark Fork, as used in this report, includes Pend Oreille River, the portion of the river system below Pend Oreille Lake.

7. *Available data.*—In addition to the data in the report under review, the principal data available at the inception of this study were:

(*a*) Okanogan quadrangle, Washington, (1905) United States Geological Survey, topographic sheet. Scale 1:125,000; contour interval, 100 feet.
(*b*) Jameson quadrangle, Washington, (1918) Corps of Engineers, U. S. Army, progressive military map. Scale 1:125,000.
(*c*) Original Township Survey and Resurvey Plats, General Land Office, photographs.
(*d*) Township maps, Metsker. Scale 2 inches equals 1 mile.
(*e*) Plan of Columbia River, International boundary to Rock Island Rapids (below Wenatchee), Wash. (1930), Corps of Engineers and the U. S. Geological Survey, 10 sheets. Scale 1:31,680 (1 mile equals 2 inches); contour interval 20 feet; land topography from aerial photographs (item (*f*) below) by stereophotogrammetry; river topography from a profile taken at low water.
(*f*) Aerial survey photographs (1930), Corps of Engineers and the U. S. Geological Survey, 4¾ inches by 4¾ inches; scale 1:22,500.
(*g*) Aerial survey photographs (1939), Agricultural Adjustment Agency, 9¾ inches by 12¼ inches; scale approximately 1 inch equals 1,320 feet.
(*h*) General highway and transportation maps. (1936) Department of Highways, State of Washington.
(*i*) State highway plans and profiles in the vicinity of Foster Creek, Department of Highways, State of Washington. Scale 1 inch equals 200 feet Horizontal, and 1 inch equals 40 feet vertical.
(*j*) Plan and profile of location from Brewster to Peach, Wash., Great Northern Railway Co., survey of December 1909 and January 1910.

8. *Prior reports.*—The only prior report on the Foster Creek site by this Department is the report under review. Earlier reports by the War Department on examinations and surveys of the upper Columbia River were primarily in the interest of navigation. These reports, all of which are listed in the report under review, were submitted at various times from 1884 to 1917, inclusive.

Chapter II—General Data

9. *Description.*—Columbia River and its tributaries drain an area of 259,000 square miles in southwestern Canada and northwestern United States, between latitudes 41° and 53° north and longitudes 110° and 124° west. Of the total area, about 39,700 square miles lie in British Columbia, Canada, and the remainder in the United States. Included are western Montana, most of Idaho, eastern and southern Washington, and eastern and northern Oregon, together with adjacent small parts of Wyoming, Utah, and Nevada.

10. Columbia River proper is about 1,210 miles in length, of which about 460 miles lie in Canada. It rises in Columbia Lake, British Columbia, at elevation 2,650, flows northwesterly for nearly 200 miles through the Rocky Mountain trench, then turns abruptly around the north end of the Selkirk Range and flows southerly through Upper and Lower Arrow Lakes to enter the United States near the northeastern corner of Washington. At the international boundary, the Columbia enters Columbia River Reservoir and continues south for 112 miles to a point below the mouth of Spokane River. It then turns and flows west for 100 miles to the mouth of Okanogan River, passing Grand Coulee Dam and Foster Creek Dam site en route. Swinging south, the river follows the eastern foothills of the Cascades for 209 miles to its confluence with Snake River. A few miles below the Snake, it turns sharply westward and flows for 324 miles, forming the Washington-Oregon boundary, to the Pacific Ocean.

11. Principal tributaries of Columbia River above the Foster Creek Dam site are the Kootenai (spelled Kootenay in Canada), Clark Fork, Kettle, and Spokane Rivers. The Kootenai rises in British Columbia north of Columbia Lake, flows southeasterly through the Rocky Mountain trench, loops through western Montana and northern Idaho, then returns to Canada to pass through Kootenay Lake and join the Columbia 30 miles north of the international boundary. It drains an area of 19,450 square miles, including 14,530 square miles in Canada, and contributes annually an average of some 34,000 cubic feet per second to the Columbia.

12. Clark Fork rises near Butte, Mont., flows northwest between the Continental Divide and the Bitterroot Mountains, passes through Pend Oreille Lake in northern Idaho, traverses the northeastern corner of Washington, and joins the Columbia in Canada about one-half mile north of the boundary. The stretch from Pend Oreille Lake to the junction with the Columbia is known as Pend Oreille River. Clark Fork and its tributaries drain an area of 25,820 square miles of which 1,180 square miles are in Canada. It delivers an average annual flow of 25,000 cubic feet per second to the Columbia.

13. Kettle River rises in Canada between the Columbia and Okanogan Rivers, flows in a southerly direction, and discharges a mean

annual flow of 3,000 cubic feet per second into Columbia River Reservoir about 40 miles south of the boundary. It drains 4,260 square miles, of which 3,150 square miles are in Canada.

14. Spokane River enters Columbia River Reservoir about 108 miles south of the international boundary, contributing a mean annual flow of 8,000 cubic feet per second from a drainage area of 6,600 square miles. The river forms the outlet of Coeur d'Alene Lake which in turn drains the westerly slopes of the Bitterroot Range through the St. Joe and Coeur d'Alene Rivers.

15. The natural profile of Columbia River between the international boundary and the mouth of Snake River is a series of steep slopes, intervening sections of comparatively low grade, and occasional pronounced drops such as Long Rapids, Rock Island Rapids, and Priest Rapids. Prior to the construction of Grand Coulee Dam, the medium low-water slope from the boundary to the dam averaged more than 2 feet per mile with extremes ranging from 0.7 foot to 37 feet per mile. From Grand Coulee to Bridgeport, the slope averages 3.3 feet per mile, as shown on plate 5.[1] Within this reach, however, the drop at Long Rapids is 14 feet per mile and from the head of Long Rapids to the foot of Foster Creek Rapids, 6 feet per mile. The average slope for the entire 421 miles from the boundary to Snake River is 2.3 feet per mile.

16. Data for a complete high-water profile of the river are not available. From records of isolated high-water elevations during the highest known flood, in 1894, extreme stage differences have been estimated to be 52 feet at Foster Creek, 68.5 at Grand Coulee, and from 35 to 77 feet elsewhere between the international boundary and the mouth of the Snake.

17. The upper Columbia River Basin, lying between the Rocky Mountains (Continental Divide) on the north and east and the Cascade Mountains on the west, is characterized by mountain ranges and broad, rugged plateaus with intervening deep, narrow valleys. The summits of the Rockies rise from 7,000 to 12,000 feet above sea level, and those of the Cascades from 6,000 to 8,000 feet, above which tower Mount Rainier (elevation 14,408 feet) and other volcanic peaks. Within the basin itself are various mountain ranges that attain altitudes of 5,000 to more than 10,000 feet above sea level. Of the benches and plateaus in the basin, the largest is the Columbia Plateau. It is bounded on the west and north by the Columbia and Spokane Rivers, on the east by the Bitterroot Mountains, and on the south by the northerly Snake River Divide. It ranges in elevation from 1,000 to 5,000 feet and is characterized by rolling prairies, exposed lava sheets, parallel ridges, and dry stream gorges. Between the mountain ranges and plateaus, great depressions provide the drainage outlets for the river system, often occuring as deep, narrow canyons, or again as extensive storage basins where glacial action has broadened the valleys into lake basins.

18. The mountainous areas of the basin receive the bulk of precipitation in the form of winter snows that compact to great depths among the high peaks. The slow thawing of this accumulation produces the single extended high water that begins in April or May, reaches a peak usually in June, and recedes during the summer and fall. Summer precipitation in most of the basin is deficient for diversified

[1] Not printed.

farming, and irrigation is a large factor in the agricultural scheme. Cultivation is limited to scattered areas, usually in valleys where suitable topography, soils, and growing conditions exist. Coniferous forests of the mountain slopes support an extensive lumber industry. Mineralization of the mountains in numerous localities provides another important resource.

19. Although navigation is hazardous and difficult on most of the upper Columbia and its tributaries, early settlement and subsequent development of transportation routes naturally followed the water grades through the mountains. The geographic pattern influenced the locating of communities along the rivers. Economically, however, these communities must rely largely upon railways and highways for transportation, and upon the upland wilderness for the raw materials of mining and lumbering, as well as for the water of irrigation. Water power is one of the great, undeveloped resources of the basin. The great discharge and fall of the streams create a tremendous power potentiality. Dam and reservoir possibilities are numerous throughout the river system. Among these, the proposed development at Foster Creek is one of the most favorable.

20. *Regional geology.*—The Columbia Plateau, at the northern border of which Foster Creek Dam site is located, is an interior, arid to semiarid region covering approximately 200,000 square miles in eastern Washington and Oregon and southern Idaho. The entire area is underlaid with basalt flows that are known to be several thousand feet thick in places. As the valley of the Columbia evidently antedates the adjacent topography, it is probable that the lava flows diverted the Columbia from its original more direct course between the mouths of Spokane and Snake Rivers, resulting in the great bend to the westward, where it has since carved out a canyon along most of its way.

21. To the north of this westward course of the Columbia, the Okanogan Highlands extend northward into Canada and eastward to join the Rocky Mountains. Underlying the greater part of this section of Washington is a series of granite batholiths with scattered exposures where erosion has removed the country rock cover.

22. The westward course of the river defines approximately the southern limit of direct glacial action. The country to the north was glaciated, and drainages of the minor streams were modified considerably. Both the Columbia and Okanogan Rivers, however, probably are flowing in their preglacial valleys with but slight modifications. Glacial drift mantles the granite bedrock as a veneer of stratified silt, sand, and gravel, intercalated with glacial sheets of varying composition. Glacial and preglacial gravels, lying directly on bedrock and overlaid by a massive till sheet, form the right bank of the river in the vicinity of Foster Creek and extend several thousand feet upstream and downstream.

23. *Soils.*—A variety of soils exist in the region, but few are residual in character. The oldest soils are those found on the uplands that were not influenced by the ice invasion. These were borne by the prevailing westerly winds and contain a considerable admixture of volcanic ash from the Cascades. In the river valleys, the glacial or alluvial debris is covered with fine-grained topsoil of Eolian origin. Areas affected by glaciation are covered in places with a veneer of glacial till, coarse sand, and gravel; in other cases they are stripped of their

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original soil covers. Among the latter are the prominent scablands of east-central Washington, exposed by the erosion of torrents from the ice fronts. In general, soils along the Columbia in the Plateau Province are lighter in color and contain much less humus than those to the east and to the west where vegetation is more abundant.

24. *Climate.*—The climate of the Columbia River Basin above Foster Creek Dam site is characterized by warm, dry summers and cool winters with considerable snow at higher elevations. Because of its geographical location, the basin is subject to modified meteorological influences, both oceanic and continental. Oceanic influences are strongest during the winter and result in comparatively heavy snowfall as the warm, moisture-laden air masses from the Pacific Ocean are cooled in passing over the mountain ranges of the upper basin. Continental influences are strongest during the summer and result in semiarid conditions over the plains and showers in the mountainous regions. Meteorological data for stations near the dam site are shown in table 2.

25. *Precipitation.*—Physical factors in the seasonal variation of rainfall over the basin are wind direction and land temperature. Prevailing winds are westerly, bringing air masses over the basin from the Pacific Ocean, which has quite uniform temperature throughout the year and contributes moisture continuously to the atmosphere. As land surfaces change temperature with the seasons more quickly than water, moisture borne by the Pacific air masses in winter is cooled and condenses when crossing the land. During the summer months, the air masses are warmed when crossing the land and therefore absorb rather than lose moisture. As the ocean is comparatively warm in winter and the land is comparatively cold, a condition occurs favorable to creation of low-pressure areas. The storms that result move inland and are the primary cause of winter precipitation. The effect of these storms coincides with that resulting from the cooling influence of the land on the moisture-holding capacity of the westerly winds. During the summer months, the low-pressure zone moves northward, and only occasional showers result.

26. In addition to the winter cooling effect of the land, the Coast, Cascade, and Rocky Mountain Ranges concentrate the precipitation because the air is further cooled by expansion as it ascends their western slopes. As the air masses move down the eastern slopes they are warmed dynamically under the greater atmospheric pressure at lower elevation and the plains lying east of the mountains receive low precipitation. This orographic influence produces abrupt changes in precipitation. The most pronounced is that between the western Cascade summits and the central Washington plain, where the respective precipitations change from over 100 inches to less than 10 inches a year within about 50 miles.

TABLE 2.—*Meteorological data*

NESPELEM, WASH.

[Elevation, 1,800 feet. Period of record, 1915–43]

Item	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation (inches):													
Mean	1.22	1.09	0.85	0.90	0.85	1.25	0.37	0.45	0.81	0.99	1.58	1.37	11.73
Maximum	2.23	4.33	2.80	2.80	3.81	3.31	2.13	2.15	2.98	2.60	3.17	3.39	19.99
Minimum	.19	.06	.05	.05	T	T	.00	T	T	.00	T	.31	6.24
Mean snowfall													27.1
Maximum snowfall													63.9
Minimum snowfall													12.8
Temperature (degrees Fahrenheit):													
Mean	22.8	28.0	39.2	47.8	54.0	62.0	68.5	67.1	58.2	48.4	34.8	27.2	46.5
Maximum	53	59	79	87	96	101	106	99	96	85	68	58	106
Minimum	−25	−28	−8	9	24	28	31	32	17	11	1	−22	−28

OKANOGAN, WASH.

[Elevation, 910 feet. Period of record, 1926–43]

Precipitation (inches):													
Mean	1.22	1.10	0.82	0.90	0.71	1.29	0.34	0.38	0.68	0.76	1.28	1.71	11.19
Maximum	2.83	3.13	1.99	3.11	3.67	4.10	1.42	2.07	2.71	2.43	3.15	4.33	20.62
Minimum	.27	T	.04	.07	.01	.04	0	0	0	.05	T	.17	4.67
Mean snowfall													29.9
Maximum snowfall													60.8
Minimum snowfall													10.8
Temperature (degrees Fahrenheit):													
Mean	24.6	29.1	43.2	53.0	60.0	67.6	75.2	73.4	64.0	52.0	36.9	29.1	50.7
Maximum	55	58	79	95	100	104	111	105	103	87	69	65	111
Minimum	−18	−23	14	18	29	35	46	40	23	11	5	−9	−23

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TABLE 2.—*Meteorological data*—Continued

SPOKANE, WASH.

[Elevation, 1,929 feet. Period of record, 1881–1940]

Item	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation (inches):													
Mean	2.05	1.66	1.26	1.07	1.22	1.25	0.57	0.55	0.88	1.19	1.99	2.19	15.88
Maximum	4.54	5.62	2.91	3.97	3.42	5.12	2.37	2.12	5.58	4.81	5.85	4.35	25.99
Minimum	.51	.09	.12	.11	.06	.01	.00	T	.03	T	T	.21	7.54
Mean snowfall													36.7
Temperature (degrees Fahrenheit):													
Mean	27.5	31.3	39.7	48.4	55.5	62.8	69.0	68.1	59.2	48.3	38.5	30.5	48.2
Maximum	62	60	74	90	97	100	108	104	98	87	70	59	108
Minimum	−30	−23	−10	12	29	34	41	37	22	7	−13	−18	−30

BREWSTER, WASH.

[Elevation, 878 feet. Period of record, 1910–30]

Precipitation (inches):													
Mean	1.35	0.96	0.51	0.60	0.88	0.93	0.39	0.42	0.67	0.75	1.64	1.38	10.48
Maximum	4.72	2.82	1.85	2.00	2.71	2.53	1.57	1.99	1.77	1.91	3.25	3.23	16.63
Minimum	.09	.03	.01	.00	.05	.04	.00	.00	.00	.00	.36	.29	7.38
Mean snowfall													31.9
Maximum snowfall													71.4
Temperature (degrees Fahrenheit):													
Mean	22.2	28.3	41.3	51.8	59.5	66.3	73.8	72.5	62.4	50.1	36.2	26.6	49.3
Maximum	62	62	80	94	100	102	110	107	101	88	65	65	110
Minimum	−17	−11	−4	21	31	35	41	39	24	19	−5	−23	−23

GRAND COULEE DAM, WASH.

[Elevation, 1,100 feet. Period of record, 1934–43]

Precipitation (inches):													
Mean	0.93	1.17	0.74	0.92	0.90	1.65	0.43	0.38	0.49	0.79	0.97	1.19	10.56
Maximum	1.65	3.58	1.70	1.75	2.70	4.29	1.17	1.75	1.42	1.56	2.58	1.89	15.87
Minimum	.35	.29	.14	.30	.04	.13	T	T	T	.05	.14	.54	6.39
Mean snowfall													19.5
Maximum snowfall													36.4
Temperature (degrees Fahrenheit):													
Mean	27.2	31.6	43.4	53.8	61.0	66.7	75.2	73.3	66.6	54.4	38.0	32.8	52.0
Maximum	52	58	74	92	99	105	113	106	104	90	63	58	113
Minimum	−13	−11	18	20	36	44	48	46	35	12	10	12	−13

MANSFIELD, WASH.

[Elevation, 2,267 feet. Period of record, 1922–43]

Precipitation (inches):													
Mean	1.22	1.04	0.65	0.66	0.61	1.17	0.30	0.39	0.61	0.70	1.21	1.48	10.04
Maximum	2.58	3.60	1.91	2.26	3.52	4.64	.99	2.13	2.51	2.41	3.11	3.20	15.92
Minimum	.36	.06	.07	.02	.03	.15	.00	.00	.00	T	.00	.38	5.60
Mean snowfall													38.0
Maximum snowfall													80.4
Minimum snowfall													19.1

27. *Temperature.*—The range in altitude and latitude, the topography, and the general north-south trend of the various mountain ranges are the influences that create local variations of temperature. In general, temperatures are such that winter precipitation over most of the basin falls in the form of snow. Although some melt occurs during the winter at lower elevations, the snow blanket over most of the basin generally continues to build up throughout the winter months until it reaches its maximum, usually in March.

28. *Stream flow.*—Columbia River above Foster Creek Dam site drains a region of diverse topographic and meteorological features. The numerous mountain ranges form an extremely rugged and precipitous terrain in most of the basin. The mountain axes trend in a north and south direction roughly parallel to the Cascade Mountains and perpendicular to prevailing winds from the west and southwest. Several times in the past, the northern part of the drainage basin has been covered to a large extent by glaciers. Movement of the glaciers gouged great troughs, also trending north and south, that are now partially occupied by a multitude of lakes. The lakes have a combined area of at least 1,100 square miles, and their capacity is about 9,000,000 acre-feet between low stage and average annual crest. The annual filling and draining of these natural reservoirs has a marked equalizing effect on run-off. The lakes capture a considerable portion of the flood flow and release it gradually during the summer and fall, thereby producing a well-sustained flow in the main river and on some of the tributaries.

29. As pointed out previously, precipitation is heavy on the western slopes of the mountains and relatively light on the eastern slopes. This unequal distribution causes marked differences in run-off per unit of area. The yields of tributaries vary widely, depending upon where their origins lie with reference to the mountains and to what extent they drain arid and semiarid intermountain basins. Therefore, estimates of stream flow based upon drainage areas or on precipitation data at sparsely located observation stations are subject to considerable uncertainty.

30. Variations in altitude and a spread in latitude of about 7½° are responsible for marked differences in the accumulation of snow and ice in the winter and in the rate of melting in the spring and summer. In the southern part of the basin, melting snow begins to augment stream flow much earlier in the season than in the northern part. The later yield of the northern part, however, is decidedly advantageous, because it produces an increased run-off during the hot, dry summer months and, in conjunction with lake storage, even into the fall months. In general, the flow at Foster Creek Dam site begins to rise in March or April and continues to increase with the intensity of snow melt until June. It does not recede to winter stage until late in October or in November, thus maintaining relatively high flows throughout the summer season. The mean annual flow for water years ending September 30 varies from year to year depending upon the amount of winter precipitation stored in the form of lake pondage and snow cover, and ranges from 51 to 103 million acre-feet at Grand Coulee. Table 3 gives pertinent stream-flow data, and plate 6 [1] shows river hydrographs for the years 1913 to 1944, inclusive.

[1] Not printed.

TABLE 3.—*Stream-flow data*

Item	Columbia River at Grand Coulee (74,100 square miles drainage), corrected for storage in Columbia River Reservoir [1]	Pend Oreille River below Z Canyon (25,200 square miles drainage)		Kootenay River at Nelson, British Columbia (17,700 square miles drainage), observed and estimated [3]	Flathead River near Polson, Mont. (7,010 square miles drainage)	
		Observed [2]	Corrected for storage in Pend Oreille Lake [2]		Observed [4]	Corrected for storage in Flathead Lake [5]
Mean monthly flow, cubic feet per second, for—						
January	38,900	12,600	12,300	8,700	4,230	3,220
February	36,300	11,800	11,700	8,070	3,510	2,900
March	42,400	13,100	14,200	8,580	3,440	4,020
April	81,300	24,200	30,400	17,400	8,110	14,720
May	197,400	55,200	64,700	52,100	27,850	37,290
June	295,200	76,300	74,500	83,100	39,230	37,380
July	230,500	47,300	35,600	61,900	21,460	14,020
August	130,400	19,200	15,100	29,900	8,360	4,870
September	81,600	11,500	10,500	18,300	5,140	3,560
October	55,800	10,300	10,300	13,700	4,280	4,000
November	48,800	11,600	11,900	12,000	4,490	4,280
December	42,500	12,200	12,500	10,100	4,360	3,840
Mean flow, cubic feet per second	107,100	25,500	25,300	27,100	11,240	11,200
Mean annual run-off:						
Acre-feet	77,540,000	18,450,000	18,340,000	19,620,000	8,134,000	8,108,000
Inches	19.62	13.73	13.65	20.78	21.75	21.68
Maximum flow, exclusive of 1894, cubic feet per second	492,000	139,000	----------	146,000	82,100	----------
Minimum flow, cubic feet per second	15,300	2,500	----------	4,100	[7] 5	----------
1894 maximum discharge (estimated), cubic feet per second	725,000	[6] 217,000	----------	225,000	115,000	----------

[1] Observed record, June to December 1923, June 1928 to September 1942; estimated record, April 1913 to June 1923, and January 1924 to May 1928.
[2] Observed record, October 1912 to September 1943.
[3] Observed record, January 1913 to September 1937; estimated record, October 1937 to September 1942.
[4] Observed record, July 1907 to September 1943.
[5] Observed record, February 1910 to September 1943.
[6] 1894 discharge of Pend Oreille River at Priest River.
[7] Caused by power regulation.

31. *The critical period.*—The most critical period of record from the standpoint of low stream flow and existing storage occurred at Grand Coulee Dam and Foster Creek Dam sites from October 1936 through March 1937. An important factor contributing to the low flow during that period was the unusually low temperature in January and February.

32. The 900 square miles of drainage area between the two sites represents a 1.2 percent increment to the area tributary above Grand Coulee gage. As this intervening area is extremely arid and contains but one small tributary, it is assumed that no appreciable increase in volume occurred between Grand Coulee and Foster Creek during the critical period. Stream-flow data therefore are used interchangeably as between the Grand Coulee gage and Foster Creek.

33. *Spillway design flood.*—The spillway design flood adopted for the Foster Creek project is 1,250,000 cubic feet per second. This figure is based on a study of maximum possible temperature conditions in the basin prior to the peak-flow date, and their effect on the accumulated snow pack that would be produced by maximum possible precipitation during the winter season. It includes a 15-percent factor

of safety and agrees closely with the spillway design flood used at Grand Coulee Dam.

34. *Existing storage.*—At the present time there are three large, controlled reservoirs upstream from Foster Creek Dam site. These are Columbia River Reservoir with 5,200,000 acre-feet of usable storage, controlled at Grand Coulee Dam; Flathead Lake with 1,200,000 acre-feet of usable storage, controlled at Kerr Dam; and Kootenay Lake in British Columbia with about 800,000 acre-feet of usable storage, controlled at Corra Linn Dam. There are a number of smaller reservoirs, the largest of which is Coeur d'Alene Lake with 178,000 acre-feet of usable storage, controlled at Post Falls Dam. The effect of upstream storage upon stream flow at Grand Coulee for the critical period is shown in table 4, by assuming regulation of existing reservoirs as indicated therein. In addition, the effect of a possible future reservoir having 3,200,000 acre-feet of usable storage on Clark Fork is shown under two plans of operation.

TABLE 4.—*Mean monthly flow in cubic feet per second, June 1936 through May 1937*

Month	Observed for Columbia River at Grand Coulee, Wash.	Existing storage in Columbia River Reservoir					
		Regulated outflow with existing storage in Columbia River Reservoir only	Existing storage in Columbia River Reservoir, Kootenay and Flathead Lakes, each operated for maximum uniform flow at site		Additional 3,200,000 acre-feet of future upstream storage operated to obtain maximum uniform flow at Grand Coulee		
			Modified inflow	Regulated outflow	Modified inflow		Regulated outflow (either method of operation)
					To maintain full pool as long as possible	To maintain maximum possible uniform inflow during the critical period	
June	301,300	301,300	290,500	290,500	281,400	281,400	281,400
July	170,800	170,800	164,100	164,100	156,500	156,500	156,500
August	106,700	106,700	102,300	102,300	99,700	99,700	99,700
September	65,950	65,950	62,400	62,400	61,600	61,600	61,600
October	41,970	41,970	43,200	44,100	52,200	51,400	52,200
November	28,480	39,800	31,900	44,100	52,200	40,400	52,200
December	23,200	39,800	27,700	44,100	50,700	36,100	52,200
January	18,220	39,800	23,600	44,100	23,200	33,600	52,200
February	18,200	39,800	23,300	44,100	23,500	32,700	52,200
March	23,840	39,800	27,700	44,100	28,000	35,300	52,200
April	44,060	39,800	45,000	44,100	48,100	48,800	52,200
May	135,500	55,000	131,800	48,100	136,800	119,900	52,200

35. *Economic development.*—Columbia River power is distributed by a network serving the States of Idaho, Montana, Oregon, Utah, and Washington. Since the early fur-trading days, the economic life of these States has been based primarily on the production and export of raw material: Lumber, agricultural products, and minerals. Extensive waterways and many natural harbors have been important factors in the economic development of coastal areas, such as Puget Sound and lower Columbia River. In these coastal areas, fishing is a large industry.

36. *Population.*—The growth of population in the five-State region is reflected in table 5, showing by States the census of urban and rural

populations for 1920, 1930, and 1940. The air-line distances and 1940 population of major cities, within 250 miles radius of the dam site, are given in the following table:

State and city	1940 population	Air-miles	State and city	1940 population	Air-miles
Oregon: Portland	305,394	222	Washington—Continued		
Washington:			Spokane	122,001	106
Bellingham	29,314	142	Tacoma	109,408	143
Everett	30,224	121	Yakima	27,221	104
Seattle	368,302	130			

TABLE 5.—*Population distribution, urban and rural*

State and year	United States		Urban places		Rural population	Percent of total		Density per square mile
	Land area, square miles	Population	Number	Population		Urban	Rural	
Idaho:								
1940	82,808	524,873	26	176,708	348,165	33.7	66.3	6.3
1930		445,032	21	129,507	315,525	29.1	70.9	
1920		431,866	20	119,037	312,829	27.6	72.4	
Montana:								
1940	146,316	559,456	23	211,535	347,921	37.8	62.2	3.8
1930		537,606	18	181,036	356,570	33.7	66.3	
1920		548,889	17	172,011	376,878	31.3	68.7	
Oregon:								
1940	96,350	1,089,684	34	531,675	558,009	48.8	51.2	11.3
1930		953,786	28	489,746	464,040	51.3	48.7	
1920		783,389	23	390,346	393,043	49.8	50.2	
Utah:								
1940	82,346	550,310	25	305,493	244,817	55.5	44.5	6.7
1930		507,847	21	266,264	241,583	52.4	47.6	
1920		449,396	17	215,584	233,812	48.0	52.0	
Washington:								
1940	66,977	1,736,191	40	921,969	814,222	53.1	46.9	26.0
1930		1,563,396	38	884,539	678,857	56.6	43.4	
1920		1,356,621	33	742,801	613,820	54.8	45.2	
Region total:								
1940	474,797	4,460,514	148	2,147,380	2,313,134	48.3	51.8	9.4
1930		4,007,667	126	1,951,092	2,056,575	48.7	51.3	
1920		3,570,161	110	1,639,779	1,930,382	45.9	54.1	

37. The distribution of population varies widely as a result of adjustment to topography, climate, water supply, soils, mineral deposits, and forest cover. The greater part of the region's population is found west of the Cascade Mountains where rich agricultural and timber resources, great natural harbors, and an equable climate exist. The densely populated metropolitan districts of Seattle, Tacoma, and Portland are within this area. East of the Cascades the population is generally scattered except for a few widely separated communities, such as Spokane, Yakima, and Butte, that have developed as a result of nearby resources, irrigation, or concentration of transportation facilities. Over much of this intermountain area rugged terrain or insufficient rainfall have tended to limit settlement. War conditions have induced some changes in the distribution pattern. Large urban centers, such as Seattle, Portland, and Spokane, have gained population rapidly through war industry. East of the Cascades some communities have lost population as a result of migration to communities with more war industries. Readjustment will take place after the war and the future trends, both of population growth and distribution,

will depend largely on the status of industries and the extension of irrigation.

38. *Resources.*—The principal resources of the region include forests, agricultural lands, minerals, fish, recreational facilities, and water power. The forests of the Pacific Northwest—Oregon, Washington, Idaho, and western Montana—cover approximately 100,000,000 acres, or about 15 percent of the wooded area of the United States. The standing timber is estimated at 883,000,000,000 board feet, and consists largely of Douglas fir and various types of pine. About half the total timber is in Federal ownership. Saw-timber production in the region was about 10,000,000,000 board feet in 1940. Paper and pulp, plywood, shingles, poles, piling, and fuel are important timber products also.

39. Agriculture has been of major economic importance since the early days of settlement. The Sixteenth (1940) Census showed that over 97,000,000 acres are in farms, distributed by States as indicated in the following tabulation:

State	Land in farms (acres, 1940)		
	Total	Cropland	Irrigated
Washington	15,182,000	3,631,000	615,000
Oregon	17,988,000	2,937,000	1,048,000
Idaho	10,298,000	2,997,000	2,274,000
Montana	46,452,000	6,245,000	1,696,000
Utah	7,302,000	1,043,000	1,176,000
Total	97,222,000	16,853,000	6,809,000

The total value of crops and livestock produced in 1939 was about $465,000,000. Use of the land differs greatly with variations in soils, climate, topography, and economic conditions. Large areas east of the Cascades are utilized mainly for grazing and, with adjacent hay lands, support large numbers of range livestock. Some areas are suitable for drought-resisting crops such as wheat, whereas in others, dairy farming and specialty crops, such as fruits, berries, and vegetables, have been developed through irrigation. West of the Cascades mixed farming is general throughout the lowlands where fertile soils and adequate rainfall exist

40. Mining was a controlling factor in the early settlement of the region. Such famous districts as Butte, Coeur d'Alene, and Metaline have produced and still yield great riches. The value of minerals produced in 1940 exceeded $264,000,000. Gold, silver, copper, lead, zinc, and mercury are the principal metals produced. The region has substantial deposits of nonmetallic minerals, but their production, with a few exceptions, has been of minor importance. The principal nonmetals found are coal, petroleum, limestone, sand, gravel, and clay. In addition to those mentioned, known deposits of other metallic and nonmetallic minerals exist, but because of their inaccessibility or comparatively low grade they have heretofore remained untouched and unevaluated.

41. Fish are a primary resource of the region. A wide variety is found in the coastal waters of the Pacific Northwest, including salmon, steelhead, halibut, pilchard, albacore tuna, cod, and various shellfish. Salmon are the most important, and normally constitute the largest portion of all the commercial catch. The rivers of the Northwest flowing into the Pacific Ocean, particularly the Columbia, are natural spawning grounds for salmon. Their migration upstream from the sea supports one of the important industries of the region. The average yearly volume and value of the canned salmon pack from the Columbia is about 360,000 cases worth nearly four and a half million dollars. During recent war years, the pack has nearly doubled.

42. The recreational value of mountains, forests, lakes, and streams has become recognized as another important natural resource. It has been estimated that over $200,000,000 is expended annually on recreational travel in the Pacific Northwest. Most of the recreation areas are publicly owned and maintained.

43. *Industries.*—Past industrial activity has centered primarily upon lumbering, fishing, mining, farming, and transportation. As the region has developed, construction, processing, and manufacturing activities have become increasingly important. A considerable part of the agricultural production is processed in the region, giving rise to industries such as fruit and vegetable packing, meat packing, and flour milling. In the forest-products industries, although manufacture of lumber and timber products is still by far the leading industry, the production of pulp, paper, and furniture are becoming increasingly important. Manufacture of forest products and processing of foods normally constitute the major part of the manufacturing activity of the region. The most significant recent industrial development is the establishment of light-metal and special-alloy plants for war production. Electrolytic pig-aluminum plants, aluminum rolling mills, metallic magnesium, and ferro-alloy plants are located throughout the Northwest. They are heavy consumers of electric power, and were located here because of the power supply and existing transmission network. Many other war plants such as shipyards that now consume large blocks of power may become dormant after the war, but some of the light-metal and alloy plants may remain active factors in the industrial and power-market situation.

44. *Existing power development.*—Reports of the Federal Power Commission show that installed electric generating plant capacity in the five-State region at the end of the year 1940 was approximately 2,300,000 kilowatts. Of this total, about 1,800,000 kilowatts were available in hydroelectric plants and the remainder in fuel-consuming plants, principally steam. By the end of the year 1944 the total rated capacity of generating plants had increased to 3,535,843 kilowatts, which increase has been largely used to supply the increased demand for electric energy brought about by the war. Until about 10 years ago, hydroelectric power was developed principally by private enterprises and by a few municipalities such as Seattle and Tacoma. Recent expansion of generating facilities in this region has been largely in connection with Federal multipurpose projects.

45. Three principal power plants of the region are located on the main stem of Columbia River—at Grand Coulee Dam, mile 597 above the mouth; at Rock Island Dam, mile 453; and at Bonneville Dam, mile 143. The Grand Coulee plant, completed in 1942 (except for additional generating units) by the United States Bureau of Reclamation, has an installed rated capacity of 818,000 kilowatts (including 20,000 kilowatts in house units), and will have an ultimate installa-

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