CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES, 1921.

NATHAN C. GROVER, *Chief Hydraulic Engineer.*

COEUR D'ALENE LAKE, IDAHO, AND THE OVERFLOW LANDS.

By R. W. DAVENPORT.

INTRODUCTION.

A controversy regarding the use of Coeur d'Alene Lake, Idaho, as a storage reservoir has existed for several years between the Washington Water Power Co. and owners of overflow lands near the lake and its tributaries. The purpose of using Coeur d'Alene Lake for storage is to equalize the flow of low-water periods and to increase the mean flow during such periods by the release of flood water stored in the spring, thereby assuring a greater output of power from the Washington Water Power Co.'s hydroelectric plants on Spokane River. The use of the lake for storage, although it has not increased the maximum water level or the maximum area of lands that may occasionally be flooded, involves the maintenance of a higher water level during low-water periods than would naturally exist, and the consequent retarding of drainage is detrimental to the interests of the landowners. Although the Washington Water Power Co. has settled with the landowners, the natural conflict of interests in the process of settling as well as in the management of the storage reservoir has fostered a great deal of ill feeling.

Because of the functions of the Department of the Interior in the administration of public lands the controversy has been placed several times before the department for consideration. A recent request made of the Geological Survey for certain technical advice has necessitated a field investigation. The writer was detailed to make this investigation and thus had a favorable opportunity to become familiar with the existing physical conditions and with the main features of the controversy.

Because the situation is very complex and involves many factors, concerning which information is lacking or meager, it has seemed advisable to publish a brief report on the conditions and the conclusions reached in order to contribute to a better understanding of

Hawks 2928

the situation and to a proper solution of the many problems involved. It is the purpose of this report, therefore, to present such conclusions as are consistent with a proper understanding of these conditions and to make constructive suggestions as to further activities.

The field investigation was made during the period from May 19 to June 3, 1920, inclusive. About six days was spent with the settlers and their representatives in seeing and considering the features that they believed deserved special attention, and about the same length of time was spent in a similar way with representatives of the Washington Water Power Co. The remainder of the period was spent in independent investigation.

At the time of the visit the stage of water in the lake was at its highest for the season. Although this afforded a good opportunity to see the extent of lands flooded by the lake at that stage, it was not so favorable for observing the character of the soil of the low lands and other conditions that would appear at a lower stage. Two trips by boat were made—one up Coeur d'Alene River as far as Lane and the other up St. Joe River as far as St. Maries. From St. Maries automobile trips were made up St. Maries River for 5 or 6 miles and up St. Joe River as far as Falls Creek, a distance of about 20 miles. The drainage projects near St. Maries were examined, and numerous interviews were had with citizens representing not only the agricultural but various other interests of the region. The officers and representatives of the Washington Water Power Co. made full statements respecting the attitude of the company, and the city engineer of Spokane was interviewed regarding the effect of floods in Spokane.

All persons concerned showed a most helpful disposition in furnishing all information in their possession and in aiding the investigation in every way. The engineering staff of the Washington Water Power Co. has collected a large amount of data regarding the physical conditions and has made studies and investigations of the different features. The settlers have done much less work of this kind but have obtained considerable information concerning the cultivation and productivity of the lands.

The writer is most grateful to all who facilitated the examination. Special acknowledgment is due to Mr. Fred Herrick, Capt. John A. Nye, and Mr. M. S. Parker, among the settlers, and to the officials and employees of the Washington Water Power Co. Valuable information was obtained from a report on the situation entitled "Preliminary report on proposed drainage district No. 4, Benewah County, and drainage district No. 6, Kootenai County," prepared by L. T. Jessup, drainage engineer, under the direction of Samuel Fortier, chief of irrigation investigations, Bureau of Public Roads, United States Department of Agriculture.

Hawks 2929

GENERAL FEATURES.

TOPOGRAPHY.

Coeur d'Alene Lake is in northern Idaho, in the "panhandle." This lake, which lies a few miles from the west boundary of the State, in the same latitude as the city of Spokane, Wash., is 24 miles long and in most places from 1 to 2 miles wide. The chief tributaries are Coeur d'Alene and St. Joe rivers, which drain a wide mountainous area that extends eastward to the crest of the Bitterroot Mountains, part of the eastern boundary of Idaho. The outlet of the lake is Spokane River, which flows westward through Spokane and joins Columbia River. Plate I is a map of the Spokane River basin.

Coeur d'Alene Lake was formed by the drowning of a narrow, steep-sided valley by a dam of gravel that was deposited by a glacial stream at a time when a great glacier extended down from the north.[1] The lake originally extended several miles up the valleys of Coeur d'Alene and St. Joe rivers, but these valleys have been gradually filled with soil washed down from the mountains and deposited by the streams where the current slackens as the water joins the lake. This material has been deposited not only where the main current slackens but also along the margins of the main current where the water has spread outward and the current is not so strong. Because of this lateral deposition, the immediate river banks are the highest land between the river and the steep slopes of the hills that bound the valleys. Decayed vegetation has also contributed to the enrichment of the lands and in some measure to their formation. The lands slope gradually toward the lake, thus illustrating the different stages of the process by which they are being built up. As a further incident of the building process small lakes and swamps have been entirely or partly cut off from the lake at its lower levels.

The natural low-water elevation of the lake is 2,120 feet above the sea. The highest level that the lake has been known to reach was 2,137.6 feet, in the spring flood of 1894. Between these two levels lies about 30,000 acres, including the alluvial bottom lands and the lakes and swamps that at low-water elevation are not a part of the lake proper. This area includes about all the lands that owe their origin to the process described. Considerably more than two-thirds of this area is below an elevation of 2,130 feet and subject to overflow by high water in spring in more than half the years. The area of the lake at a level of 2,120 feet is about 27,000 acres. Its depths are generally great, and navigation is practicable for

[1] Calkins, F. C., A geological reconnaissance in northern Idaho and northwestern Montana: U. S. Geol. Survey Bull. 384, p. 32, 1909.

Hawks 2930

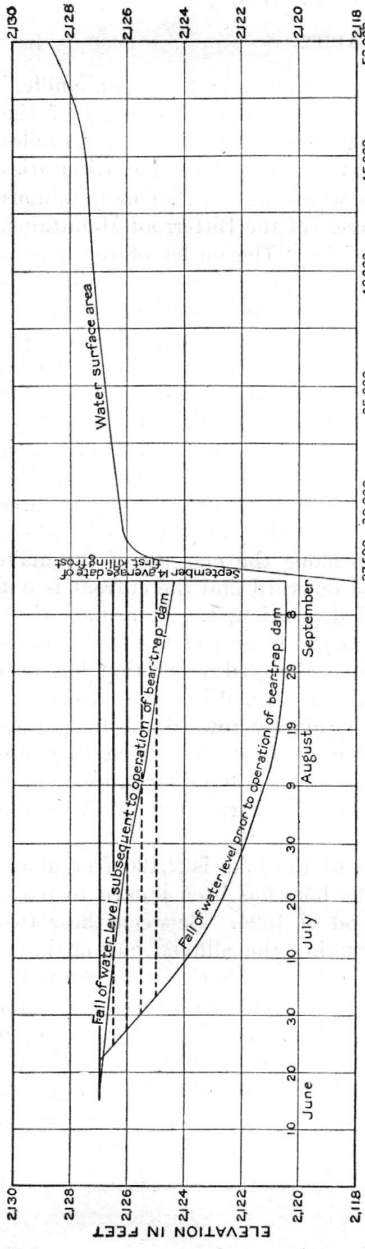


FIGURE 1.—Diagram showing fall of water level of Coeur d'Alene Lake, Idaho, during summer before and after operation of bear-trap dam, in relation to water-surface area.

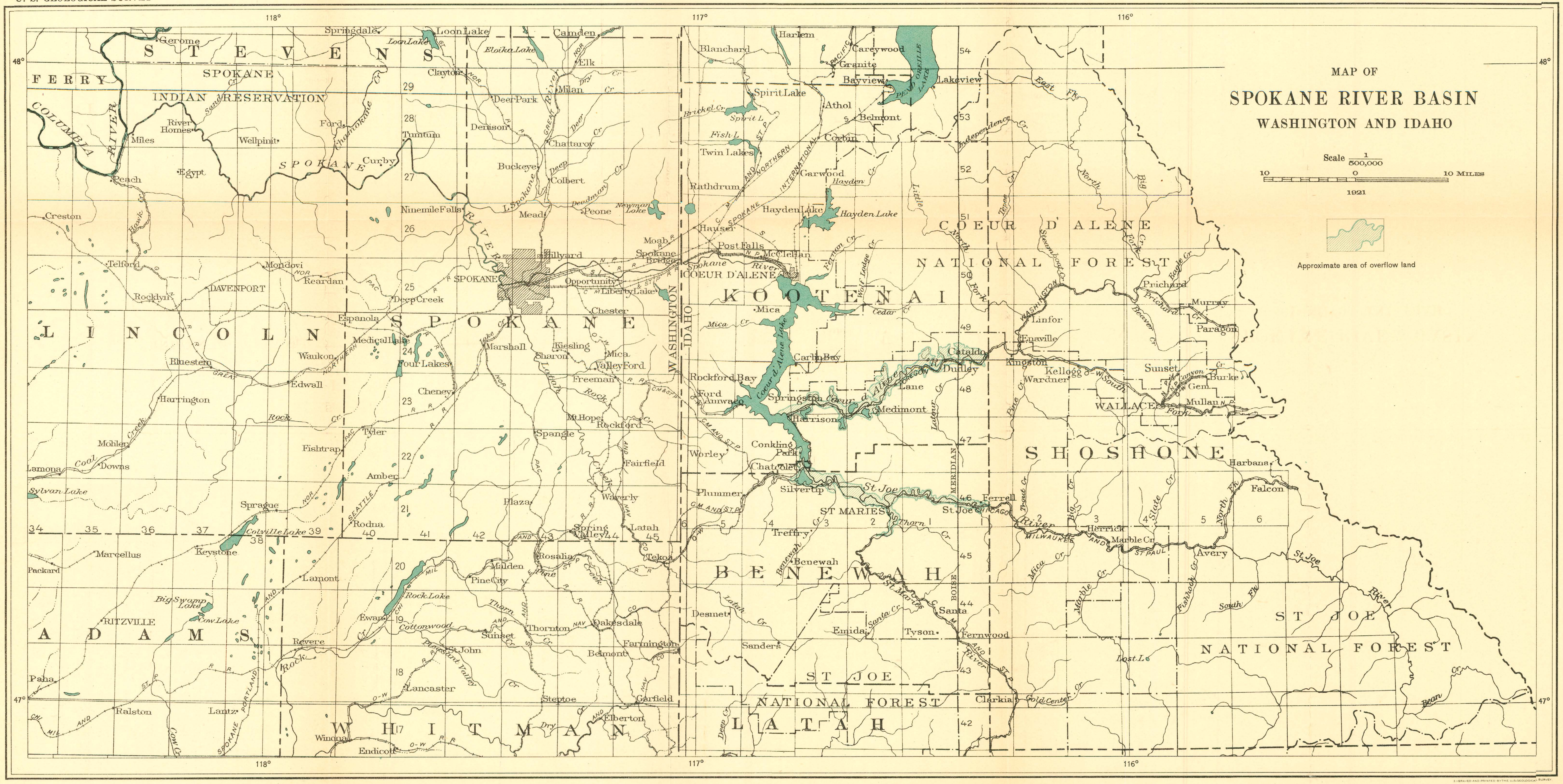
several miles up its chief tributaries. Figure 1 represents the area of the lake at different levels and indicates also the elevation of the overflow lands.

Coeur d'Alene Lake and its tributaries, Coeur d'Alene and St. Joe rivers, are far famed for their beauty. Although many have described them, the description by Capt. John Mullan is perhaps the most interesting, because he saw the region before it had been scarred by the operations of lumbermen and by navigation. Capt. Mullan was on the Coeur d'Alene in 1854 to 1862, superintending the construction of the military road called by his name, extending from Fort Walla Walla to Fort Benton. In July, 1859, he first saw the lake in the vicinity of the mouth of St. Joe River, near the present log-sorting gap. The following extract[2] from his report of 1863 is of historical as well as descriptive interest:

> The valley of the St. Joseph's is a beautiful gem, embedded in a noble range of mountains. Viewed from an elevation on a summer's day the scenery and effect is grand and picturesque—the river winding from side to side in graceful curves, while copses of willow, cottonwood, and alder fringe its banks, and silvery lakes dot here

[2] Mullan, John, Report on the construction of a military road from Fort Walla Walla to Fort Benton, p. 16, Washington, Government Printing Office, 1863.

Hawks 2931


MAP OF
SPOKANE RIVER BASIN
WASHINGTON AND IDAHO
Scale 1/500,000
10 0 10 MILES
1921
Approximate area of overflow land
118°
117°
116°
48°
47°
FERRY
STEVENS
SPOKANE INDIAN RESERVATION
COLUMBIA RIVER
LINCOLN
SPOKANE
ADAMS
WHITMAN
KOOTENAI
BENEWAH
LATAH
SHOSHONE
COEUR D'ALENE NATIONAL FOREST
ST JOE NATIONAL FOREST
WASHINGTON
IDAHO
BOISE MERIDIAN
SPOKANE
COEUR D'ALENE
DAVENPORT
RITZVILLE
WALLACE
ST MARIES
Pend Oreille Lake
Coeur d'Alene Lake
Spokane River
St Joe River
Hayden Lake
Spirit Lake
Loon Lake
Medical Lake
Rock Lake
Colville Lake
Newman Lake
Liberty Lake
Post Falls
Harrison
Kellogg
Wardner
Mullan
Burke
Avery
Cheney
Rockford
Tekoa
Oakesdale
Farmington
Sprague
Reardan
Deer Park

Hawks 2932

and there the green sward in which it is clothed. The spurs that form its either boundary, gently rising to an elevation of a thousand feet, are densely clad with one of the finest growths of fir and pine to be found in the mountains; and, enlivened, as it is, with here a camp of hunters and there the light bark canoe of the Indian, forms one of the most beautiful scenes it was our fortune to meet with in the Rocky Mountains. It was in this valley that, as early as 1842, the Jesuit fathers chose a site for the first of their Rocky Mountain missions. A small plateau, projecting into the valley from the north, where fine springs gushed from the slopes, on which the forest lay as yet untouched by the woodman and a rich virgin soil smiled in a beauty of profusion, cultured by the hand of nature alone, offered them a choice garden that, with slight attention, should yield abundant fruits. Here they maintained themselves for many years until, finding the overflow of the lower portion of the valley entered as an impediment both to pleasant travel and to the extension of their fields, they removed to their present location on the Coeur d'Alene Lake.

Spokane River is a little over 100 miles in length and has a fall of about 1,050 feet. For 9 miles below the outlet of the lake the river has a very flat slope. It then drops 40 feet at Post Falls, and it has a concentrated fall of over 140 feet within the city limits of Spokane. The Geological Survey has made a profile survey of Spokane River from its mouth to Chamokane Creek, a distance of 35 miles.[3]

CLIMATE.

The nearness of the Pacific Ocean, the prevailing winds, and the topography have given northern Idaho a milder climate than its latitude indicates. The following table, taken from the reports of the United States Weather Bureau, shows a summary of temperature records at St. Maries, Idaho, which is representative of the region considered.

Summary of temperature records, in degrees Fahrenheit, at St. Maries, Idaho, for 12 years.

[Altitude, 2,263 feet.]

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Highest	52	67	72	88	92	92	102	102	96	86	73	51	102
Lowest	−16	−26	0	20	28	29	37	32	25	15	−8	−2	−26
Average	30.1	32.5	39.0	47.4	54.2	60.0	66.0	64.8	57.2	48.9	39.1	32.6	47.6

As shown by the following table the part of the year that is free from frosts is so short that for the best results crops of quick growth must be selected and must be planted as soon as the danger of frosts is over in order to insure as long a growing season as possible:

Frost data at St. Maries, Idaho.

Length of record	12 years.
Average date of last killing frost in spring	May 8.
Average date of first killing frost in autumn	September 14.
Earliest date of killing frost in autumn	August 19.
Latest date of killing frost in spring	June 8.

[3] Marshall, R. B., Profile surveys in Spokane River basin, Wash., and John Day River basin, Oreg.: U. S. Geol. Survey Water-Supply Paper 377, pls. 1-3, 1915.

Hawks 2933

The table below shows the mean monthly precipitation at St. Maries for a period of 12 years. During this period the annual precipitation varied between approximate limits of 24 and 34 inches, with a mean annual amount of 28.82 inches. The mean precipitation for June, July, and August is 3.94 inches, but in many years the amount will undoubtedly be less than this. Although the precipitation for the year is fairly plentiful, the comparatively low rainfall during the growing season makes an auxiliary supply of water advantageous, if not necessary, for the production of many varieties of crops on lands that have no other supply than rainfall. In winter the precipitation in the mountains is in the form of snow, which except for melting caused by occasional chinooks tends to accumulate until spring.

Mean monthly precipitation, in inches, at St. Maries, Idaho, for a period of 12 years.

January	3.38	August	1.03
February	2.53	September	1.46
March	2.84	October	2.32
April	1.76	November	4.41
May	2.62	December	3.56
June	1.87		
July	1.04	Annual	28.82

STREAM FLOW.

Records of stream flow have been maintained for many years on Spokane River at different points and for shorter periods on some of the tributaries of Coeur d'Alene Lake. The records of water levels of the lake have been maintained since 1903. These records are published in the water-supply papers of the United States Geological Survey and are readily available. Inasmuch as these records are voluminous, they are not inserted in this report, but some of the more important facts obtained from them are shown below:

Flow, in second-feet, of Spokane River at Spokane, Wash.

Maximum flow:	
May 31, 1894	48,000
May 17, 1917	41,700
Minimum flow:	
Prior to storage operation (Sept. 30, 1905)	1,240
Subsequent to storage operation	[4] 1,700
Mean annual flow	7,400
Estimated average inflow between Post Falls and Spokane	400

Water level, in feet, of Coeur d'Alene Lake.

Maximum elevation:	
May 31, 1894	2,137.6
May 17, 1917 (second highest)	2,135.9
Mean of annual maximum elevations, 1903–1920	2,130.9
Minimum elevation:	
Prior to storage operation	2,119.9
Subsequent to storage operation	2,120.52

[4] Varies below this, but this is a reasonable estimate of the flow that can be maintained.

Hawks 2934

The chief source of run-off is the melting snow in the mountains, and consequently the highest stages of water occur in spring. Chinook thaws cause occasional rises in winter. A good example of such a rise is that of January, 1918, when the lake reached a level of 2,135.9 feet, the same as in May, 1917, the second highest level on record. The records indicate that rises of such magnitude in winter are rare.

RESOURCES AND INDUSTRIES.

The economic importance of the streams and lakes of the country is well illustrated by Coeur d'Alene Lake. This lake has taken a prominent part in the development of the region in which it lies and is likely to take a more prominent part in the future. Its first important service was in furnishing a means of economical transportation prior to the construction of railroads. It continues to be of service in this respect, although railroads are now easily accessible from most of the region. At the present time a fleet of steamers is operated on the lake, maintaining a daily service from Coeur d'Alene to St. Maries throughout the year. In 1917 the traffic was reported to consist of 150,000 passengers and 60,000 tons of freight annually.[5] Coeur d'Alene Lake and its connections that are now navigable lie wholly within the State of Idaho, and consequently the United States Government may not in the near future exercise the authority over the lake that it has over waterways utilized in interstate navigation. A large quantity of timber near Coeur d'Alene Lake makes lumbering an important industry of the region, and the lake and its tributaries are used extensively for floating logs to the sawmills. The summer cottages about the border of the lake are a noteworthy feature of development in the region, and the natural beauty of the lake and its environs may be counted as a valuable asset.

Although the resources and industries just mentioned are more or less directly involved in the present discussion, the resources with which this report is primarily concerned are those of agriculture and of storage for the development of power. More than 20,000 acres of overflow land, the origin of which has been explained, lies along St. Joe and Coeur d'Alene rivers. Near St. Maries about 2,000 acres has been diked, drained, and put under cultivation. As would be expected of lands formed as these have been, they are very productive. A county farm bureau has been organized, and under the supervision of a county agricultural agent assigned by the State scientific tests are being made to determine the varieties of crops best adapted to the lands. These tests show that the lands are well suited to truck gardening, a type of development that would make them very valuable. Other factors that make the lands valuable are the relative

[5] Acher, A. H., Report on preliminary examination of St. Marys and St. Joe rivers, Idaho: 65th Cong., 2d sess., H. Doc. 1216, 1917.

Hawks 2935

scarcity of agricultural lands in northern Idaho; the nearness to Spokane and to the mining towns and other good markets of the mountain region; and the excellent transportation facilities, both by rail and by water.

The landowners are interested in the establishment of two drainage districts—No. 4, Benewah County, and No. 6, Kootenai County. These districts include lands below an elevation of 2,138 feet; and their areas are given by M. S. Parker, consulting engineer for the districts, as 10,056 and 15,729 acres, respectively. Additional areas of lands at higher elevations would be adapted to combination as farm units with overflow lands and probably could not be farmed so advantageously unless they were combined.

Data are not available to answer conclusively the question how the productivity of the undiked overflow lands would compare with the productivity of the diked lands. Considerable areas on Coeur d'Alene River have been covered with deposits of lead compounds washed down from the tailing dumps of the mining districts. These deposits have killed the vegetation and have left the lands in an unproductive state. The mining companies have settled the resulting damage claims privately or through condemnation proceedings or have bought the damaged lands outright. Those who are familiar with this condition believe that the lands could be restored to productivity if the deposits could be kept off the lands for two or three years.

The character of the soil of the lands nearest the mouths of the rivers apparently should receive further investigation. The process by which the lands have been built up would favor the sorting of the material deposited to a certain extent, so that for this and other reasons incident to the different conditions to which it has been subjected the soil of the lower lands is not necessarily equivalent to that of the lands farther up the rivers. Answering questions of this kind would be an essential part of such an investigation as should be made before any extensive scheme of reclamation is undertaken.

The value of the lake as a storage reservoir in connection with the development of water power arises from the fact that a dam of relatively low height will store a great amount of water and from the further fact of its strategic location at the head of a stream with great fall. Water power that can be developed from stored water as it is needed has a much greater value than water power that is limited by the fluctuations in the flow of a stream. Water power from storage enables a power company to contract to supply a larger amount of power throughout the year than it could contract to supply without storage, and the measure of the increase is not the kilowatt-hours derived from the stored water alone, but the kilowatt-hours derived from the stored water and that part of the natural flow of the stream that it supplements and that would run to waste except for the

Hawks 2936

storage. With the storage now developed by the dam at Post Falls it is probably practicable to develop more than 80,000,000 kilowatt-hours a year that would not be developed without the storage. This is nearly two-thirds of the electric power used by the Chicago, Milwaukee & St. Paul Railway in the operation of its lines over the entire Rocky Mountain and Missoula divisions, a distance of 440 miles. On the assumption that 3 pounds of coal would produce 1 kilowatt-hour, it would take 120,000 tons of coal a year to produce the power made possible by the storage now developed.

In the above calculations consideration is given not only to the water power that is now developed on Spokane River, but to the water power that it is estimated will ultimately be developed.

Obviously the extension of agricultural development conflicts with the extension of storage development. Both have merits that deserve careful consideration, and in considering them proper attention must be given to the other resources and industries that are concerned.

HISTORICAL STATEMENT.

The first white settlers in the Coeur d'Alene region were Jesuit missionaries, who established a mission a short distance above the mouth of St. Joe River. Capt. Mullan [6] gives the date of the establishment as 1842; Bancroft [7] gives it as 1841.

In 1846 the mission was moved to its present site on Coeur d'Alene River because the overflow in the lower portion of the valley near the old site was objectionable. In 1858–1862 the Mullan military road was constructed. Spokane was settled in 1872.[8] Frederick Post probably first developed water power on Spokane River some time prior to 1876, for Bancroft [9] states that in that year Post was induced by the settlers at Spokane to remove his mill from Trent to Spokane Falls by a gift of 40 acres of land and water-power privileges.

In 1879 Fort Coeur d'Alene, afterward Fort Sherman, now abandoned, was established at the outlet of the lake at the present site of Coeur d'Alene. In or about 1880 the railroad reached the region. During the eighties settlement proceeded very rapidly because of the greater accessibility of the region afforded by the railroad and because of mining discoveries and developments on the branches of Coeur d'Alene River.

Coeur d'Alene Lake and the lands surrounding it were included within the limits of the Coeur d'Alene Indian Reservation by Executive order November 8, 1873. The northern part of the reservation, including a large part of the lake, was ceded to the United States by agreement of September 7, 1889; and the lands were opened to

[6] Op. cit., p. 16.
[7] Bancroft, H. H., History of Washington, Idaho, and Montana, 1845–1889, p. 562, 1890.
[8] Idem, p. 390.
[9] Idem, p. 391.

Hawks 2937

homestead entry in accordance with the provisions of section 22 of the act of March 3, 1891 (26 Stat., 989). A further cession was made by agreement of February 7, 1894, and the lands were opened in accordance with the provisions of section 14 of the act of August 15, 1894 (28 Stat., 286). The act of June 21, 1906 (34 Stat., 325), made provision for surveying the diminished reservation, allotting lands to Indians, and opening the unallotted lands to homestead entry.

The land at Post Falls on which the present power plant is situated is owned by the Washington Water Power Co., successor to Frederick Post, who obtained it from the Indians in 1871, the Indian grant being confirmed by the act of March 3, 1891, and patent issued in 1894. Prior to 1891 dams in the three channels at Post Falls were constructed by Post, but they affected the level of the lake very little and probably not at all. New dams were completed by the Washington Water Power Co. in June or July, 1906. (See Pl. II.) The new dams (hereinafter referred to as a single dam) have a greater discharge capacity than the old dams but are constructed with control gates that allow the water to be held up to an elevation of 2,126.5 feet and gradually released as the low-water season advances. The water was first held in the summer of 1907. From July 1 to October 1 of that year the water level of the lake averaged about 3 feet higher than in the same period in 1906, owing mainly to the new control operations. The effect of the operation of the new works on the water level is discussed on page 14.

In holding the water to a higher level the Washington Water Power Co. at first relied upon its legal right to overflow lands because of its successorship to the grant of water-power privileges acquired by Post, by and with the consent of the United States, and because of the alleged inferior character of the lands. The company maintained that it had the right to overflow the lands and that the owners had no legal rights to recover damages. In Gaskill *v.* Washington Water Power Co. (17 Idaho, 128), the Supreme Court of Idaho held, on October 29, 1909, that the power company had waived the above-mentioned right as a defense and that it had invoked condemnation procedure as a means of securing the right to overflow. On March 28, 1911, the Supreme Court of Idaho held, in Washington Water Power Co. *v.* Waters (19 Idaho, 595), that the construction of a dam in Spokane River at Post Falls and the increase in storage thereby for use in the low-water season for power purposes constitute a public use within the contemplation of the State laws granting the right of eminent domain.

Soon after the lake was first used as a reservoir the company undertook surveys of the lands below an elevation of 2,128 feet. Although the company was maintaining that it had a legal right to overflow, in 1907 and 1908 it acquired many easements from settlers by

Hawks 2938

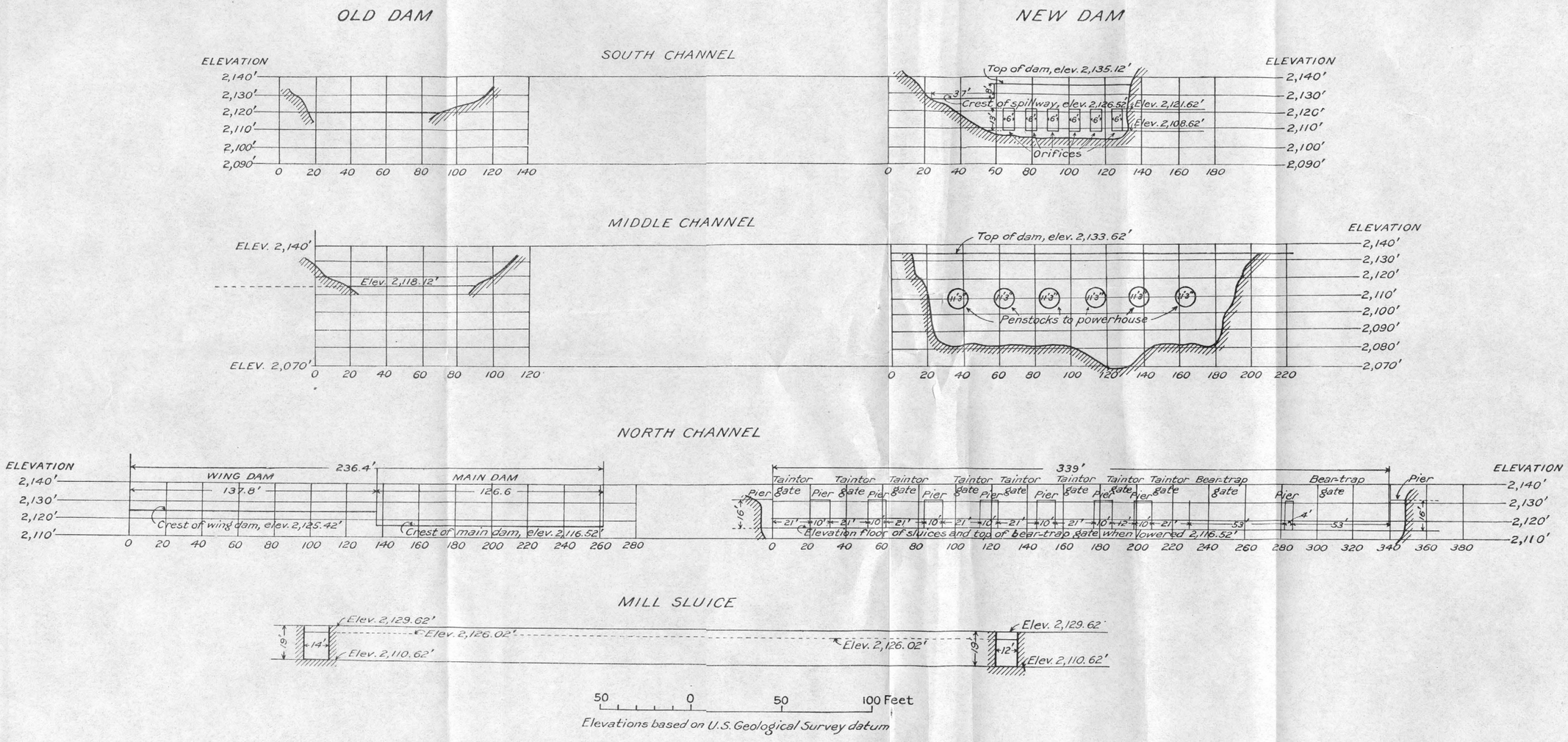


DIAGRAM SHOWING DETAILS OF ELEVATIONS OF OLD AND NEW DAMS ON SPOKANE RIVER AT POST FALLS, IDAHO.

Hawks 2939

purchase at about $20 an acre, such easements generally giving overflow rights to an elevation of 2,128 feet.

On April 27, 1908, in pursuance of representations made by the Interior Department and representatives of the Washington Water Power Co., a bill was introduced in Congress by Hon. Burton L. French authorizing the Secretary of the Interior to grant overflow easements on the affected lands in Coeur d'Alene Indian Reservation. Later, however, because a strong local sentiment was found against the passage of the bill, Congressman French took steps to have it withdrawn from further consideration, and this was done about December 20, 1908.

On January 25, 1909, the company applied to the Department of the Interior for permit to overflow the Indian lands under the act of February 15, 1901 (31 Stat., 790). The permit was granted on February 22, 1909, on condition that the company would pay $1.25 an acre for the Indian lands flooded, and such payment, amounting to $7,801.25, was duly made.

In pursuance of protests made by settlers to the Secretary of the Interior against the continuance of the permit, proceedings were initiated in April, 1909, that culminated in a hearing before the register and receiver of the United States land office at Coeur d'Alene extending from December, 1909, to April, 1910. As a result of the hearing an order of revocation was issued on July 29, 1910, but the company immediately filed a motion for review of the decision, and on April 21, 1912, the department issued an order in which the revoking order was "vacated and set aside."

As above noted, the Supreme Court of Idaho held, March 28, 1911, that the right of eminent domain might be invoked for lands on Coeur d'Alene Lake flooded by the storage operations. Exclusive of lands in the former reservation covered by the Interior Department permit (including Heyburn Park), the right to overflow to an elevation of 2,128 feet has been acquired for approximately 9,000 acres of private lands, of which about 1,000 acres was condemned. It is to be noted that the department's decision setting aside the order of revocation was not inharmonious with that of the State court in confirming the public purpose of the company's operations and its right to condemn private lands.

In pursuance of the provisions of the act of June 21, 1906, for opening the reservation lands, the proclamation of May 22, 1909 (36 Stat., 2494), was issued. This proclamation provided specifically for the opening of lands to settlement and entry, including a drawing beginning August 9, 1909, receipt of application for entry beginning April 1, 1910, and general settlement and entry beginning September 1, 1910. The Government surveys included lands down to an elevation of about 2,121 feet. Most of the lands covered by the permit were

Hawks 2940

immediately applied for, although their agricultural value, unless they were effectively drained, was questionable. The homesteading of these lands, which by governmental notice was subject to the rights of the Washington Water Power Co. under the overflow permit, was thus actually in progress during the period between the issuance and vacating of the order revoking the permit when the order was under review and when it still might have become effective from the date of issuance. Some settlers perhaps were led to believe that the rights of the power company were dead; and relying on this belief, which later proved to be mistaken, they have suffered injury and loss.

PHYSICAL CONDITIONS.

Coeur d'Alene Lake is a part of the watercourse system through which the water of Spokane River passes on its way to Columbia River and the sea. Like any watercourse its level rises and falls in general relation with increases or decreases in the flow of water to be carried. Records of the Geological Survey show that in 1904, 1905, and 1906, prior to the operation of the present Post Falls dam, the average range of stage between the high and low water season was 9.1 feet on Coeur d'Alene Lake and 7.6 feet on Spokane River at Spokane. Doubtless the range of stage is greater at some places on Spokane River than on the lake.

The lake is unlike an ordinary river channel, however, in its large amount of surface area, which introduces the factor of storage to a marked degree. If it were not for the effect of storage the outflow from the lake would always equal the inflow. The general controlling influence of a lake upon a watercourse is too well understood to require an extended explanation, and therefore this phase of the subject will be treated only briefly.

When unaffected by storage manipulations the amount of flow out of Coeur d'Alene Lake depends primarily on the stage of the lake. Other conditions being unchanged, the same amount of water will pass out at a certain stage of the lake, say 2,130 feet, in one year as in another. If the inflow to the lake becomes greater than the outflow the stage of the lake and the outflow will increase, and the outflow will maintain a definite relation to the stage. If the inflow continues constant in amount the outflow will in time become equal to the inflow, a condition that would be much more promptly attained in an ordinary river channel. A part of the inflow has been used to raise the level of the lake, so that up to this point the total volume of inflow is greater than the total volume of outflow by the amount of such storage. If the inflow decreases the order of adjustment will be reversed.

It may be considered that as the inflow increases or decreases the outflow is continually striving to become equal to it, which merely

Hawks 2941

means that the watercourse is trying to operate as much as possible like an ordinary river channel. Because of the intervention of the storage influence, however, the sudden fluctuations of the inflow are reflected in the outflow only in a greatly reduced degree. As above indicated, if the inflow remains at approximately the same amount for several days the outflow may have time to become adjusted to it. If the inflow is large for a considerable length of time the stage of the lake will tend to increase until the lake can discharge from the outlet the quantity of water that it is receiving. The direct relation between the inflow to Coeur d'Alene Lake on the one hand and the stage of the lake and the outflow on the other is a fundamental fact that it is very important to understand in the consideration of problems involving any changes in the regimen of the lake.

The general details of both the new and the old works at Post Falls are shown on Plate II. The river has three channels at this place, and originally the restrictions to the flow caused a lakelike expansion immediately above the falls at low-water stages. Capt. Mullan's report states [10] that the high-water mark at the falls was 18 feet above the level at the time of the examination made the last of August, 1859. At the time of the construction of the present works a bear-trap dam and a system of Taintor gates were installed, and the main north channel was considerably enlarged by the excavation of rock at the side, as indicated in the diagrams. As would be expected from a comparison of the details of the new and old works, the flood discharge capacity is now considerably greater than it was with the old dam.

The method of operating the dam at Post Falls as reported by representatives of the Washington Water Power Co. is as follows: When the spring rise commences all the gates at the dam are opened wide to give the maximum discharge capacity. As soon as the lake falls to an elevation of 2,126 feet or thereabout the bear-trap dam is raised and the Taintor gates are manipulated so as to maintain the water level as near 2,126.5 feet as possible. As the low-water season advances the stored water is gradually released as need requires. When the autumn rains commence a small amount of stored water is accumulated for use in the periods of low water that occasionally occur in winter.

The records of the flow of Spokane River at Spokane and of the stage of Coeur d'Alene Lake, published in the water-supply papers of the United States Geological Survey, furnish a basis for investigating the manner in which the gates at Post Falls dam have actually been operated. The outflow from Coeur d'Alene Lake under natural conditions depends primarily on the stage of the lake. Except at the lower stages the flow at Spokane may be considered as essentially the

[10] Mullan, John, op. cit., p. 110.

Hawks 2942

same as the outflow from the lake. Sufficient records have been obtained at times when it was known that manipulations of the dam were not influencing the level of the lake to indicate the normal relation between the stage of the lake and the outflow. If at any time this relation does not exist and other adequate explanation does not appear, it may be assumed that the outflow is being affected by the dam. The time at which the bear-trap dam was lowered may be satisfactorily checked merely from analyzing this relation and comparing the flow at Spokane with the level of the lake. Normally a sudden decrease in discharge at Spokane should reflect a corresponding decrease in the level of the lake, but when such a decrease is accompanied by a rise in the level of the lake or when the lake maintains a stage that is not in normal relation with the decreased flow it is generally convincing evidence that the control of the outflow from the lake by the Post Falls dam has begun. Of course the control of the flow from the lake necessarily interferes with the normal relation between the stage of the lake and the outflow.

A study of these data, which are available to anyone because they are published Government records, shows that the Washington Water Power Co. has operated the dam, except possibly in one year, in accordance with the procedure above set forth. The records indicate that in the spring of 1909, the third year of the operation of the dam, the control of the lake by the dam was begun when the lake level was about 2,128 feet. In all other years the control was apparently begun when the lake level was approximately 2,126 feet or below.

The highest discharge of Spokane River at Spokane prior to the construction of the present dam and since regular records of the level of the lake have been maintained occurred in 1904, when the lake reached a height of 2,132.8 feet. The discharge of 1904 and the actual discharges measured at Spokane when the lake reached a height of 2,132.8 feet at times since the construction of the present dam are listed in the following table:

Discharge, in second-feet, of Spokane River at Spokane at times when the level of Coeur d'Alene Lake was 2,132.8 feet.

Prior to construction of present dam:	
1904	27,900
Subsequent to construction of present dam:	
1910	26,800
1913	27,000
1916	28,200
1917 (spring)	28,800
1917–18 (winter)	28,600
Average	27,900

The differences in discharge in the different years are so small as to be insignificant. Similar comparisons made for lake levels down

Hawks 2943

to 2,128 feet show only differences that are also insignificant or that are plainly due to other factors than the effect of the new dam. The results are consistent with the conclusion that the outflow from the lake at levels above 2,128 feet has not been appreciably changed by the present Post Falls dam.

At first thought it would seem that if some stored water were being held in the lake by the dam at the beginning of a flood the lake would have less capacity for accumulation of more stored water and therefore would rise to a higher level than it would if the stored water were not being held. This is true theoretically, but considerable study of the conditions of flow that have existed shows that any increase in flood stage from this cause has been and probably will be inappreciable, even though storage should be maintained to a higher level than at present.

For example, let two cases be considered in each of which the inflow to the lake is the same from day to day, but in (1) there is no storage in the lake at the beginning of a flood and in (2) say 3 feet of stored water is being held. In (2) when there are signs that a considerable rise has begun the bear-trap dam and Taintor gates under proper methods of operation will at once be opened, and the outflow will be determined primarily by the height of the lake. Because the level of the lake in (2) is higher than in (1) the outflow will be correspondingly greater. If the outflow is greater in (2), but the assumed inflow is the same, the excess of storage of (2) over (1) will be reduced. As the excess of storage is reduced the difference in lake level between (2) and (1) will be reduced, and the excess of outflow in (2) over that in (1) will decrease correspondingly. As a result the excess of storage of (2) over (1) will be steadily reduced as time goes on, but by amounts that will be successively smaller for equal intervals of time. Reduction in the excess of storage means that the lake level in (2) will gradually approach the same height as in (1). Computations indicate that in a few days a difference in level of 3 feet at the beginning of a rise will be reduced to an amount that is practically inappreciable.

The situation may also be considered in the light of the principle previously stated that under natural conditions the outflow is always striving to adjust itself to the inflow. In any rise the outflow in trying to keep pace with the inflow would practically overcome the handicap incident to any probable amount of storage and would be practically in the same position at the peak of the rise that it would have been in if there had been no storage at the beginning.

A sudden high rise such as that in January, 1918, would be most likely to show the effect of initial storage because the outflow might have insufficient time to "catch up" with its normal position. How-

Hawks 2944

ever, just before the flood of January, 1918, the level of the lake was considerably lower than normal for the season of the year, even prior to the construction of the present dam, and therefore the maximum height of that flood was not increased because of storage.

A study of the stream-flow data indicates that in any year storage to a level of 2,124 feet on December 14, the approximate date of beginning of the flood of January, 1918, would provide sufficient

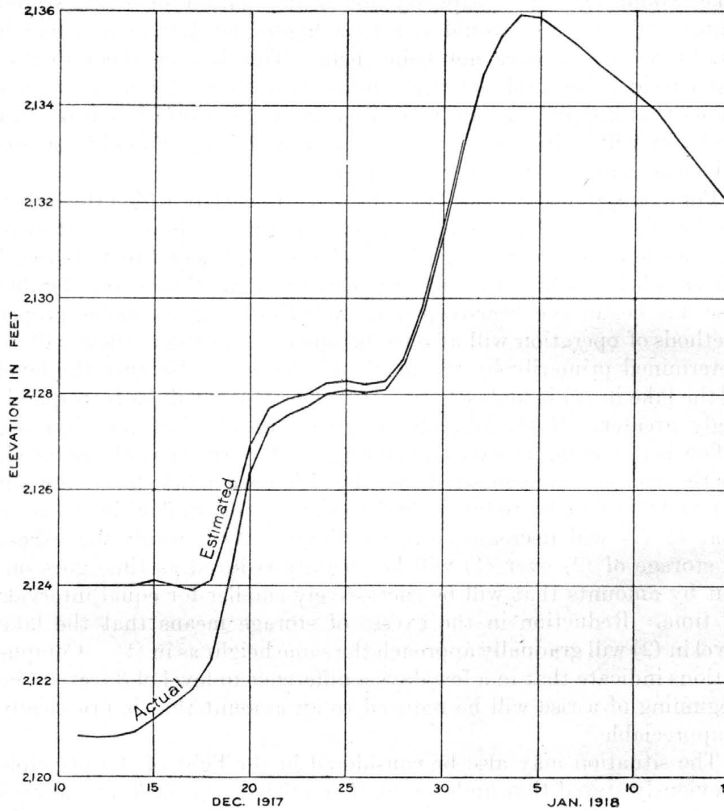


FIGURE 2.—Comparison of actual hydrograph for heights of Coeur d'Alene Lake in flood of January, 1918, and estimated hydrograph assuming storage in lake to level of 2,124 feet at beginning of flood.

storage regulation thereafter until the spring rise, even if storage were increased so as to assure a greater flow than it is now attempted to maintain. It is hardly conceivable that a greater amount of stored water need ever be held at that season under any condition. Figure 2 shows the actual hydrograph of the lake for the flood of January, 1918, and the estimated hydrograph on the assumption that the lake level at the beginning was 2,124 feet. A certain amount

of assumption was necessary in the computations on which the estimated hydrograph was based, but it was of such a nature that the result may be considered substantially accurate in showing the general tendency of adjustment. It indicates that by December 31 the difference between the estimated lake level and the actual level would be less than one-tenth of a foot.

Similarly, figure 3 shows the actual hydrograph of the flood of May, 1917, and the estimated hydrograph on the assumption that the level

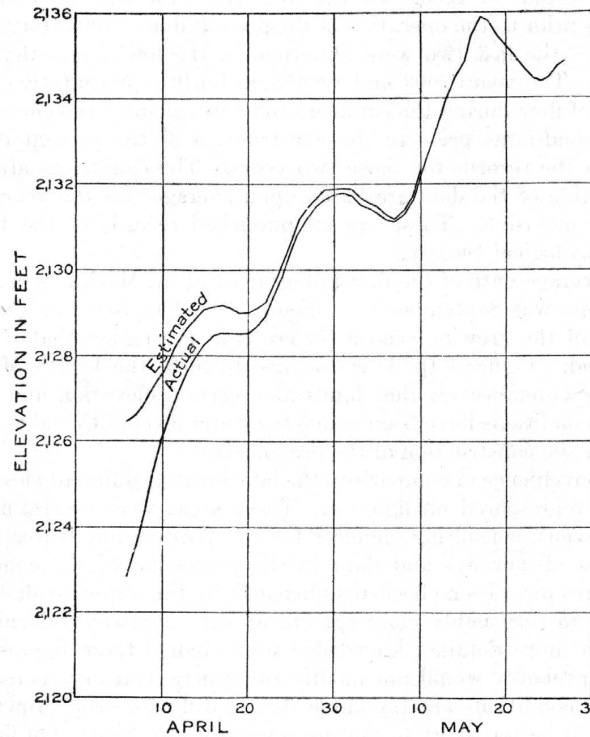


FIGURE 3.—Comparison of actual hydrograph for heights of Coeur d'Alene Lake in flood of May, 1917, and estimated hydrograph assuming storage in lake to level of 2,126.5 feet on April 6.

of the lake stood at an elevation of 2,126.5 feet on April 6. By May 10 the difference between the estimated lake level and the actual level would have been less than one-tenth of a foot. Of course, no condition is conceivable that would necessitate that amount of storage at that season, and the only purpose of the assumption is to test the principles that are being discussed.

Because of the reasons and facts above presented the conclusion is reached that the operation of the Post Falls dam has not appreciably

Hawks 2946

affected the natural level of Coeur d'Alene Lake above an elevation of 2,128 feet. For all practical purposes it may be considered that any rise of the lake above that elevation would have occurred even if there had been no control works at Post Falls.

The effect of the present dam on lake levels below 2,128 feet during the summer is graphically represented on figure 1 (p. 4), which shows the average dates on which the lake reached certain levels before and after the construction of the present dam. Records of the stage of the lake began in 1903. Of the four years for which records are available prior to the operation of the present dam—1903, 1904, 1905, and 1906—the last two were abnormal in the low stages that were reached. The years 1903 and 1904 were fairly representative in the amount of flow during the summer, and consequently the curve illustrating conditions prior to the construction of the present dam is based on the records for those two years. The conditions after the construction of the dam are based upon averages for the years 1907 to 1916, inclusive. These are all published records of the United States Geological Survey.

The average date of the first killing frost at St. Maries for a period of 12 years was September 14. (See p. 5.) This is a fair index of the end of the growing season for crops in the region that is being considered. Figure 1 (p. 4) is designed to show the length of time, prior to September 14, that lands at a certain elevation and under average conditions have been above the water level of the lake, before and after the construction of the present dam.

For convenience of comparison the lake areas at different elevations are also represented on figure 1. These areas were determined by J. C. Stevens, consulting engineer for the Washington Water Power Co., from all surveys and data in the possession of the company. The figures have been checked sufficiently by the writer to show that they are in reasonably close agreement with available information. Although more detailed knowledge may change these figures, such changes probably would not modify the general conclusions reached.

Unless conditions are favorable during July for crop growth the season will be too short to mature a crop of any kind. On figure 4 is a comparison of the elevations of the water surface of Coeur d'Alene Lake on July 1, 15, and 31, before and after the construction of the bear-trap dam, and the land areas overflowed at different elevations above 2,120 feet, the extreme lower-water level of the lake prior to the construction of the present dam. The areas shown include an undetermined area of water surface, such as lakes and swamps that are cut off from the main body of the lake as the level falls. (See p. 3.) The proportion of such undetermined area is so small that in the absence of more accurate data these areas may be considered

Hawks 2947

reasonably indicative of the relative distribution of land areas at the different elevations.

The effect of holding the water of the lake at a certain level is not confined to the lands below that level. As the lake falls the lands that are exposed are left saturated with water. In order to drain off from the soil, the water must overcome a certain amount of resistance from the soil particles and therefore must have some fall to create a flow. Consequently, the water table or the surface of the saturated soil will slope upward from the water surface of the lake. It may be observed from the diagrams on figure 4 that throughout July under average conditions the water surface of the lake is within 1 to 2 feet of most of the bottom lands near the lake. Although evaporation helps to dry the soil, conditions are very favorable for keeping the main part of the bottom lands well saturated with water throughout July. As these are average conditions the main part of the overflow land is not well suited to the production of wild hay or any other crops unless it is adequately drained.

Before the lake was used for storage the water surface during July under average conditions ranged from about 2 to 5 feet below the main part of the lands. This would make considerable difference in the facility with which the lands could be drained. Comparisons similar to those on

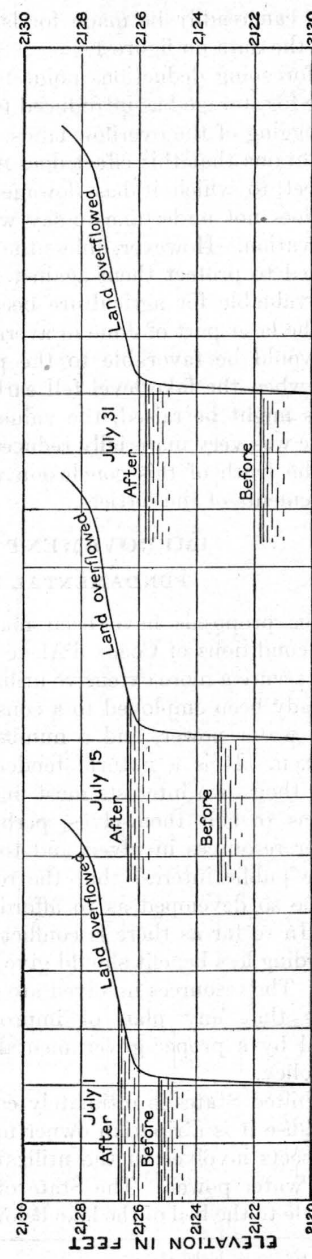


FIGURE 4.—Diagram showing elevation of water level of Coeur d'Alene Lake, Idaho, on certain dates before and after the operation of the bear-trap dam at Post Falls and area of lands overflowed at different levels above 2,120 feet.

Hawks 2948

figure 4 can readily be made for later dates in the season by reference to the data on figure 1.

The foregoing deductions point to the conclusion that the use of the lake for storage has introduced factors that would cause a serious water-logging of the overflow lands. The Washington Water Power Co. maintains that this effect does not extend above an elevation of 2,128 feet, to which it has flowage rights under the permit. The writer does not undertake to say whether the effect extends above that elevation. However, unless the water-logged lands were drained and diked to protect them against the spring overflow, they would not be valuable for agriculture because they could not be worked before the later part of June in average years. Although their condition would be favorable to the production of wild hay, and in seasons when the lake level fell early enough crops such as oats or potatoes might be raised, the value of the lands for agriculture of this type was very materially reduced by the use of the lake for storage. The truth of this conclusion was supported very strongly by the statements of the settlers.

IMPROVEMENT MEASURES.

FUNDAMENTAL PRINCIPLES.

Various proposals have been made for the modification of the natural conditions of Coeur d'Alene Lake and the overflow lands in order to secure a more extensive utilization of the resources. Storage has already been employed to a considerable extent for the development of water power, and a number of diking projects have been undertaken. It is a natural tendency for the different parties to consider their own interests most important and to desire to change conditions to suit themselves, perhaps with inadequate regard to the other resources involved and to the interest of the public. It is in the public interest that the resources of Coeur d'Alene Lake should be so developed as to afford the maximum possible benefit to all. In so far as there is conflict between the different uses, the use affording less benefit should give way to the use affording greater benefit. The resources involved are of great value, and the situation demands that any plan of improvement undertaken should be approved by a proper governmental agency as in accord with best public policy.

The United States is intimately concerned in any changes on the lake because it is a riparian owner upon it and because of the interstate aspects involved in the utilization of storage for the development of water power. The State of Idaho is interested because it claims title to the bed of the lake below the natural high-water mark [11]

[11] Calhoun *v.* Price (26 Idaho, 745).

Hawks 2949

and for various other reasons incident to the fact that the lake is within its jurisdiction.

The possibilities for improvement on Coeur d'Alene Lake should be studied in a comprehensive way, and a plan should be outlined that will assure the ultimate realization of the maximum possible benefit and enjoyment. Thereafter all improvements made should conform to this plan. Such a plan to be most successful would require the cooperation of all interests, including governmental agencies as well as the individuals and the organizations concerned. Considerable study and thought have been given to available information dealing with the subject, and it is the attempt here to give a composite picture of this information in so far as it bears upon the determination of a proper plan and policy of development.

IMPROVEMENT OF THE OUTLET OF COEUR D'ALENE LAKE.

For many years it has been recognized that the alluvial bottoms of St. Joe and Coeur d'Alene rivers would be benefited for agriculture if the outlet of Coeur d'Alene Lake could be improved in such manner as to relieve the lands from the damage of overflow. Capt. John Mullan was the first person known to consider this problem. In his report on the construction of the military road through this region [12] he states:

> The overflow of the Coeur d'Alene and St. Joseph rivers and the means of preventing it is a subject to which I have given much attention; and having made surveys, both in high and low water, I have been enabled to collect many facts and data, which I will treat of at greater length at a future point of my report.

Elsewhere in his report [13] in discussing the agricultural lands along the line of the military road he states:

> One of the largest bodies of good land is in the valleys of the St. Joseph and Coeur d'Alene, and if these valleys are once drained, a body of 40,000 acres of the finest soil in the world will be reclaimed—soil 6 and 8 feet deep and as black as coal. This overflow can be prevented by widening the natural outlet and making an artificial one alongside of it; an appropriation of $5,000 will meet this difficulty, and the ends to which it looks are well worthy the experiment. Rock blasting is the only method of accomplishing it and should be done during a low stage of water. The overflow is alone occasioned in the highest stages of water, when the mouth of the outlet of the lake is not capacious enough to discharge the volume of water sent into it by its feeders.

Capt. Mullan's estimate of the cost of improvement was apparently based on erroneous knowledge of the conditions at the outlet. Theodore Kolecki, a topographer of his party, who was sent (Aug. 27 and 28, 1859) to reconnoiter Post Falls, then called Little Falls of Spokane River, reported that he estimated "the average fall from the lake to the falls, a distance of 8 miles, to be 20 feet per mile."[14] As a

[12] Mullan, John, op. cit., p. 16.
[13] Idem, p. 42.
[14] Idem, p. 110.

Hawks 2950

matter of fact the fall at low water under natural conditions is little more than 1 foot to the mile. The assumption that the improvement work would consist mainly of rock blasting was also erroneous, for present information indicates that the material below the outlet is gravel for several miles. Nevertheless Capt. Mullan's proposal possesses historical interest.

The scheme of lowering the outlet has been considered at different times by groups of settlers and others. In 1905 T. A. Noble, engineer of the United States Reclamation Service, proposed a scheme that involved, among other things, the enlargement of the channel of Spokane River from the lake to Post Falls so as to make it possible to lower the low-water level of the lake 16 feet. The cost of deepening and widening the channel was estimated at $3,000,000, but the writer has been unable to find data that would warrant placing much reliance on the accuracy of this estimate.

It has been in the interest of the Washington Water Power Co. to make studies of the feasibility of lowering the outlet as a means of developing storage capacity, and since about 1912, when such studies were started, a considerable amount of information has been collected by the company. It is understood that the conclusions reached from these investigations induced officials of the company to express themselves in 1915 as favorable to undertaking the dredging of the channel of Spokane River so as to reduce the low-water level of the lake about 4 feet, provided that the owners of property on the lake would secure without cost to the power company the rights necessary to complete the project. The proposal was not agreeable to the settlers.

Drainage districts for the reclamation of the flooded lands have been in process of organization within the last three or four years. In 1918 a project was planned for enlarging the channel of Spokane River for about 12,000 feet below the outlet by widening in places and by the removal of snags and other obstructions so as to increase the flow at flood stages. At the time of writing this report it is understood to be the intention of the drainage districts to carry out this work.

The outlet of Coeur d'Alene Lake can be modified for two purposes—(1) to relieve the damage to lands and property located thereon caused by high water and overflow, and (2) to develop storage for use in connection with the development of water power. The settlers are interested primarily in the first purpose and the water-power interests in the second. To a large extent an improvement for the first purpose would require certain excavation that would be necessary for the second purpose, and as each party would be benefited it does not seem equitable that the work should be paid for solely by one party. Any improvement should be made with a view to attaining both purposes as far as possible. The circumstances of the situation

Hawks 2951

appear to point definitely to the desirability of joint participation in a scheme of improvement which will obtain the greatest practicable benefit to each party and toward the cost of which each party should contribute in proportion to its benefit. Such a procedure would secure to each party the maximum benefit to itself for a minimum expenditure.

Although the Washington Water Power Co. has collected a considerable amount of information regarding the conditions in Spokane River below the outlet, this information is insufficient for a comprehensive consideration of a dredging project. Thoroughly realizing this fact, the writer has studied the available data with a view to determining what they indicate as to the general feasibility of such a project. It has been assumed that any improvement would be made with a purpose both to obtain relief from overflow and to increase storage.

The problem assumed the improvement of the channel so as to carry the maximum outflow of the spring flood of 1917 at an elevation of the lake 2 feet lower than that which the lake then reached. Then the channel carried approximately 41,500 second-feet at an elevation of 2,135.9 feet, and under the assumed condition it was to carry the same flow at an elevation of 2,133.9 feet. The cross sections of the river used in the studies and the places at which they were obtained are shown on Plate III. Although the individual cross sections are no doubt reasonably accurate, the places at which they were made are so far apart that considerable inaccuracy is involved in assuming that they properly represent the character of the channel between the cross sections.

The slope of the stream between the lake and the Post Falls dam for the spring flood of 1917 is also shown on Plate III. It was determined chiefly from the maximum heights of this flood as obtained by employees of the Washington Water Power Co. Some use was made of known heights of the flood of the spring of 1910 and of a general knowledge of conditions. The result probably has some inaccuracies, but it is perhaps sufficiently reliable to warrant certain general conclusions.

No borings have been made, but from more or less casual observation the channel of Spokane River for about 5 miles below the outlet of the lake appears to be in gravel of various grades, which would offer no special difficulty to dredging. The stream bed, however, contains sunken logs that might add appreciably to the cost of dredging. Below this point there is a stretch where the excavation of the channel would be more difficult and consequently more expensive because of boulders, steeper banks, and the possibility that rock might be encountered. These conditions constitute an important factor in determining how far downstream dredging of the channel

Hawks 2952

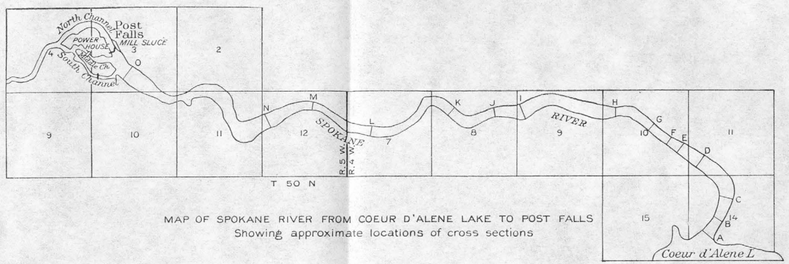
would be carried under any project of improvement. The farther downstream that dredging could be carried in order to lower the water level of the lake 2 feet the greater would be the slope secured, and consequently the smaller the size of the channel that it would be necessary to dredge out.[15] Nevertheless, if the excavation were carried through the section of more difficult excavation it might cost more than a larger channel in the less difficult material.

To estimate the volume of excavation it is necessary to assume how far down the river the improvement will extend. The elevation of the water surface for the flood of 1917 at this limiting point subtracted from 2,133.9 feet, the assumed elevation at the lake, will give the amount of fall available in the improved channel. This fall and the distance from the outlet of the lake to the assumed point determine the slope of the channel. At each determined cross section may be calculated by means of engineering formulas a new cross section of the channel that would carry the 41,500 second-feet with the water surface at an elevation established by the slope thus determined. The new sections should be so planned as to require a minimum amount of excavation but at the same time should be fairly uniform. The enlargement found necessary at the different cross sections and the distance between them constitute the factors for the determination in a very rough way of the volumes of excavation that would be necessary. It was concluded that the assumed improvement could be made with the excavation of 2,500,000 to 3,000,000 cubic yards of material that would probably be very largely gravel. On the assumption that the cost of dredging would be 50 cents a cubic yard, it is estimated that the cost of excavation would be approximately $1,500,000. To obtain the total cost of the project, including damages and many other items, this amount would have to be increased considerably.

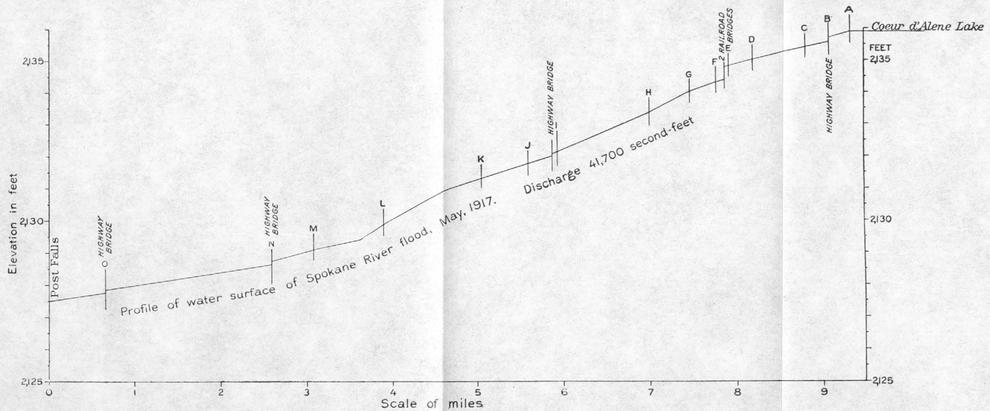
The proposed improvement would lower the heights of flood approximately 2 feet and would probably increase the maximum flood flow of Spokane River, and the ability to draw the lake to a lower level would afford additional storage capacity. The reduction of flood heights would lower the height to which dikes would have to be built and would therefore be a benefit to the landowners of the diking districts. This would amount to a saving in dike construction equivalent to 2 feet on the bottom of all dikes. Whether the length of the dikes that will ultimately be built is 50 miles or 100 miles, it is evident that this saving would be large. The increase in storage capacity would of course be a great benefit to the development of water power on Spokane River.

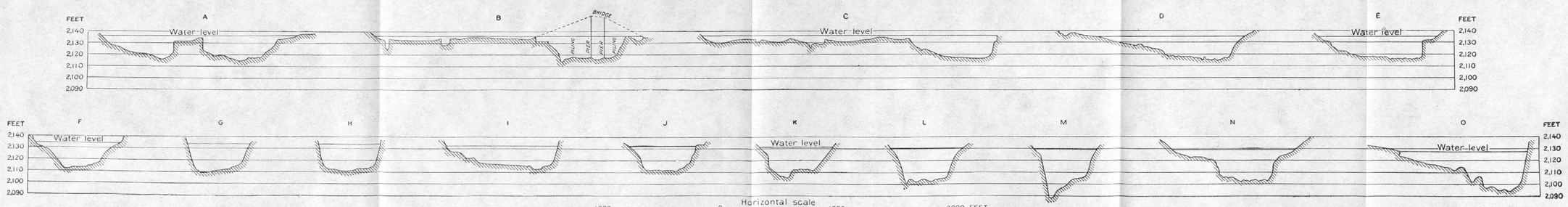
[15] For example, if the slope of a channel is twice as great as the slope of another channel, its cross-sectional area needs to be only about one-fourth as great to carry the same amount of water.

Hawks 2953



MAP OF SPOKANE RIVER FROM COEUR D'ALENE LAKE TO POST FALLS
Showing approximate locations of cross sections





CROSS SECTIONS OF SPOKANE RIVER
Showing water level in May, 1917, flood
(Looking downstream)

PROFILE AND CROSS SECTIONS OF SPOKANE RIVER FROM OUTLET OF COEUR D'ALENE LAKE TO POST FALLS, IDAHO.

Hawks 2954

An increase in the maximum flood flow would cause some additional damage at Spokane, although this would hardly be appreciable for the relatively small increase in flood flow that would be involved in the example that is being considered. This possible additional damage, however, is a factor that should be thoroughly investigated prior to undertaking any improvement. Considerable damage is done by the flooding of buildings and basements in Spokane at times of the highest floods. It is understood, however, that the most critical features are the Olive Street concrete-arch bridge and the city's dam and pump works. Although the high water in 1917 was lower than that in 1894, which occurred prior to the construction of the dam at Post Falls, it was seriously questioned by officials of the city engineer's office whether a higher flood than that in 1917 would not be disastrous. The cost of proper protection would be determinable and should be duly considered in connection with any improvement project. The city would be a beneficiary from the increase in storage, because the increased stream flow in low-water season would be available for the operation of the pumps of its water-supply system.

There might also be possible damage to riparian owners and navigation interests on the lake. The writer believes that a lowering of 2 or 3 feet, such as would probably be involved in the scheme suggested, would interfere with navigation by necessitating the extention of docks and perhaps some dredging at a few critical places. The damage to riparian owners would apparently not be very serious, but substantial payment for it would probably have to be made to them.

The assumed improvement may be feasible. It is to be emphasized, however, that the limitation to a lowering of 2 feet has no special significance except as a concrete basis for considering the problem. The most definite conclusion that can properly be drawn is that a project for lowering the outlet of Coeur d'Alene Lake, if participated in jointly by landowners and storage interests, promises sufficient benefits to warrant a detailed investigation. Apparently the cost of even a 2-foot lowering would be large, and the increase in cost as the channel was deepened more would be relatively greater than the corresponding increase in benefits. Therefore, a deepening of more than a very few feet would probably not be feasible.

Less extensive schemes of improvement of the outlet may be practicable. It might be very beneficial if the three bridges immediately below the outlet were so reconstructed as to present less obstruction to the current. These bridges have comparatively short clear spans, the rest consisting of piles so closely spaced that they tend to catch driftwood and snags. It is reported that a fall of as much as 1 foot has been observed at one of these bridges. An obstruction of the current

Hawks 2955

to this extent probably would not continue very long, but the aggregate effect of the three bridges may amount to nearly half a foot, and this with the possibility of an increase by snags damming up from time to time presents a very undesirable condition. A modification of some of the log booms a short distance below the outlet of the channel and the removal of some snags and sunken logs, all with the purpose of decreasing the obstruction to flow immediately below the outlet, are improvement measures that might reduce the heights of maximum floods sufficiently to warrant their cost. More extensive improvements, and perhaps even these, would best await comprehensive study of the entire problem.

DIKING AND DRAINAGE.

Diking is the only effective means of preventing the flooding of the overflow lands during periods of high water. The height of floods may be reduced by enlargement of the outlet, but not sufficiently to prevent the floods from being an obstacle to the highest agricultural development of the lands. Relief from water-logging of the lands can be obtained only by proper drainage, and the lands must be diked before they can be drained successfully. Making the fullest practicable use of the lake as a reservoir need not increase the flood heights of the lake (see p. 16) and therefore would not make it necessary to construct higher dikes. It might increase the necessity for draining the diked lands, for if the water in the lake were held at a higher level in summer the water table of the diked lands would tend to maintain a correspondingly higher level. This would mean that more water would have to be pumped from the diked areas.

The rainfall during the growing season is rather low, so that for best results intensive agricultural operations, such as truck farming, require some other source of water supply.

The ability to control the elevation of the water table by a diking and drainage system might furnish a practicable means of subirrigation. If the level of the lake were lowered so much as to make it impossible to control the water table the growth of intensive crops might suffer for lack of water. This phase of the matter should at least be given consideration in the study of any scheme that involves lowering the level of the lake during the growing season, for the ability to maintain a relatively high water table may be an advantage rather than a disadvantage to the diked lands.

The determination of the height to which dikes should be built requires consideration of the probable maximum flood height. This flood height is not that which has occurred in the past but that which will occur in the future. The possibility of a reduction in flood heights by dredging out the outlet has already been considered. However, even if flood heights had been reduced in this manner, thereafter, as areas along Coeur d'Alene and St. Joe rivers that are

Hawks 2956

normally subject to overflow were diked, there would be a tendency for lake heights to increase and for backwater to develop on the rivers owing to restrictions of their overflow channels.

If it could be conceived that Coeur d'Alene Lake were limited to the size of an ordinary river channel in the flood of May, 1917, thereby greatly reducing the effect of storage, then it would follow that the outflow would nearly have equaled the inflow, and the stage of water level at the outlet would probably have been 3 or 4 feet higher than it was. Any reduction in the storage on the overflow lands would similarly increase the water-stage level at the outlet, though in a less degree. If 15,000 acres had been diked in that flood, the lake level would have been increased about 1 foot. If there had been 15,000 acres diked in the flood of January, 1918, the lake level would have been increased about 1½ feet. The increase in the height in the flood of January, 1918, would be greater than that in the flood of May, 1917, because the inflow was greater, causing a more rapid rise and making storage of relatively greater importance.

If the flood flow were restricted to narrower channels by dikes, the current would require a greater velocity in order to carry the water through. This would mean that the streams would have a greater fall and that backwater would be caused at points upstream. If there were extensive diking of lands along the river below St. Maries, for example, the flood heights at St. Maries would be increased not only because of the higher lake level due to decrease in storage capacity but because of backwater caused by the restricted channel. The combined increase in flood heights at St. Maries from these two factors might be as much as 4 or 5 feet. If the flood heights were increased 4 feet owing to the construction of dikes and reduced 2 feet by improvements of the channel at the outlet, there would be a net increase in flood heights at St. Maries of 2 feet. Obviously this is a very important matter. It emphasizes the desirability of an exhaustive study of the problem in order that dikes may be constructed to safe heights and that the dike systems may be so designed as to leave adequate capacity for flood flow. Construction of dikes without such study invites disaster. Many dikes in the region have failed already and have caused serious loss, chiefly because of inadequate engineering.

If flood levels of the lake are increased by diking, the flood discharge at Spokane will also be increased, and the consequent damage should be considered thoroughly.

DEVELOPMENT OF STORAGE.

The use of Coeur d'Alene Lake as a storage basin in connection with the development of water power has been decided by the courts to be a public use for which necessary private lands may be con-

Hawks 2957

demned. The Washington Water Power Co. has apparently settled practically all claims arising from the overflow of lands below an elevation of 2,128 feet that are not covered by the permit. Such lands constitute about 65 per cent and the lands under permit constitute about 35 per cent of the lands below that elevation for which overflow rights have been obtained. The use of storage as practiced by the company has been detrimental to a large part of the overflow lands, because it has raised the water table so high as to interfere seriously with the production of crops unless the lands are diked and drained. If the lands are diked and drained the raising of the water table can cause little injury and, as previously suggested, may even be of some advantage in dry seasons. Inasmuch as the highest development of the lands for agriculture requires that they be diked and drained, the present storage operations can not be very detrimental to lands that are of sufficient value to warrant reclamation in that manner. Neither would lands that are diked and drained be seriously damaged if storage were maintained to a higher level than at present, provided that flood heights were not increased, and the flood heights would not be increased appreciably if the control gates were properly operated. The importance of storage to development of water power is discussed on pages 8–9. It seems feasible to increase storage on Coeur d'Alene Lake to a considerable extent. At least prospects are sufficiently promising to warrant a careful investigation.

The possibilities of increasing the storage capacity by lowering the outlet and thereby making it possible to lower the level of the lake are set forth on pages 21–26.

COMBINED STORAGE AND AGRICULTURAL DEVELOPMENT.

In the preceding discussion it has been shown that holding the water of the lake at a higher level for purposes of storage will not cause serious injury to lands that are diked and drained. Consequently, further development of storage is not incompatible with the agricultural development of diked lands, but the undiked lands will be practically ruined for agricultural use if storage is materially increased by holding the water at a higher level. For such lands as it was feasible to dike there would be the alternative of diking so that they could be used agriculturally. Before diking the individual owner would be inclined to inquire how much it would cost to dike the lands, how much they would be worth when diked, and how much they would bring if sold to be used as a part of the storage reservoir. If the difference between the cost of diking and the value when diked was no greater than the price that the lands would bring for storage without diking the owner would have no incentive to dike them but would probably sell them.

Hawks 2958

The general public has a broader interest in the matter than the individual owner, and therefore consideration should be given to the problem from its point of view.

In the West, as a whole, agricultural possibilities are limited by other factors than the quantity or quality of available land. Because of the general aridity of the climate the primary limiting factor is the water supply that may be used at a reasonable cost for irrigation. Because of the economic principle that the agricultural industry is the foundation of all other industries, there is a disposition in many Western States to consider the use of water for irrigation as higher than its use for the development of power.

By somewhat similar reasoning it might appear that the agricultural use of the overflow lands should take precedence over their use as a reservoir in connection with the development of water power. Such a principle has some merit, but it should not be followed without regard to the circumstances of the case. For example, assume an acre of land on which 3 feet of water may be held for storage. This amount of water in its fall of more than 1,000 feet from the lake to Columbia River during the summer could generate enough power to raise water by pumping at some other place sufficient to irrigate and reclaim 3 or 4 acres of land that otherwise would not be reclaimed. In which is the public the more interested, the reclamation of 1 acre of overflow lands or that of 3 or 4 acres of desert lands? Of course, the identical power generated from this water might not be utilized for irrigation pumping, but it would add to the power supply of the region, and in so far as a favorable power supply is beneficial to the development of irrigation pumping it would be beneficial to the development of agriculture. It is evident that it is not necessarily in the public interest that agricultural use of the overflow lands should take precedence over their use for storage.

The writer believes that the public and the individual owner would follow the same line of inquiry for determining the lands that should be used for agriculture and the lands that should be used for a reservoir. The determination should rest, first, on the feasibility of diking and, second, if it is feasible, on the cost of diking, the value of the lands when diked, and the value of the lands for storage. If these factors can be reliably determined by impartial investigation, no good reason appears why all parties concerned should not consent to abide by the results.

Assume merely for illustration that no lands are diked; that storage is carried to a considerably higher level than at present, perhaps to 2,132 feet; and furthermore that available storage is developed to the economic limit by lowering the outlet of the lake. The low-water period for the summer and fall of 1919 and the winter of 1920 is probably the most critical with reference to power devel-

Hawks 2959

opment on Spokane River that has occurred since records of flow have been kept. In this period storage of the extent assumed would have been used for regulation of flow about 250 days. Now if an area having an average elevation of 2,130 feet were diked off from the reservoir, it is evident that the reduction in the amount of storage would be about 2 acre-feet per acre of the area. Such a reduction would not appreciably shorten the period through which storage regulation could be maintained. With allowance for loss by evaporation incident to storage, the reduction in the regulated flow over 250 days would be about 1 second-foot for each 300 acres of the assumed area. Although data are insufficient for a close determination it is estimated that such a supply, even if only 1 second-foot, would be worth several thousand dollars in the power development that it would make possible at the water-power sites, developed and undeveloped, on Spokane River. This suggests a line of reasoning by which the value of lands for storage may be determined for comparison with their value for agriculture.

Investigation would probably show that a considerable part of the lands could be more profitably diked than made a part of the reservoir site, because of a fortunate combination of high value when diked and a comparatively low cost of diking, although their value as a part of the site might be rather high. Although more land might be acquired for storage by proceedings under the right of eminent domain, the merits of a proper adjustment between agriculture and storage might not be adequately considered in such proceedings. The public interest will best be served by developing both agriculture and storage to the greatest possible extent and by deciding conflicts between the two uses on their respective merits.

FUTURE PROGRAM.

Most of the bad feeling and dispute between the owners of overflow lands on Coeur d'Alene Lake and the Washington Water Power Co. has been a natural outgrowth of the conflicting interests. The landowners have not obtained a broad knowledge of all the circumstances of the situation, but the power company has collected a considerable amount of data and has had means to present effectively the features favorable to its side of the case. Many of the company's data have become a matter of public record in the various suits and hearings that have been held and have become available to the settlers in other ways. The circumstances, however, have been essentially such that the landowners have lacked the organization and other facilities for dealing advantageously with the company. The best hope for future progress in the development of the resources of Coeur d'Alene Lake and the overflowed lands lies in founding operations on the grounds that the different interests have in common. It may be

Hawks 2960

assumed that both the agricultural and power interests recognize that the resources should be so developed as to realize the maximum amount of benefit from them all, and that individual rights may need to be subordinated to this principle—although, of course, not without due compensation for any resulting damage. It may also be assumed that all parties, including the State and National governments, are interested in the solution of the problem upon this principle. So far insufficient studies have been made, and, as has been emphasized in this report, what is needed most is a comprehensive investigation in order that the problem of development may be correctly solved. There are important questions of economics and engineering that should be thoroughly considered. No reason appears why the cost should be very large, and the advantages gained would many times repay the cost.

It would be very appropriate to the circumstances if the investigation were undertaken by Government agencies under a cooperative agreement, perhaps especially sanctioned by an act of Congress, and when a plan of development had been decided upon, all interested parties might very fittingly cooperate to carry it out. In any work that is undertaken the principle that the different parties should contribute to the cost in proportion to their benefits should be followed as nearly as practicable.

The interest of the public in the operation of the Taintor gates and the bear-trap dam at Post Falls might desirably be recognized in a more direct way in the future than in the past. The United States has a right to require that these works shall interfere as little as possible, consistently with effective operation, with the use and development of the lands by the settlers. The power company should hold the water level of the lake no higher than is necessary to insure adequate storage for proper regulation. The water supply can be predicted to a certain extent, and it may be that when conditions were favorable for a good supply the power company could safely draw the lake to a lower level than when a poor supply was expected, thereby benefiting the lands. Even though it is assumed that the power company has done all to this end that might be reasonably expected, which it has, in the writer's opinion, and that this fact might have been ascertained at any time by properly authorized agencies, the settlers who are most intimately concerned have had no easy means of assurance that such was the case, and the situation has encouraged misunderstanding. It seems appropriate for the Government to interest itself in cooperating with the power company in measures toward holding the level of the lake as low as possible with proper regard to storage, in order that the settlers may have ample assurance that the water is not being held unnecessarily high and that their interests are being properly guarded.

Hawks 2961