72D CONGRESS, 1st Session } HOUSE OF REPRESENTATIVES { DOCUMENT No. 148

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CHEHALIS RIVER, WASH.

LETTER

FROM

THE SECRETARY OF WAR

TRANSMITTING

REPORT FROM THE CHIEF OF ENGINEERS ON CHEHALIS RIVER, WASH., COVERING NAVIGATION, FLOOD CONTROL, POWER DEVELOPMENT, AND IRRIGATION

DECEMBER 10, 1931.—Referred to the Committee on Rivers and Harbors and ordered to be printed, with 9 illustrations

WAR DEPARTMENT,
Washington, December 9, 1931.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am transmitting herewith a report dated December 9, 1931, from the Chief of Engineers, United States Army, on Chehalis River, Wash., 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 of January 21, 1927, together with accompanying papers and illustrations.

Sincerely yours,

PATRICK J. HURLEY,
Secretary of War.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, December 9, 1931.

Subject: Report on Chehalis River, Wash.
To: The Secretary of War.

1. I submit for transmission to Congress my report, with accompanying papers and illustrations, on Chehalis River, Wash., made under the provisions of House Document No. 308, Sixty-ninth Con-

2. The Chehalis River rises in the southwestern part of the State of Washington and flows in a generally northwesterly direction, emptying into the eastern part of Grays Harbor. It is 110 miles long and drains a total area of 2,000 square miles. Its principal tributaries are Satsop River, which is 36 miles long and drains 320 square miles, and Wynoochee River, which is 60 miles long and drains 193 square miles. The Chehalis Basin includes no high mountain ranges and the divides are comparatively low, except on the headwaters of the Wynoochee and Satsop, where the elevation is 5,000 feet. The higher portions of the basin are rugged in character and densely forested. The lower parts contain excellent farm land.

3. The population of the watershed is about 60,000 and the largest cities are Aberdeen, with 21,700 inhabitants, Centralia, with 8,100, and Chehalis, with 5,100. The industries are lumbering, farming, canning, coal mining, and the sand and gravel business. Lumbering is the most important. The forests of the basin contain over 14,000,000,000 board feet and the cut per year is approximately 500,000,000 board feet.

4. The mean annual precipitation is about 80 inches at Aberdeen, and decreases toward the central part of the basin, being 46 inches at Centralia. About 80 per cent of the rainfall occurs during the fall and winter months while very little occurs in July and August.

5. The existing project for navigation on the Chehalis River provides for a channel 18 feet deep at mean lower low water and 200 feet wide from deep water in the bay to Cosmopolis, a distance of 10 miles, and for a channel 16 feet deep at mean lower low water and 150 feet wide from Cosmopolis to Montesano, a distance of 10½ miles. The controlling depth below Cosmopolis is 26 feet, local interests having dredged the lower channel to that depth. The controlling depth between Cosmopolis and Montesano is 7 feet. The 16-foot channel in this section was authorized by the river and harbor act of 1930 at an estimated cost of $423,000, subject to the requirement that local interests pay half the first cost, assume all maintenance and provide suitable terminal facilities at Montesano. These conditions have not yet been complied with.

6. The commerce of the river consists principally of logs, lumber, and sand and gravel. Steamer and barge service extends to Montesano 13½ miles above the mouth, and the rafting of logs is confined to the section below Elma, which is 25 miles above the mouth. There is no commerce above Elma. During the five years ending with 1929 the logs rafted between Elma and Montesano averaged 540,000 tons per year. In 1928 the steamer and barge traffic between Montesano and Cosmopolis, which is about 3 miles above the mouth, amounted to about 350,000 tons and the rafted logs to about 675,000 tons. Terminal facilities are adequate for the existing commerce.

7. Highways and railroads provide quick and convenient methods of transportation in the upper part of the basin and the district engineer reports that no extension of the present project into that area in the interest of navigation is justified. He considers the existing project adequate to the needs of the present and prospective commerce below Montesano.

8. The streams of the Chehalis Basin do not generally present favorable opportunities for the economical development of power. Most of the best dam and reservoir sites are found so far upstream

power. On the lower parts of the streams where there is adequate flow, the foundations are poor and large areas of expensive land would become inundated by the construction of dams. At the present time there is only one development in the basin. It is on Sylvia Creek and has an installed capacity of 539 horsepower. A number of applications for permits for the development of small water powers within the basin have been received by the State of Washington but no construction has been undertaken. The most important of these were two for development on the Wynoochee River, which has more favorable conditions for the development of power than the other streams of the basin. The district engineer has investigated the power possibilities of the Wynoochee River and devised a plan of improvement involving the following projects:

Project	Usable storage capacity	Miles above mouth	Average head	Installed horsepower (based on power available 50 per cent of time)	Horsepower available 90 per cent of time	Construction cost	Construction cost per kilowatt installed
	Acre-feet		*Feet*				
Weatherwax No. 2	228,000	39	245	14,150	12,030	$3,800,000	$360
Save Creek	None.	24	96	5,790	4,760	2,100,000	485
Lower reservoir	74,800	8	90	7,020	5,970	3,541,000	676
Total				26,960	22,760	9,441,000	469

He is of the opinion that the cost of these installations is in excess of reasonable economic limits at the present time.

9. The Chehalis Basin contains approximately 150 square miles of bottom lands subject to inundation from floods. These extend in a narrow belt from the mouth of the river to above Newaukum and for varying distances up the different tributaries. Floods occur during the months November to March, inclusive, and at the average rate of one every four years. The only damages of record are for a flood in 1897 when the high water cut through a farm and damaged a road, and for one in 1909, when a 90-foot section of the right of way of the Northern Pacific Railroad between Montesano and Cosmopolis was washed out. The majority of the crops grown in the valley are rarely planted before March and are harvested by November, so there is no crop damage by floods. The district engineer is of the opinion that such a small amount of damage does not justify the construction of flood-control works.

10. The rainfall in the Chehalis River Basin is ample for the needs of most crops except during July and August. Many farms located conveniently to the streams are irrigated during these months by small pumping plants. Other farms not so situated are planted with crops which either mature earlier or else do not require water during the dry months. The extensive development of irrigation in the basin does not seem probable and a considerable extension of irrigation of the prevailing type would not use enough water to interfere materially with other uses of the stream.

11. The district engineer concludes that the existing project for navigation is adequate for the present and prospective requirements of navigation, that irrigation is of minor importance on the Chehalis

24, township 21 north, range 8 west, the Wynoochee flows through alternating gorges and open bottom lands, falling about 23 feet per mile. Below this last canyon, the valley near the stream consists of an alluvial outwash, through which the Wynoochee meanders between deeply eroded banks, dropping about 11 feet per mile to its confluence with the Chehalis.

9. The Satsop also drains a portion of the Olympic Peninsula, entering the Chehalis from the north 6½ miles above the mouth of the Wynoochee. The Satsop is a stream of two forks and many branches, and drains a wide basin. Considered as continuous with its West Fork, the Satsop is about 36 miles long, and drains about 320 square miles.

10. The next important tributary is the Black, which enters the Chehalis near Oakville, 40 miles above Aberdeen and 16 miles above tidewater at Elma. This river has been the subject of two reports on preliminary examination of a "Ship canal connecting Puget Sound with Grays Harbor, Wash.," dated April 11, 1907, and February 4, 1920, respectively, the former being published as House Document No. 7, Sixtieth Congress, first session. Black River and its source, Black Lake, are described in the report of February 4, 1920, in the following language:

> The most favorable location for a waterway connecting Puget Sound with Grays Harbor is from the head of Budds Inlet, an arm of Puget Sound near Olympia, through Black Lake and down Black River and the Chehalis River to Grays Harbor.
>
> Black Lake is located on the divide between Puget Sound and Grays Harbor about 3 miles southwest of Olympia and 2¾ miles from the head of Budds Inlet. It is about 125 feet above tidewater in Puget Sound and is 2½ miles long by one-half to three-quarters of a mile wide, with a depth of water varying from 25 to 100 feet. Its water supply is derived from small streams and springs in the vicinity. Its usual outlet is Black River, a tributary of the Chehalis River, but at times of high water it also flows into Puget Sound through Percival's Creek which is separated from the lake by a divide only a few feet high.
>
> Black River flows southwesterly past the towns of Little Rock and Gate into the Chehalis River. It is 12½ miles from the lake to Gate and 28 miles from Gate down the Chehalis River to Montesano. The total distance from Puget Sound to Montesano, following the route of the proposed canal, is about 47 miles. Between Black Lake and Little Rock, Black River flows through a swamp lying at the southern end of the lake and connecting with it. Between Little Rock and Gate the river runs through a prairie and has but little fall.

11. The Skookumchuck and the Newaukum both rise in the western part of Rainier National Forest in the southeast angle of the basin, joining the Chehalis at Centralia and Chehalis (city) respectively. The Skookumchuck is about 42 miles long, and falls about 900 feet from its source to its mouth; the Newaukum is about 29 miles long and falls approximately 1,200 feet from its source to its juncture with the Chehalis.

12. The Chehalis Basin includes no high mountain ranges. It is separated from the main range of the Olympics by the valleys of streams flowing into the Pacific Ocean and into Hoods Canal, and from Mount Rainier and the Cascade Range by streams tributary to the Columbia or to Puget Sound. Consequently, the divides are comparatively low, except on the headwaters of the Wynoochee and Satsop where the watershed reaches 5,000 feet elevation. The Willapa Hills on the west and southwest of the basin do not exceed 1,500 feet, and the high points around the southeast angle of the basin rarely top 2,500 feet. In the vicinity of Black Lake, the divide is

130 feet above sea level. Thus the basin of the Chehalis lies generally below the line of heavy snows and extensive snow storage.

13. The higher portions of the Chehalis Basin are rugged in character, with their steep hillsides densely forested and deeply eroded. The lower parts of the Chehalis Basin are usually excellent agricultural land, flat enough to be readily cultivated and rolling enough to afford good drainage. Along the river bottoms, timber is comparatively light, and there are frequent grassy prairies with a good loam soil. The higher benches, particularly along the eastern side of the basin between the Skookumchuck and the Satsop contain more sand and gravel, with wide expanses of grassy prairie suitable for grazing.

14. In the vicinity of the city of Chehalis, immediately adjacent to the river, the valley opens out into a broad flood plain of a stiff rich loam, through which the Chehalis meanders to the sea. The general level of this valley floor at Centralia is about 160 feet above sea level, and about 18 feet above the low-water stage of the river.

15. *Profile.*—The upper reaches of the Chehalis have the steep slopes usual to streams in this vicinity, the slope decreasing from source to mouth. See Plate II at end of report. At low water, the Chehalis opposite Centralia is at elevation 145 and is approximately 120 feet wide. It falls gradually to 61 feet elevation near the mouth of the Black, or an average slope of 5 feet per mile. From the mouth of the Black to tidewater at Elma the slope is less than 4 feet per mile. No falls exist in this stretch of the river, but there are many rapids over gravel bars. The depth on these bars is less than 1 foot in low water, while between bars depths of 3 to 15 feet are encountered. The current varies from 1 to 3 miles per hour between rapids. The Chehalis is from 500 to 1,000 feet wide between Montesano and Cosmopolis, with an average tidal range of 8½ feet at Aberdeen and 7 feet at Montesano.

16. *Geology.*—The geology of the region is described by Henry Landes, dean of the college of science and professor of geology and mineralogy of the University of Washington, and consulting geologist for this office, in the following terms:

> The main stream of Chehalis River occupies a broad valley which extends from the head of Grays Harbor easterly and then southerly to the country about the city of Chehalis. The principal tributaries drain a large portion of the southern slopes of the Olympic Mountains and the northern and eastern parts of the Willapa Hills, or that area between the lower Columbia and Chehalis Rivers. All of the larger tributaries are situated in areas of heavy rainfall, and their valleys have been deeply eroded, giving rise to a very rough topography. All of the erosion has been done by running water, and none by glaciers.
>
> Only a limited variety of rocks is found in the Chehalis drainage basin. The Willapa Hills are composed of sandstones, shales, and conglomerates, with many layers of basalt that essentially are conformable with the sedimentary beds. In a broad region around Chehalis and Centralia the strata are mostly sandstones and shales which contain several seams of workable coal. In this general area the basalts and other igneous rocks are almost wholly absent. Along the lower courses of the tributaries which come out of the Olympics the prevailing outcrops of rock are sandstones and shales, but toward the headwaters the formations are mainly quartzites and slates, with various igneous rocks occurring as dikes. The Black Hills, which lie southwest of Olympia, are made up almost wholly of basalt.
>
> The Puget Sound glacier did not extend far enough south to encroach to any degree upon the Chehalis Basin. When the glacier was at its maximum size the drainage from the melting ice all reached the sea by way of the lower Chehalis River. The streams flowing from the ice front were all overburdened with débris and deposited large quantites of stratified sand and gravel which filled the broad Chehalis Valley to a depth of many feet. These outwash plains or valley

TABLE 4.—*Chehalis River 1½ miles southwest of Grand Mound*

[Discharge in cubic feet per second]

Year ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Mean for year
1929	543	1,100	2,740	2,800	2,300	3,940	4,390	1,240	900	405	193	197	------
1930	272	326	2,890	2,070	6,830	3,100	1,570	1,200	710	287	155	189	1,600
Mean monthly in second-feet	407.5	713	2,815	2,435	4,565	3,520	2,980	1,220	805	346	174	193	1,681
Mean monthly run-off in inches	0.51	0.86	3.49	3.02	5.12	4.37	3.58	1.51	0.97	0.43	0.22	0.23	24.31

Water stage recorder at the town of Grand Mound.
Drainage area, 928 square miles; crest discharge, 12,000 second-feet Feb. 8, 1930; minimum discharge, 147 second-feet Aug. 29, 1930; maximum daily, 12,000 second-feet, Feb. 8, 1930.

TABLE 5.—*Chehalis River 2½ miles southwest of town of Chehalis*

[Discharge in cubic feet per second]

Year ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Mean for year
1929	------	------	------	------	------	2,040	2,580	662	561	208	107	823	------
1930	103	99.2	1,750	1,200	3,830	1,610	829	649	324	140	87.4	83.8	87.4
Mean monthly in second-feet	103	99.2	1,750	1,200	3,830	1,825	1,704.5	655.5	442.5	348	97.2	453.4	1,012
Mean monthly run-off in inches	0.25	0.23	4.33	2.96	8.57	4.52	4.10	1.62	1.06	0.86	0.24	1.09	29.83

Water stage recorder at the town of Chehalis.
Drainage area, 465 square miles; crest discharge 7,580 second-feet Dec. 23, 1929; minimum daily discharge, 54 second-feet Oct. 1, 1929; maximum daily discharge, 7,580 second-feet, Dec. 23, 1929.

TABLE 6.—*Satsop River at town of Satsop*

[Discharge in cubic feet per second]

Year ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Mean for year
1929	------	------	------	------	------	2,300	2,490	992	794	413	284	227	------
1930	314	280	2,030	1,540	4,850	1,890	2,050	894	556	342	250	296	1,250
Mean monthly in second-feet	314	280	2,030	1,540	4,850	2,095	2,270	943	675	377.5	267	261.5	1,325.0
Mean monthly run-off in inches	1.14	0.99	7.43	5.64	16.04	9.50	8.04	3.46	2.39	1.38	0.98	0.93	57.92

Water stage recorder at the town of Satsop.
Drainage area, 315 square miles; crest discharge, 10,700 second-feet, Dec. 23, 1929; minimum discharge, 203 second-feet, Sept. 21, 1930; maximum daily discharge, 10,700 second-feet, Dec. 23, 1929.

TABLE 7.—*Newaukum River 3 miles southeast of town of Chehalis*

[Discharge in cubic feet per second]

Year ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Mean for year
1929	------	------	------	------	------	781	696	246	160	59.1	39.0	35.8	------
1930	41.3	47.6	513	437	1,130	604	302	273	145	57.4	35.0	37.2	297
Mean monthly in second-feet	41.3	47.6	513	437	1,130	692.5	499	259.5	152.5	58.25	37.0	36.5	325.33
Mean monthly run-off in inches	.30	.35	3.73	3.18	7.44	5.05	3.51	3.66	1.07	.42	.27	.25	29.23

Drainage area, 158 square miles; crest discharge, 3,020 second-feet Mar. 24, 1930; minimum daily discharge, 27 second-feet, Sept. 23, 1930, maximum daily discharge, 2,670 second-feet Mar. 24, 1930.

TABLE 8.—*Skookumchuck River 13 miles northeast of town of Centralia*

[Discharge in cubic feet per second]

Year ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Mean for year
1929	------	------	------	------	------	------	356	153	102	44.4	30.4	25.6	------
1930	26.8	25.7	289	165	584	316	151	136	76.3	38.0	26.5	23.7	152
Mean monthly in second-feet	26.8	25.7	289	165	584	316	253.5	144.5	89.1	41.2	28.5	24.6	166
Mean monthly run-off in inches	.52	.48	5.47	3.22	10.3	6.17	4.83	2.82	1.68	.81	5.53	.46	42.29

Drainage area, 59 square miles; crest discharge, 1,840 second-feet Mar. 22, 1930; minimum daily discharge, 21 second-feet Sept. 23, 1930; maximum daily discharge, 1,760 second-feet Oct. 22, 1930.

21. *Cities and population.*—The population of the Chehalis Basin was about 52,000 in 1920 and about 60,000 in 1930. The principal cities and towns in the basin are as follows:

TABLE 9

City	County	Population		
		1910	1920	1930
Aberdeen	Grays Harbor	13,660	15,337	21,718
Centralia	Lewis	7,311	7,549	8,100
Chehalis	do	4,507	4,558	5,100
Montesano	Grays Harbor	2,488	2,158	3,278
Cosmopolis	do	1,132	1,512	1,582
Elma	do	1,532	1,253	2,462
Pe Ell	Lewis	838	861	888
Tenino	Thurston	1,038	850	935

22. *Railways.*—The main line of the Northern Pacific, also used by the Great Northern and Union Pacific railroad systems between Seattle and Portland, crosses the Chehalis Basin from Tenino south, passing through Centralia and Chehalis. The Chicago, Milwaukee, St. Paul & Pacific Railroad enters the basin from the Puget Sound region about 4 miles northeast of Tenino and branches at Maytown, one branch passing through Centralia and Chehalis and crossing the Willapa Hills to South Bend on the Willapa River. The other branch

Engineers, 1891. Favorable for improvement of inner harbor by construction of dikes at an estimated cost of $46,200 and for dredging channel and closing subsidiary channels in Chehalis River up to Montesano at an estimated cost of $103,400.

(*d*) Preliminary examination and survey of "Grays Harbor, inner portion and Chehalis River to Montesano" ordered by the river and harbor act of March 3, 1905. Reports on preliminary examination dated June 23, 1905, and on survey dated January 10, 1906, House Document No. 507, Fifty-ninth Congress, first session. Favorable for a 200-foot channel 18 feet deep at mean lower low water from Grays Harbor City to Cosmopolis, at an estimated cost of $187,500. Unfavorable for any additional improvement above Cosmopolis.

(*e*) Survey and estimate, "with a view to the improvement of the Chehalis River up to Montesano by the removal of bars," ordered by the river and harbor act of March 2, 1907. Report dated March 31, 1908, House Document No. 1125, Sixtieth Congress, second session. Favorable for an increase in depth to 6 feet between Cosmopolis and Montesano, at an estimated cost of $50,000.

(*f*) Preliminary examination and survey of "Chehalis River, Wash.," ordered by the river and harbor act of March 3, 1925. Reports on preliminary examination dated August 22, 1925, and on survey dated November 22, 1927, House Document No. 315, Seventieth Congress, first session. Favorable for 200-foot channel 18 feet deep from deep water in bay to Cosmopolis and 150-foot channel, 16 feet deep, from Cosmopolis to Montesano, at an estimated cost of $423,000, local interests to pay half of first cost, assume all maintenance, and provide terminal at Montesano; estimated cost to United States $211,500.

In addition to the foregoing, part of the Chehalis River was examined incidental to the surveys for a proposed canal connecting Grays Harbor and Puget Sound, mentioned in paragraph 10 above.

32. *Previous projects.*—There have been two previous projects, as listed below:

(*a*) Removal of snags and log jams, from mouth to Claquato, estimated first cost $5,000, with annual maintenance thereafter. Project based on report of January 26, 1882. Appropriations totaled $19,000; first one of $3,000 made by river and harbor act of August 2, 1882. Progress: Rafts were removed in 1884, and snagging carried on intermittently thereafter. Some work done as far upstream as Chehalis, but majority accomplished between Montesano and Elma.

(*b*) Two hundred foot channel, 16 feet deep at half tide, from deep water in bay to Montesano, by construction of dikes in harbor (estimated cost, $46,200) and by dredging four shoals and closing sloughs in Chehalis River (estimated cost $103,400). Project based on report of April 29, 1891; authorized by river and harbor act of July 13, 1892. Progress: Between 1893 and 1895 dikes were constructed in harbor and some in river; no dredging done. Work suspended in 1896. Project revived by river and harbor act of June 13, 1902, appropriating $50,000 for "improving Grays Harbor, inner portion, between Aberdeen and the entrance to said harbor and Chehalis River, Wash." Additional appropriation of $30,000 made by river and harbor act of March 3, 1905. Progress: Harbor dikes were repaired and a channel 15 feet deep at mean lower low water was dredged below Aberdeen. Snagging was continued in lower part of river but no other river work was done. Upon completion of work a maximum draft of 11 feet at mean lower low water could be carried to Cosmopolis and one of 5½ feet to Montesano. Total amount spent: $150,549.83, divided into $113,134.48 for improvement, and $37,415.45 for maintenance of dikes and snagging.

(*c*) Channel 150 feet wide, 6 feet deep at mean lower low water from Cosmopolis to Montesano, by dredging and dike work, at estimated cost of $50,000 together with annual snagging. Project based on survey report published in House Document No. 1125, Sixtieth Congress, second session. Authorized by river and harbor act of June 25, 1910. Progress: Work done by United States Engineer Department dredge *Oregon* in 1910. No dike work was done, the sloughs being closed by depositing dredged material therein.

33. *Existing projects.*

(*a*) Channel 200 feet wide and 18 feet deep at mean lower low water from deep water in bay to Cosmopolis, by dredging at estimated cost of $187,500. Project based on report published in House Document No. 507, Fifty-ninth Congress, first session. Authorized by river and harbor act of March 2, 1907.

Progress: Work started by contract in 1907, completed by United States Engineer Department dredge *Oregon* in 1910.

(*b*) Channel 150 feet wide, 16 feet deep at mean lower low water, from Cosmopolis to Montesano by dredging, at an estimated cost of $423,000, local interests to pay half of first cost, assume all maintenance and provide suitable terminal facilities at Montesano. Project based on survey report of November 22, 1927, published as House Document No. 317, Seventieth Congress, first session. Authorized by river and harbor act of July 3, 1930. Progress: No work done, awaiting local cooperation.

34. *Work done and present condition.*—In obtaining the project depth and width in these channels, approximately 1,800,000 cubic yards were dredged of which 64,000 were from the river above Cosmopolis. Frequent redredging has been necessary and such maintenance dredging has amounted to approximately 1,430,000 cubic yards, of which 60,000 were from the upper project. Snagging has been done as needed. The controlling depths at mean lower low water in June, 1930 were 7 feet between Cosmopolis and Montesano and 26 feet below Cosmopolis, local interests having dredged the lower channel to that depth. Expenditures to date have been as follows:

From United States funds:		
Previous project		$150,549.83
Existing project—		
New work	$238,188.26	
Maintenance	121,042.68	
		359,230.94
From contributed funds:		
Existing project		32,496.12
Maintenance (approximate)		935,160.00

35. *Bridges.*—There are three bridges at Aberdeen and nine bridges between the mouth of the Wynoochee and the city of Chehalis, all authorized by the Secretary of War. Above the city of Chehalis there are several railway and highway bridges that have not been so authorized and for which no record of clearances is on file in this office. The following table gives the pertinent data on the 12 authorized bridges.

TABLE 12.—*Chehalis River, Montesano to Cosmopolis, 1928*

Commodities	On steamers		On barges		Floated	
	Tons	Value	Tons	Value	Tons	Value
Shingles	486	$14,580	797	$23,910		
Lumber	51,417	651,282	102,640	1,231,686	675,000	$4,050,000
Logs			187,958	187,958		
Sand and gravel			1,200	72,000		
Steel rails			6,875	48,125		
Fuel oil						
Total	51,903	665,862	299,470	1,563,679	675,000	4,050,000

These amounts are absorbed in the tables for Grays Harbor given below as the lower Chehalis Basin is commercially tributary to the cities on Grays Harbor.

39. *Adjacent ports.*—Grays Harbor is 45 miles north of the entrance to Columbia River and 15 miles north of the entrance to Willapa Harbor and River. On the latter are located the towns of Raymond and South Bend, from which large shipments of lumber are made. To the north there are no harbors suitable for deep-draft vessels between Grays Harbor and Cape Flattery at the entrance to the Strait of Juan de Fuca. Aberdeen and Hoquiam, the principal ports on Grays Harbor, are immediately adjacent to the Chehalis Basin, part of Aberdeen lying within that basin. The commercial importance of these cities is indicated by the following tables. The Chehalis Basin contributes an undetermined part to all classes of commodities therein tabulated:

TABLE 13.—*Grays Harbor and Bar Entrance, Wash., freight traffic*

	Imports		Exports		Total	
	Tons of 2,000 pounds	Value	Tons of 2,000 pounds	Value	Tons	Value
1928						
Foreign	1,750	$22,295	804,175	$10,418,590	805,925	$10,440,885
Coastwise	171,960	5,388,181	1,389,918	14,045,129	1,561,878	19,433,310
1929						
Foreign	1,671	29,850	817,964	10,926,090	819,635	10,955,940
Coastwise	186,430	5,005,540	1,191,957	13,018,710	1,378,027	18,028,250

TABLE 14.—*Grays Harbor, inner portion—Comparative statement of traffic*

Year	Vessel traffic		Floated timber	
	Tons	Value	Tons	Value
1920	189,129	$425,275	1,482,793	$13,345,137
1921	147,633	472,502	1,761,000	8,488,000
1922	179,778	2,897,549	2,352,768	12,484,300
1923	352,812	3,717,356	3,386,250	23,703,750
1924	373,398	4,730,519	3,831,726	22,090,354
1925	294,394	3,819,016	3,937,854	21,658,197
1926	279,971	4,078,641	4,351,000	23,930,500
1927	264,957	3,369,653	4,248,000	23,364,000
1928	331,710	2,731,020	4,289,054	25,734,324
	458,853	3,869,647	3,860,149	21,230,819

TABLE 15.—*Grays Harbor (inner portion) between Aberdeen and the entrance to said harbor and Chehalis River, Wash., not including traffic crossing bar*

FREIGHT TRAFFIC

Classes of commodities	Internal receipts and shipments	
	Tons, 1928	Tons, 1929
Animals and animal products	912	729
Wood and paper	4,407,931	4,125,901
Nonmetallic minerals	208,065	187,722
Machinery and vehicles	428	1,319
Unclassified	3,428	3,331
Total	4,620,764	4,319,002
Total value	$28,465,344	$25,100,466

40. *Discussion.*—The work completed in this locality has provided a channel 26 feet in depth at mean lower low water from deep water in Grays Harbor to Cosmopolis, 3 miles up the Chehalis, and a channel 7 feet deep, thence to Montesano, 10½ miles farther upstream. The existing project to deepen this 10½ mile reach is awaiting the fulfillment of statutory requirements of cooperation by local interests. The improvements attempted and those contemplated by the existing project thus involve only the lower 13½ miles of the channel and the necessary seaward connections. At certain stages the Chehalis is probably navigable for light drafts to a point above the mouth of the Newaukum, a distance of 73 miles. No navigation exists now on the upper reaches and due to railroad and auto truck service, the establishment of river commerce is improbable. Certainly no improvement of the river above Montesano in the interests of navigation is justified by present or reasonably prospective commerce. The canalization of the Chehalis is not feasible, as foundations are not suitable for locks and navigation dams and the banks are so low and the valley so wide and flat that such installations would flood the best agricultural lands in the basin.

2. WATER POWER

41. *General conditions.*—The streams of the Chehalis basin generally do not present favorable opportunities for the economical development of hydraulic power. The more practicable dam and reservoir sites are normally found so far upstream that the water supply is not sufficient to justify installation of equipment for the generation of power. Downstream, where the flow is adequate, the hydraulic gradients are slight, foundations unsatisfactory, and the adjacent valley so wide and flat as to necessitate lengthy barrages and reservoirs of large areas. Such reservoirs would flood the best farms of the basin and would not only be expensive in the acquisition of flood rights, but would also destroy the local power market and materially impoverish the natural resources of the basin.

42. *Power possibilities.*—Although some good dam sites are found on the Chehalis between Pe Ell and Adna, the valley bottoms are becoming closely settled, and the cost of flooding out these communities is judged to be so excessive as to prohibit power development. Isolated possible sites are found on the Skookumchuck and Satsop

Jones report estimated that this installation would yield 3,030 horsepower and 4,520 horsepower 90 per cent and 50 per cent of the time respectively. It is believed that such installation would be entirely too expensive in cost per kilowatt generated and it is not considered economically feasible. Accordingly, the possible regulating effect of this reservoir has been omitted from consideration at the power sites downstream.

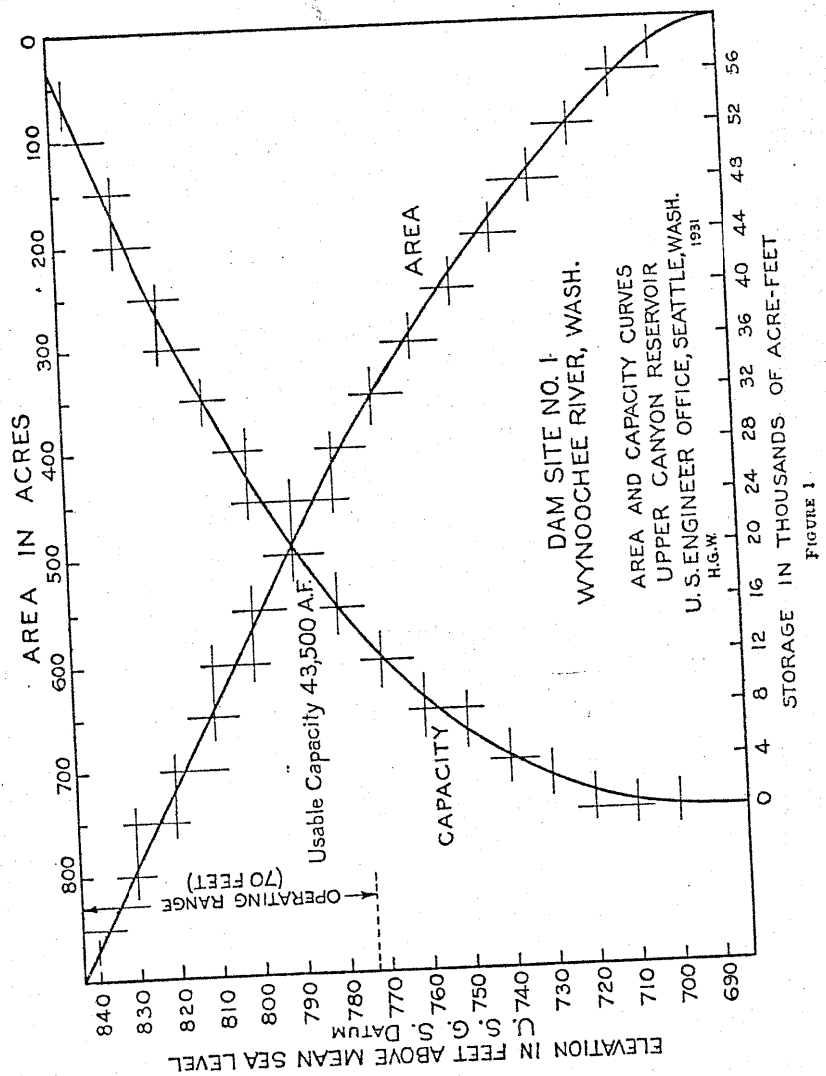


FIGURE 1

49. *Weatherwax, site 2.*—After leaving the short gorge of the upper canyon, the Wynochee first flows through a somewhat constricted section, then into an open valley bordered by high hills. This valley is the Weatherwax Basin, about 3 miles long and a mile or more wide. At the lower end of this basin the Wynoochee enters a tortuous [illegible] which offers several apparently feasible dam sites.

This canyon is from 600 to 800 feet wide at the top, where its rock walls are overlaid by detritus from the adjacent hills. The city of Aberdeen has made extensive and thorough investigation of the foundations at the several sites in this canyon, and as a result of these studies selected the dam site shown on Plate V at end of report as No. 2, in section 12, township 21 north, range 8 west. A cross section of this site is also shown on Plate V.

50. The low water surface at this dam site is at elevation 434 United States Geological Survey datum, and bed rock seems readily available up to elevation 693. Two dam heights have been considered, one to elevation 693, and one to elevation 728, with its spillway at elevation 718. The area and capacity curves of the resulting reservoirs are shown in Figure 2. The essential quantities of the two proposed methods of development are shown in parallel columns in Table 17 below. Scheme A is taken from the Jones report, being modified somewhat to conform to the power house location and dam site selected, and to include the more recent years of stream-flow data which are now available. Scheme B is derived from the Weatherwax Basin project of the city of Aberdeen, unaltered except to change to United States Geological Survey datum and to recompute power and flows to include the more recent discharge data. The storage and regulation curves are shown in Figure 3 [1] and the duration of flows in Figure 4.

TABLE 17.—*Essential quantities of proposed developments of Weatherwax Basin*

Item		Scheme A	Scheme B
Dam:			
Crest at elevation	feet	693	728
Spillway crest at elevation	do	693	718
Crest length, approximately	do	900	1,000
Reservoir:			
Maximum water surface at elevation [1]	do	693	718
Minimum water surface at elevation	do	596	608
Drawdown, amount [2]	do	104	117
Total capacity	acre-feet	200,000	274,000
Usable capacity	do	166,000	228,000
Power:			
Mean tailwater elevation	feet	433	433
Maximum operating head	do	260	285
Mean operating head	do	221	245
Least regulated flow, 90 per cent of time	second-feet	575	614
Least regulated flow, 50 per cent of time	do	677	722
Horsepower 90 per cent of time, 70 per cent efficiency		10,170	12,030
Horsepower 50 per cent of time, 70 per cent efficiency		11,970	14,150

[1] Both schemes back water over upper canyon, dam site No. 1.
[2] The use of interchangeable runners on the turbines is contemplated in this excessive drawdown.

51. In the above table the power house was assumed near the dam, with but 400 feet of penstock, for the purpose of simplifying study and comparison. It is possible to locate the generating equipment farther downstream, thus increasing the head and power and decreasing the ratio of drawdown. Such location would make better utilization of the resources of the stream, but at an increased cost of installation. An economic study of this feature has not been attempted in this report, but should be undertaken by interested parties prior to development.

[1] Not printed.

TABLE 18.—*Estimated power available at the Save Creek diversion*

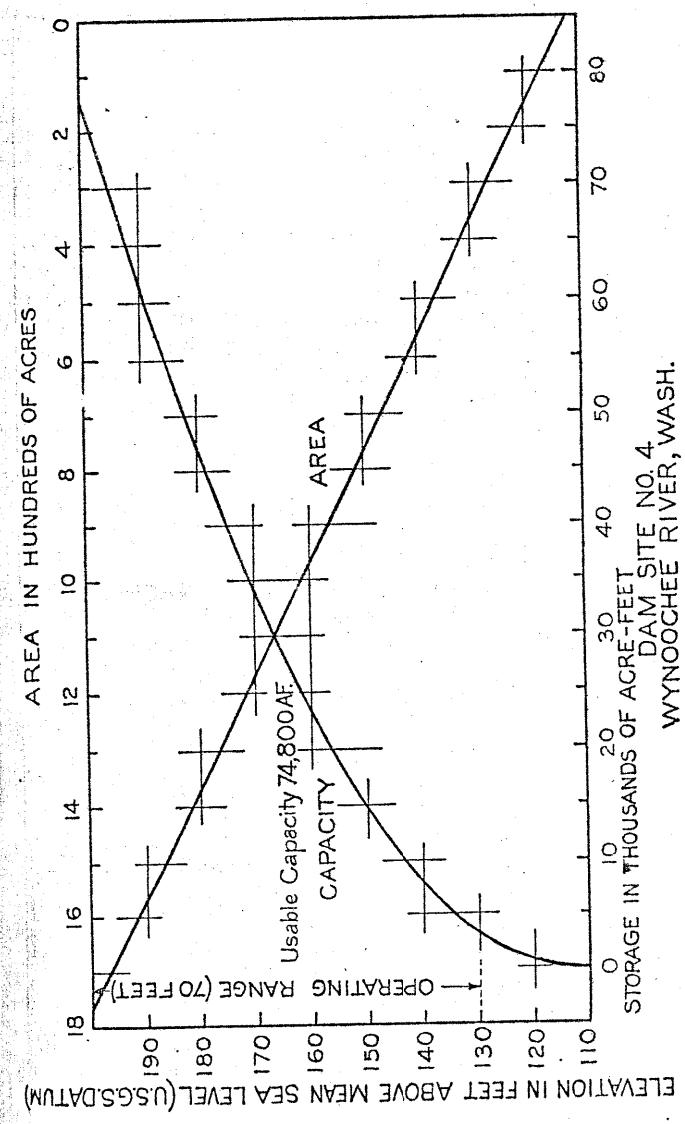
Regulation	Least flows in second-feet		Horsepower at 70 per cent efficiency	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	139	583	1,070	4,480
Scheme A at Weatherwax	581	709	4,460	5,445
Scheme B at Weatherwax	620	754	4,760	5,790

53. *Lower reservoir, site 4.*—The third possible location for a relatively high dam is in secs. 27, 28, T. 19 N., R. 8 W., about 14.5 miles above the mouth of the Wynoochee. (See Plates III and V at end of report). At this point the river has cut a gap about 300 yards wide through a dike of hard limestone. The exposed rock rises abruptly from the valley floor on both banks to a height of approximately 50 feet above the water, where the outcrop disappears under a mantle of débris and dirt. No foundation investigations have been made at this site, but from the presence of many angular fragments of dike limestone in the overburden, it seems probable that the dike lies close to the surface. The exposed rock while very hard is much fractured, but it is believed that borings and test pits will show that good foundations for the dam and its abutments can be obtained after the weathered exposures are removed.

54. The open valley above this dike will afford opportunity for a reservoir of medium capacity at the suggested dam height. Area and capacity curves of this reservoir are shown in Fig. 5. The scheme of development suggested for this site contemplates a dam 88 feet high, its base at elevation 112 and its crest at elevation 200. Such a dam would have a crest length of approximately 1,880 feet and would create a reservoir having a capacity of 78,100 acre-feet. With a drawdown to elevation 130, the usable capacity of the reservoir would be 74,800 acre-feet. A diagram showing the effect of this storage on the regulated flows from the Weatherwax is appended in Figure 6.[1] The duration of flows is shown in Figure 7.

55. The water thus impounded would be conducted through a pipe line 7 miles long to a power house located in sec. 28, T. 18 N., R. 8 W., at a point immediately upstream from the present diversion dam and intake works of the city of Aberdeen's Van Winkle Creek Reservoir, or site 5, on Plates III and V at end of report. Under this suggested plan the mean reservoir surface would be at elevation 175 and the mean tailrace level would be at elevation 36, giving a mean static head of 139 feet, or assuming a loss of head of 7 feet per mile in the supply lines and penstock, the effective head would be 90 feet. Under ideal regulation of the upstream reservoirs, the flows of the last seven years and the power produced under the suggested scheme of development would have been as shown in Table 19.

[1] Not printed.



AREA AND CAPACITY CURVES
LOWER RESERVOIR SITE
DAM SITE NO. 4
WYNOOCHEE RIVER, WASH.
U.S. ENGINEER OFFICE, SEATTLE, WASH. 1931

FIGURE 5

principal systems. These lower river communities are served by steam plants whose total present capacity is approximately 24,150 kilowatts, and by a small hydroelectric plant at Sylvia Creek with 200 kilowatts capacity. An additional hydroelectric development with an initial capacity of 12,500 kilowatts is contemplated on North River, a tributary of Willapa Harbor.

59. *Power markets.*—The only large block of potential hydroelectric power in the Chehalis Basin is found on the Wynochee River. Although a 15-mile transmission line would connect the development at the Weatherwax with the Lake Cushman plant of the city of Tacoma, and with the large and growing power needs of the Puget Sound region, the primary market for power generated on the Wynoochee River is considered to be centered in and around the Grays Harbor cities. The power consumed in this region for the years 1916 to 1926, inclusive, is shown in the following table, transcribed from the reports to the city of Aberdeen on the Weatherwax project referred to in paragraph 44 above.

TABLE 21.—*Power consumption, Grays Harbor district*

Year	Millions of kilowatt hours				Kilowatts per capita	Kilowatts, average	Maximum kilowatts for 1 hour	Yearly load factor
	Lighting	Power	Municipal	Total				
								Per cent
1916	1.68	0.98	0.33	2.99	83	340	1,700	20
1917	1.83	1.49	.35	3.67	98	420	1,850	23
1918	2.32	3.58	.30	6.20	155	710	2,960	24
1919	2.52	3.60	.31	6.43	151	735	2,920	25
1920	2.96	2.76	.30	6.01	135	685	2,540	27
1921	2.92	4.96	.29	8.18	174	935	3,480	27
1922	3.30	7.85	.33	11.48	229	1,310	4,395	30
1923	5.10	7.64	.37	13.12	250	1,500	4,759	31
1924	5.98	6.64	.43	13.05	238	1,490	5,200	29
1925	6.72	9.99	.46	17.17	295	1,960	6,500	30
1926 [1]	6.11	[2] 14.86	.46	21.43	----------	2,450	----------	----------

[1] 1926 data from records at Olympia.
[2] This includes 2,037,240 kilowatt-hours sold to other electric-power companies.

60. The data regarding the power generated and purchased by the electric power companies in this section have been obtained from the power companies concerned. These data are set forth in Table 22 below. A discrepancy between Tables 21 and 22 for the year 1926 will be noted, which is probably due to incomplete information at the time of compiling Table 21 and to transmission losses.

TABLE 22.—*Power generated and purchased by power plants in Grays Harbor section*

Year	Millions of kilowatt-hours	Average kilowatts	Maximum hourly peak in kilowatts	Hour-yearly load factor
				Per Cent
1926	28.1	3,210	6,192	52
1927	29.2	3,340	7,600	38.1
1928	35.2	3,670	8,100	45
1929	41.2	4,690	9,350	50

61. From the foregoing Tables 21 and 22 it can be shown that the output of energy has increased each year by approximately 20 per cent of the preceding year's figure, and that the momentary yearly load factor approaches 50 per cent. Under the assumption that during the next decade the power output will increase at the same rate and that momentary yearly load factor will average about 50 per cent, the year 1935 will see the entire total installed capacity of 24,350 kilowatts needed, and the additional 12,500 kilowatts initial capacity at North River will be fully used in 1938. Thus before 1940, power additional to that cited in paragraph 58 will be required in the Grays Harbor cities.

62. The city of Aberdeen contemplates development of the Weatherwax project as a municipal development and is confronted with the fact that the consumers of large blocks of power for industrial purposes in this region hold long-term contracts with the private power corporations. Thus the present market for Weatherwax power is confined to municipal and domestic needs. However, due to the abundance of raw material in this locality, it seems not improbable that the future industrial development of this region will be accompanied by the establishment of pulp and paper mills, and such new plants as may be established will provide a possible industrial market for the municipal power developments.

63. *Discussion.*—Although topographic and water supply data are far from complete, the available information indicates that except for some very minor possibilities elsewhere in the basin, the Wynoochee River presents the only power potentialities in the Chehalis drainage basin. The total undeveloped power on the Wynoochee is approximately 17,000 kilowatts 90 per cent of the time, produced by three plants. A logical market for such power appears to depend on the industrial development of the Grays Harbor region. The costs of such developments, however, are not believed to lie within reasonable economic limits. The projects are therefore not considered feasible at the present time.

3. FLOODS AND FLOOD CONTROL

64. *Flooded areas.*—The drainage basin of the Chehalis and its tributaries occupies 2,000 square miles of which approximately 150 square miles are in the valley bottoms and subject to occasional inundation. These flooded areas extend in a narrow belt up the Chehalis from its mouth to above the Newaukum, and for varying distances up the different tributaries.

65. *High-water season.*—Due to the generally mild winter temperature and the low altitudes within the basin, snow accumulations are slight and the effect of melting snows in the early summer is negligible. Thus, the high-water season each year corresponds roughly to the period of maximum precipitation, and high water can be expected at any time between November and April.

66. *Flood records.*—The most severe flood of record occurred in November, 1909. The meager records available show other floods in December, 1891, in 1892, 1897, 1903, March 21, 1908; January, 1914; December 21, 1915, 1917; and January, 1923. In other words, floods have occurred at the rate of one every four years.

the improvement of the river for navigation can not be combined to the benefit of either.

79. *Acknowledgment.*—This report has been prepared largely either by or under the direct supervision of First Lieut. A. G. Matthews, Corps of Engineers, for which it is desired to give due credit.

V. Recommendations

80. I am of the opinion that the existing project for improvement of the Chehalis River in the interests of navigation is adequate for all present and reasonably prospective commerce on this stream, and that further Federal participation is not justified at this time. I am also of the opinion that it is not feasible to combine improvements in the interest of flood control, navigation, power and irrigation, and that no further study with that end in view should be made.

Jno. S. Butler,
Major, Corps of Engineers, District Engineer.

[First indorsement]

Office, Division Engineer, North Pacific Division,
Portland, Oreg., February 3, 1931.

To the Chief of Engineers, United States Army:

I concur in the conclusions and recommendations of the district engineer.

G. R. Lukesh,
Colonel, Corps of Engineers, Division Engineer.

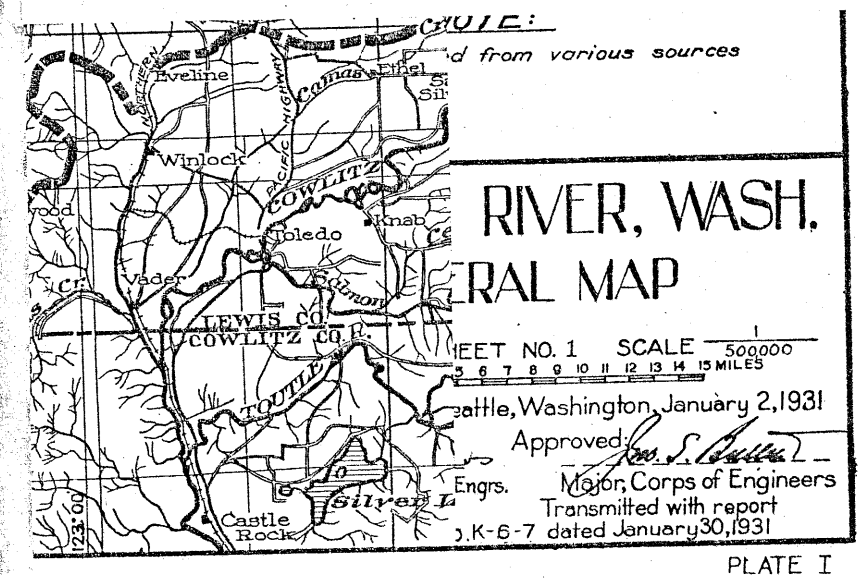


PLATE I