

The Biennial Report

OF THE

Board of Geological Survey

OF THE

State of Washington

FOR THE TERM 1919-1921



OLYMPIA
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1921

LETTER OF TRANSMITTAL.

To the Legislature of the State of Washington:

The Board of Geological Survey transmits herewith its biennial report for the term 1919-21, as required by statute.

Respectfully submitted,

LOUIS F. HART, *President.*

W. W. SHERMAN, *Secretary.*

HENRY SUZZALLO,

ERNEST O. HOLLAND.

Olympia, December 22, 1920.

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BIENNIAL REPORT OF THE BOARD OF GEOLOGICAL SURVEY

GENERAL PURPOSES OF SURVEYS.

TOPOGRAPHIC SURVEYS.

The Topographic Map.—A topographic map is designed to represent the form and slope of the surface of the land and the elevation of all points above sea level. The positions of streams, lakes and ponds, public and private roads, towns and railroads, are shown in their correct relative positions. The map indicates boundaries of counties and the position of section lines wherever there have been land surveys. In the making of the necessary surveys for such maps permanent marks, consisting of iron posts, copper bolts or tablets, are set at frequent intervals to mark the exact elevation above sea level to serve as datum points for further spirit level work, for engineering investigation, and for such public works as canals, water supply, railway and other public or private surveys.

The topographic map is made with such accuracy and in such detail that it is useful to almost every citizen. In a new state that is inviting immigration, the map is valuable in order to show the location of desirable farm lands and the general character of the country. From it the positions of streams and lakes may be seen and the possibilities of these for purposes of water power or irrigation may be largely determined. The topographic map facilitates the construction of railroads and wagon roads, since upon it available routes and grades may be laid out without the preliminary surveys ordinarily necessary for improvements of this kind. In our public schools such a map is indispensable in that it places before the children truthful maps of our commonwealth, instead of those that are glaringly inaccurate.

In the making of topographic maps the areas selected for survey are defined by lines of latitude and longitude and are called quadrangles. Each quadrangle, and the topographic map which represents its features, is designated by the name of the most prominent place or topographic feature included within it. The scale generally used in map construction is about two miles to the inch, and on this scale the area embraced in a quadrangle is about eight hundred square miles. In Washington, the topographic map when completed will comprise, in round numbers, ninety sheets, complete and fractional, of which about forty have already been surveyed.

HYDROMETRIC SURVEYS.

Hydrometric surveys furnish a basis for determining the water resources of the state. They are essential to indicate the supply of water suitable for domestic and industrial purposes, for comprehensive development of power and irrigation projects, for navigation and flood prevention, and for wise and equitable sanitary regulation. The water supply is of more importance to the life and pursuits of the people than any other natural resource, as the health and economic development of every community are directly dependent upon the character and volume of the available supply.

Our water resources are unlike the other mineral resources in that they are continually existent. Our coal beds and mineral lodes are exhausted when mined and placed upon the market, but the water supply is constantly renewed. Therefore, failure to put water into beneficial use is an economic loss, for the energy and utility does not serve the needs of civilization effectively prior to hydraulic development.

Available water supply must be ascertained far in advance of actual need. It is the most important question arising when irrigation, power, and other hydraulic projects are contemplated because all other essential physical features, except water supply, can be determined within a relatively short time. A record of flow for ten years or more is prerequisite for proper design and plans for operation. The enormous capital outlay required for hydraulic development makes it necessary to anticipate the need for stream-flow records many years in advance of development. Many irrigation and power projects have failed on account of being placed in operation without an adequate knowledge of stream flow. Others designed upon the basis of short time records have levied an enormous toll upon the public through high rates made necessary by unexpected seasonal variation in flow. The run-off for streams in Washington is extremely irregular, especially in respect to minimum flow which is most important in considering operation of any project.

Comparative run-off values are shown in the following table:

COMPARATIVE RUN-OFF OF SOME STREAMS IN STATE.

STREAM AND LOCATION	Run-Off in Second-Feet Per Square Mile for Year Ending September 30, 1917	
	Minimum Calendar Month	Average for Year
Baker River near Concrete.....	4.29	10.80
Quinault River near Quinault.....	2.45	12.20
Skagit River at Sedro Woolley.....	2.63	5.90
Puyallup River at Puyallup.....	2.01	3.67
Yakima River at Cle Elum.....	0.86	4.24
Spokane River at Spokane.....	0.44	1.68
Pend Oreille or Clark Fork at Metaline Falls.....	0.33	0.87
Methow River at Pateros.....	0.17	0.87
Snake River at Riparia.....	0.12	0.39

The foregoing indicates that Baker River yields 36 times as much water per unit of area for the minimum calendar month and 28 times as much for the year as Snake River.

Aside from the design and operation of irrigation and power projects, stream flow records are vitally essential in considering means of preventing damage from floods. Occasionally "Chinook" winds accompanied by heavy rains melt the snow in the mountains, causing disastrous floods in the lowlands.

A serious flood of this kind occurred December, 1917. Fortunately data were obtained at a large number of gaging stations from which maximum flow was computed. Similar floods are reported for 1896, 1897, 1906, and 1909. Few gaging stations were in operation during the early floods but information has

been collected for estimating flood discharge of a number of rivers during those years by using the high flow computed for December, 1917, as a basis.

Hydrometric surveys cover two fields of investigation, the surface supply and the underground supply. The surface supply furnishes by far the greatest volume of water and is readily accessible in the various rivers and creeks. Gaging stations are maintained along principal streams of the state for determining the daily flow throughout a series of years. Daily records are published and are used extensively in designing hydraulic works of all kinds.

The successful operation of irrigation projects has demonstrated enormous agricultural possibilities in eastern Washington. A vast acreage in central eastern Washington is susceptible of irrigation and is capable of doubling or trebling the present agricultural products of the state. Comprehensive plans for development should be devised whereby arid regions will gradually be converted into producing farms.

The state will ultimately be benefited greatly through hydro-electric development because it ranks first among the states in the Union in respect to estimated potential water power. The following is an abstract from a table in "Electric Power Development in the United States;" 64th Congress, 1st session, United States Senate document 316, Part II, table 2, page 14:

POTENTIAL WATER POWER RESOURCES OF THE UNITED STATES.

	MINIMUM		MAXIMUM	
	Horse-power	Per-cent	Horse-power	Per-cent
Washington.....	4,932,000	17.65	8,647,000	16.04
California.....	3,424,000	12.25	7,818,000	14.50
Oregon.....	3,148,000	11.27	6,613,000	12.27
Pacific Coast.....	11,504,000	41.17	23,078,000	42.81
United States.....	27,943,000	100.00	53,905,000	100.00

NOTE.—The water power resources for every State in the Union is given in the table referred to above. Only statistics for the three leading States, the Pacific Coast and the United States are presented here. Montana and Idaho practically tie for fourth place among the states.

One transcontinental railway has installed electrical equipment to provide motive power for 209 miles of its main line within the state and another has used electric energy for operating trains through a Cascade Range tunnel for a number of years. It seems certain that all railways in the state will be electrified and that combined advantage of large natural resources in raw materials and cheap electrical power will eventually insure Washington predominance in industrial activity.

The installed capacity of hydro-electric plants in the state is 409,000 horsepower. Applications for permits now pending before the new Federal Power Commission contemplate the development of over 1,000,000 horsepower additional.

Water power possibilities are being investigated as rapidly as possible. The records of flow indicate water supply. River profiles or level lines along the principal power streams indicate the fall, dam sites, reservoir sites, and

other pertinent data. An analysis of the information is being made in a series of seven reports on the water powers of the Cascade Range, three of which are published. These reports summarize the most reliable information obtainable and will greatly encourage hydro-electric enterprise.

Investigation of underground water supplies is equally as important as in the case of surface waters. This work includes a determination of the areas that are underlain by water-bearing strata, of the depths at which these strata occur, and of the amount and quality of water that may be obtained. A knowledge of the existence of water-bearing strata is very necessary, not alone for the purpose of irrigation, but in some parts of Washington settlement is well-nigh impossible because not even enough water for domestic purposes has as yet been obtained.

GEOLOGICAL SURVEYS.

Geological surveys have been organized in nearly all the states of the Union, and in some of the older states they have been continuously active for over fifty years. In most states they are regular departments of the state government, and receive definite financial support in the way given to every other bureau or department. They are usually in charge of a board of three or five men, who direct the work of the survey, and who are responsible for its management.

The general purpose of a geological survey is to disclose and make known the mineral resources of a state. Under such heading would naturally come the metalliferous deposits, coal fields, iron ores, building stones, soils, clay beds, road materials, water power, and kindred subjects. The field work of a survey consists in mapping accurately the locations of all such valuable products as those just mentioned, and determining the areal extent and quantity of each. The office work consists of careful tests and analyses of all samples collected in the field, and the preparation of reports which describe fully the mineral resources under investigation. The reports and maps when published are valuable alike to the citizens of the state and to outside capitalists and investors. Surveys examine and test those minerals, ores and rocks that are but little known and determine whether or not they are of economic value. They also suggest ways of preventing waste in mining operations, and assist in all ways to conserve the natural resources. Surveys are potent factors in making available valuable information regarding the mineral resources of the state, which knowledge may be utilized by the poorest citizen as well as the wealthiest corporation.

PRINCIPAL FEATURES OF STATE LAWS PROVIDING FOR SURVEYS.

The law establishing a state geological survey was passed by the legislature at the session of 1901. As set forth in the various sections of the law, the principal objects of the measure are as follows: An examination of the economic products of the state, such as gold, silver, copper, lead, and iron ores, as well as building stones, clays, coal, and all mineral substances of value; an examination of the soils, road-building material, water supplies, artesian wells, water power, etc.; an examination of the physical features of the state with reference to their practical bearing upon the occupations of the people; the preparation of special geographic and economic maps to illustrate the resources of the state; and the publication from time to time of the results of the work of the survey in reports and bulletins, and the dissemination of these among the people.

At the session of 1903 the legislature amended the above law, by providing for cooperative work between the federal and the state bureaus engaged in geological survey work. The amendment authorized the state board of geological survey to make provisions for topographic, geologic, and hydrometric surveys of the state, in cooperation with the United States geological survey, in such manner as would be of the greatest benefit to the agricultural, industrial and geological requirements of the state. The amendment carried a proviso that the director of the United States Geological Survey should agree to expend on the part of the United States upon such surveys a sum equal to that expended by the state.

At the session of the legislature for 1909 the work of the state geological survey was provided for by a law having these provisions:

Section 1. In order to complete the topographic map of the State of Washington, and for the purpose of making more extensive stream measurements, and otherwise investigating and determining the water supply of the state, there is hereby appropriated the sum of thirty thousand dollars (\$30,000), for cooperation with those branches of the United States Geological Survey engaged in this work. This appropriation, however, shall be contingent upon, and not become available unless the United States government apportion an equal amount to be expended for similar purposes within the state. The board of geological survey is hereby authorized and directed to enter into such agreements with the director of the United States Geological Survey as will insure that the said surveys and investigations be carried on in the most economical manner, and that the maps and data be available for the use of the public as quickly as possible.

Sec. 2. In order to enable the board of geological survey to carry on investigations authorized by law, there is hereby appropriated the sum of twenty thousand dollars (\$20,000) for the use of said board in the geological and other investigations provided for in chapter 165 of the Session Laws of the State of Washington for 1901, and as amended in chapter 157 of the Session Laws of 1903.

Sec. 3. In order to carry out the purposes of this act, all persons employed hereunder are authorized to enter and cross all lands within the state: Provided, That in so doing no damage is done to private property.

Sec. 4. The sum of fifty thousand dollars (\$50,000) herein appropriated for the purposes specified in this act shall be available in the following manner: One-half during the first twelve months after this act takes effect, and the unexpended balance during the second twelve months after this act takes effect.

REPORT FOR 1919-21

ORGANIZATION.

The State Board of Geological Survey consists of the following members: Governor Louis F. Hart, President; State Treasurer W. W. Sherman, Secretary; President Henry Suzzallo, of the State University; and President Ernest O. Holland, of the State College. The State Geologist is Dean Henry Landes, who has his office at University Station, Seattle. In the cooperative work with the United States Geological Survey the Director of that organization is represented by T. G. Gerdine, Geographer in Charge, Northwestern Division, and Glen L. Parker, District Engineer, 406 Federal Building, Tacoma.

TOPOGRAPHIC SURVEYS.

From 1909 until the beginning of the present biennium approximately 30 quadrangles were surveyed, under a cooperative agreement with the United States Geological Survey. The cost of making the topographical surveys is shared equally by the State Geological Survey and the United States Geological

Survey, although the cost of printing and engraving is entirely assumed by the latter organization. In selecting quadrangles for survey it has been the general policy to choose those areas where the demand for the maps is very great and where they are most likely to be used in the development of the state.

During the field seasons of 1919 and 1920 the areas surveyed were the Sultan and Trinidad quadrangles. The former was chosen because all the surrounding quadrangles had already been mapped and it was a section of the Cascades with large water power possibilities. The Trinidad quadrangle is in the arid section of Washington, and includes the area north and east of Ellensburg, where large irrigation enterprises are contemplated.

Copies of all engraved topographic maps may be purchased of the United States Geological Survey, Washington, D. C., at ten cents each, or at six cents each in lots of one hundred or more.

HYDROMETRIC SURVEYS.

The water resources of the state have been investigated jointly by the federal and state surveys, each party contributing equal sums. The work is directed from a district office of the Federal Survey, located in the Federal Building at Tacoma. In addition the Federal Survey maintains gaging stations on Indian reserves, the cost of which is borne by the United States Office of Indian Affairs. It also cooperates with the United States Reclamation Service, and the United States Forest Service in collecting and publishing stream flow data. The funds for carrying on stream gaging work are not sufficient to meet the demand for such work, so that power companies, irrigation districts, cities, and individuals have contributed services of employees, instruments, material, equipment and other help. The cost of hydrometric work carried on in the state during the present biennium is shown in the following table, the value of all services and other assistance rendered by cooperating parties being estimated when not known definitely:

ESTIMATED COST OF WATER-RESOURCES INVESTIGATIONS IN THE STATE FOR THE BIENNIUM ENDING MARCH 31, 1921.

STATE:		
Board of Geological Survey.....	\$14,000	
Reclamation Board	500	\$14,500
FEDERAL:		
Geological Survey; gaging streams, power reports, and publishing water-supply papers.....	\$17,020	
Reclamation Service	8,140	
Indian Service	4,800	
Forest Service	630	
District office rent furnished in Federal Building, at Tacoma	2,400	32,990
Municipalities, power companies, irrigation districts and individuals		16,340
Total.....		\$63,830

Cooperation with the British Columbia Hydrometric Survey was continued. Gaging stations are maintained jointly on Pend Oreille River or Clark Fork at Metaline Falls and on Columbia River at Trail, B. C. Joint activity is proposed in establishing and maintaining gaging stations on all important streams crossing the international boundary between Washington and British Columbia.

The chief object of hydrometric surveys is to obtain accurate information regarding the amount of water that can be depended upon for irrigation and for power purposes. All of the water that can be secured by storage that is tributary to arid Washington will soon be needed for irrigation. The rapid industrial development of western Washington demands increasing use of the available water power. The detailed investigations have been along two lines, viz.: establishment and maintenance of gaging stations, and a series of reports summarizing power possibilities of the Cascade Range.

Gaging Stations.

Gaging stations have been maintained upon the principal streams of the state. Measurements of flow are made frequently and daily records indicating height of water on substantially set gages are kept by local observers or by means of several types of water stage recorders driven by clock mechanism, which give continuous record of water elevations. Measurements of flow and gage height records form the basis of computing average amount of water each day of the year. The discharge of any stream varies considerably from day to day, season to season, and year to year, so that records for a series of years are necessary for properly designing hydraulic works. The records are particularly important during low water periods which occur on some streams in the early fall and on others in mid-winter.

During the biennium stream-gaging results were obtained at 104 gaging stations, of which 55 were equipped with automatic recording instruments. A list of gaging stations, grouped alphabetically by counties, follows:

GAGING STATIONS IN OPERATION DURING BIENNIUM.

Benton County:

- *Columbia River near Priest Rapids, 1913-21.
- Yakima River near Prosser, 1904-06 and 1913-21.

Chelan County:

- Chelan Lake at Chelan, 1905; 1910-21.
- Chelan River at Chelan, 1903-21.
- Entiat River at Entiat, 1910-21.
- Wenatchee River near Leavenworth, 1910-21.

Clallam County:

- Crescent Lake at Piedmont, 1919-21.
- Elwha River at McDonald bridge, near Port Angeles, 1897-1901; 1918-21.
- Lyre River at Piedmont, 1917-21.
- Soleduck River near Fairholm, 1917-21.

Clarke County:

- Lewis River near Amboy, 1911-21.

Columbia County:

- *Snake River at Riparia, 1915-21.

* Stream forms boundary between two counties; gaging station listed in both counties.

Cowlitz County:

- Kalama River near Kalama, 1911-13; 1916-21.
- Toutle River near Silver Lake, 1919-21.

Ferry County:

- Curlew Creek near Curlew, 1917-21.
- Hall Creek at Inchelium, 1912-21.
- Stranger Creek at Meteor, 1916-21.

Grant County:

- *Columbia River near Priest Rapids, 1913-21.

Grays Harbor County:

- Quinault River at Quinault Lake, 1911-21.

King County:

- Cedar River at Cedar Falls, 1914-21.
- Cedar River near Landsberg, 1914-21.
- Miller Creek near Miller River, 1911-19.
- Snoqualmie River near Snoqualmie, 1898-99; 1900; 1902-21.
- Snoqualmie River, Middle Fork, near North Bend, 1907-21.
- Snoqualmie River, North Fork, near North Bend, 1907-21.
- Snoqualmie River, South Fork, at North Bend, 1907-21.
- *White River at Buckley, 1899-1903, 1910-11; 1913-21.

Kittitas County:

- Cle Elum Lake near Roslyn, 1906-21.
- Cle Elum River near Roslyn, 1903-21.
- Kachess Lake near Easton, 1905-21.
- Kachess River near Easton, 1903-21.
- Keechelus Lake near Martin, 1906-21.
- Yakima River near Martin, 1903-21.
- Yakima River at Cle Elum, 1906-21.
- Yakima River at Umtanum, 1906-21.

Klickitat County:

- Columbia River at The Dalles, 1878-1921.
- White Salmon River at Husum, 1909-21.
- White Salmon River near Underwood, 1915-21.

Lewis County:

- Cowlitz River at Lewis, 1911-19.
- East Creek near Elbe, 1918-21.
- Johnson Creek near Lewis, 1907-14, 1918-21.
- Lake Creek at outlet of Packwood Lake, near Lewis, 1911-21.

Lincoln County:

- *Spokane River below Little Falls, near Long Lake, 1912-21.

Mason County:

- North Fork of Skokomish River near Hoodspout, 1910-11, 1913-21.

* Stream forms boundary between two counties; gaging station listed in both counties.

Okanogan County:

- Bonaparte Creek near Anglin, 1920-21.
- Chewack Creek below Boulder Creek, near Winthrop, 1920-21.
- Lost Creek near Aeneas, 1920-21.
- Methow River at Twisp, 1919-21.
- Methow River at Pateros, 1903-20.
- Nespelem River at Nespelem, 1911-21.
- Okanogan River at Okanogan, 1911-21.
- Salmon Creek near Conconully, 1910-21.
- Similkameen River near Oroville, 1911-21.
- Sinlahekin Creek at Blue Lake, near Loomis, 1920-21.
- Toats Coulee Creek near Loomis, 1920-21.

Pend Oreille County:

- Clark Fork at Metaline Falls, 1908-10; 1912-21.
- Sullivan Lake near Metaline Falls, 1912-21.
- Sullivan Creek near Metaline Falls, 1912-21.

Pierce County:

- *Nisqually River near La Grande, 1906-11; 1920-21.
- Puyallup River near Electron, 1909-21.
- Puyallup River at Alderton, 1914-21.
- Puyallup River at Puyallup, 1914-21.
- Tacoma Power Conduit near La Grande, 1919-21.
- *White River at Buckley, 1899-1903; 1910-11; 1913-21.
- White River flume at Buckley, 1913-21.

Skagit County:

- Skagit River near Sedro Woolley, 1908-19.

Snohomish County:

- Deer Creek at Oso, 1917-21.
- Sauk River above Whitechuck River, near Darrington, 1910; 1917-21.
- Sauk River at Darrington, 1914-21.
- Sauk River, North Fork, near Barlow Pass, 1917-21.
- Sauk River, South Fork, near Barlow Pass, 1917-21.
- Skykomish River, North Fork, at Index, 1910-21.
- Skykomish River, South Fork, near Index, 1902-05; 1911-12; 1913-21.
- Suiattle River near Darrington, 1920-21.
- Sultan River near Sultan, 1911-21.
- Whitechuck River near Darrington, 1910; 1919-21.

Spokane County:

- Spokane River at Spokane, 1891-1921.
- Little Spokane River near Spokane, 1903-05; 1911-13; 1919-21.

Stevens County:

- Columbia River near Trail, B. C., 1913-21.
- *Spokane River below Little Falls, near Long Lake, 1912-21.

* Stream forms boundary between two counties; gaging station listed in both counties.

Thurston County:

*Nisqually River near La Grande, 1906-11; 1920-21.

Whatcom County:

Baker River below Anderson Creek, near Concrete, 1910-21.
 Nooksack River, Middle Fork, near Deming, 1910-11; 1920-21.
 Nooksack River, North Fork, at Excelsior, 1920-21.
 Nooksack River, South Fork, at Saxon Bridge, 1920-21.
 Ruby Creek at Ruby, 1919-20.
 Skagit River at Reflector Bar near Marblemount, 1913-21.
 Skagit River below Ruby Creek at Ruby, 1919-21.
 Thunder Creek near Reflector Bar near Marblemount, 1919-21.

Whitman County:

*Snake River at Riparia, 1915-21.
 Palouse River near Potlatch, Idaho, 1914-19.

Yakima County:

Ahtanum Creek, North Fork, near Tampico, 1907-21.
 Ahtanum Creek, South Fork, near Tampico, 1908-21.
 Bumping Lake near Nile, 1909; 1910-21.
 Bumping River near Nile, 1906; 1909-21.
 Klickitat River near Glenwood, 1909-21.
 Naches River below Tieton River, 1905; 1909-12.
 New Reservation canal at Parker, 1904-21.
 Old Reservation canal at Parker, 1904-21.
 Reservation drain at Alfalfa, 1912-21.
 Satus Creek below Dry Creek, near Toppenish, 1913-21.
 Simcoe Creek near Fort Simcoe, 1909-21.
 Sunnyside canal near Parker, 1904-21.
 Tieton River at Rimrock, 1908-14, fragmentary; 1918-21.
 Tieton canal near Naches, 1910-21.
 Toppenish Creek near Fort Simcoe, 1909-21.
 Yakima River at Union Gap, 1893-96, fragmentary; 1896-1921.
 Yakima River near Parker, 1908-21.

A description of each gaging station, results of measurements, computed daily discharge, and a summary of monthly discharge are published annually by the United States Geological Survey in water-supply papers. A sample of data published is given below for the year ending September 30, 1920.

* Stream forms boundary between two counties; gaging station listed in both counties.

COLUMBIA RIVER NEAR PRIEST RAPIDS, WASH.

Location.—In Sec. 11, T. 13 N., R. 24 E., at the Richmond Ferry, half a mile north of Vernita, 6 miles below Priest Rapids, in Benton County.

Drainage Area.—95,500 square miles. Areas in United States measured on topographic maps and United States Geological Survey maps, scale 1-500,000. Areas in British Columbia measured on Department of the Interior Railway Belt maps scale 1-500,000; Department of Mines, West Kootenay sheet, scale 1-253,440; and Department of Lands map, scale 1-1,125,000.

Records Available.—Flood heights only, at Wenatchee, 1894 to 1903; continuous gage-height record at Wenatchee, April 18, 1904, to December 31, 1916; at Beverly, January 1-13, 1917; near Priest Rapids, January 14, 1917, to September 30, 1920; daily discharge ascertained from May 1, 1913, to September 30, 1920. Gage-height record at Wenatchee published by United States Weather Bureau.

Gage.—Since March 25, 1918, vertical staff gage in eight sections, on right bank at ferry; read by J. P. Richmond. Prior to Jan. 1, 1916, staff gage, one inclined and six vertical sections reading from 0 to 64 feet, on right bank about a mile above highway bridge at Wenatchee; zero of gage 583.00 feet above sea level. January 1 to December 31, 1916, vertical staff reading from -2 to 61 feet on pier of highway bridge at Wenatchee; zero of gage 579.30 feet above sea level. January 1-13, 1917, vertical staff on pier of Chicago, Milwaukee and St. Paul Railway bridge at Beverly, supplemented by temporary low-water vertical section on left bank at same location. January 14 to July 11, 1917, vertical staff gage in four sections on left bank at ferry, at Vernita. July 12 to October 25, 1917, temporary vertical staff in six sections at present site on right bank. October 25, 1917, to March 24, 1918, five sections of present gage. All gage readings at Vernita refer to same datum. 388.7 feet above sea level. Gages at Wenatchee read by Weather Bureau observers.

Discharge Measurements.—Made from standard gaging car on ferry cable at Vernita or, when ice conditions are severe, from railroad bridge at Beverly.

Channel and Control.—Bed composed of gravel and boulders. High-water control Coyote Rapids 6 or 7 miles below gage; low-water control riffle noticeable at low stages about three-fourths mile below gage; apparently permanent.

Extremes of Discharge.—Maximum stage recorded during year 26.0 feet on July 15, 16, 17, and 18 (discharge, 359,000 second-feet). Minimum discharge, 23,900 second-feet (current-meter measurement) December 14, when stage-discharge relation was affected by ice.

1913-1920: Maximum stage recorded, 45.7 feet at Wenatchee, June 15 and 16, 1913 (discharge, 528,000 second-feet). Minimum discharge, 23,900 second-feet (current-meter measurement) January 31, 1917, and December 14, 1919, when stage-discharge relation was affected by ice.

Maximum stage recorded at Wenatchee by United States Weather Bureau and Great Northern Railway Co., 58.0 feet June 7, 1894 (discharge estimated, by extending rating curve, at 710,000 second-feet).

Ice.—Stage-discharge relation affected by ice except during mild winters. Flow estimated from gage-height record, discharge measurements, observer's notes, and weather records.

Diversions.—Some water diverted for irrigation.

Regulation.—None.

Accuracy.—Stage-discharge relation permanent; affected by ice December 9, 1919, to March 11, 1920. Rating curve well defined. Gage read twice daily to hundredths. Daily discharge ascertained by applying mean daily gage-heights to rating table. Records excellent except for period when stage-discharge relation was affected by ice.

Cooperation.—Maintained in cooperation with Washington Irrigation & Development Co.

Discharge Measurements of Columbia River Near Priest Rapids, Wash., During the Year Ending Sept. 30, 1920.

[Made by John McCombs]

<i>Date</i>	<i>Gage Height</i>	<i>Dis-charge</i>	<i>Date</i>	<i>Gage Height</i>	<i>Dis-charge</i>	<i>Date</i>	<i>Gage Height</i>	<i>Dis-charge</i>
	ft.	Sec.-ft.		ft.	Sec.-ft.		ft.	Sec.-ft.
Nov. 5.....	1.87	36,000	Jan. 12.....	*2.54	26,900	June 11.....	19.18	225,000
Dec. 14.....	*6.70	23,900	Feb. 2.....	*1.42	32,500	Sept. 2.....	11.88	124,000

* Stage-discharge relation affected by ice.

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Daily Discharge, in Second-Feet, of Columbia River Near Priest Rapids, Wash., for the Year Ending Sept. 30, 1920.

DAY	October	November	December	January	February	March	April	May	June	July	August	Sept.
1	68,800	37,500	35,100		31,000		37,500	64,600	199,000	315,000	274,000	126,000
2	67,200	37,500	34,500		32,500		33,100	68,800	197,000	317,000	265,000	123,000
3	64,600	37,500	33,900				37,500	70,600	196,000	321,000	259,000	119,000
4	62,900	36,900	34,500				36,900	72,200	194,000	328,000	254,000	115,000
5	62,100	36,900	33,900				36,300	74,800	196,000	332,000	248,000	110,000
6	61,300	36,900	32,700	26,000		28,000	33,900	78,400	197,000	341,000	241,000	106,000
7	58,900	36,900	30,000		32,000		36,300	80,200	200,000	345,000	232,000	103,000
8	56,500	36,300	28,300				36,900	83,800	202,000	348,000	226,000	101,000
9	55,000	36,300					36,000	80,200	205,000	348,000	218,000	98,700
10	53,400	35,700					36,300	94,000	214,000	348,000	211,000	96,800
11	52,000	35,100	25,000				35,700	104,000	222,000	345,000	205,000	94,900
12	50,500	34,500		26,900		27,200	35,100	113,000	226,000	348,000	202,000	94,000
13	49,800	34,500				27,200	37,500	120,000	231,000	354,000	199,000	93,000
14	49,800	34,500	23,900			27,800	37,500	131,000	234,000	352,000	194,000	92,000
15	48,400	33,900				28,800	40,000	140,000	238,000	359,000	191,000	94,900
16	47,800	33,900		29,000		28,300	45,200	150,000	246,000	359,000	187,000	94,900
17	47,100	37,500	26,000		31,000	35,100	45,200	160,000	259,000	359,000	182,000	94,900
18	45,800	37,500				41,200	47,100	171,000	267,000	359,000	179,000	93,000
19	45,200	36,900				39,900	48,400	182,000	274,000	357,000	178,000	92,000
20	43,800	36,900				38,100	49,100	194,000	284,000	354,000	175,000	91,100
21	43,200	37,500				33,900	49,800	199,000	290,000	352,000	172,000	91,100
22	42,600	36,900				33,900	51,200	203,000	296,000	352,000	168,000	92,000
23	42,600	36,300				33,900	52,000	208,000	302,000	350,000	162,000	93,000
24	42,600	36,300			39,000	36,900	52,700	210,000	315,000	345,000	156,000	94,900
25	41,900	36,900				36,300	54,200	211,000	323,000	339,000	152,000	96,800
26	41,200	37,500		28,000		37,500	55,000	211,000	319,000	332,000	147,000	96,800
27	41,200	37,500	28,000			38,100	56,700	211,000	317,000	333,000	143,000	97,800
28	39,300	36,900				37,500	56,500	209,000	317,000	315,000	138,000	96,800
29	38,700	37,500				37,500	57,300	208,000	317,000	304,000	134,000	96,800
30	38,100	36,100				36,900	60,500	205,000	315,000	294,000	132,000	96,800
31	37,500					37,500		205,000		292,000	128,000	

NOTE—Braced figures are means for periods included. Discharge for Dec. 14, Jan. 12 and Feb. 2 are results of current-meter measurements.

*Monthly Discharge of Columbia River near Priest Rapids, Wash., for the Year
Ending Sept. 30, 1920.*

[Drainage area 95,500 square miles.]

MONTH	DISCHARGE IN SECOND-FEET				RUN-OFF	
	Maximum	Minimum	Mean	Per Square Mile	Inches	Acre-Feet
October.....	68,800	37,500	49,700	0.520	0.60	3,060,000
November.....	37,500	33,900	36,400	.381	.43	2,170,000
December.....	35,100	23,900	28,100	.294	.34	1,730,000
January.....	.....	.....	27,500	.288	.33	1,690,000
February.....	.....	.....	31,100	.326	.35	1,790,000
March.....	41,200	27,200	32,100	.336	.39	1,970,000
April.....	60,500	33,900	44,400	.465	.52	2,640,000
May.....	211,000	64,600	146,000	1.53	1.76	8,980,000
June.....	323,000	194,000	253,000	2.65	2.96	15,100,000
July.....	359,000	282,000	338,000	3.54	4.08	20,800,000
August.....	274,000	128,000	192,000	2.01	2.32	11,800,000
September.....	126,000	91,100	99,500	1.04	1.16	5,920,000
The Year.....	359,000	23,900	107,000	1.12	15.24	77,600,000

Yearly Discharge of Columbia River Near Priest Rapids, Wash.

[Drainage area 95,500 square miles.]

YEAR ENDING SEPTEMBER 30	DISCHARGE IN SECOND-FEET					ANNUAL RUN-OFF		
	Maximum Day	Minimum			Annual Mean	Annual Mean Per Square Mile	Inches	Acre-Feet
		Day	Calendar Month					
			Mean	Month				
1914.....	343,000	.....	39,600	Feb.	127,000	1.44	19.53	91,600,000
1915.....	232,000	.....	32,600	Feb.	106,000	1.20	16.30	76,900,000
1916.....	520,000	.....	32,400	Jan.	153,000	1.73	23.64	112,000,000
1917.....	430,000	24,600	28,900	Mar.	127,000	1.34	18.20	91,900,000
1918.....	430,000	41,300	45,700	Nov.	133,000	1.39	18.90	96,200,000
1919.....	368,000	.....	40,700	Jan.	123,000	1.29	17.45	88,800,000
1920.....	359,000	23,900	27,500	Jan.	107,000	1.12	15.24	77,600,000
Period 1914-1920.....	520,000	23,900	27,500	Jan., 1920	125,000	1.36	18.47	90,700,000

NOTE—Yearly summaries are not published in the water-supply papers. The information is included here to condense the records of previous years.

Records prior to Jan. 1, 1917, were based on gage readings at Wenatchee, where the drainage area is 88,500 square miles, or 7.3 per cent less than the drainage area at Priest Rapids. The inflow between the two points is perhaps less than 2 percent of the flow at Priest Rapids, hence the flow may be considered nearly the same but the results under headings "Annual Mean Per Square Mile" and "Inches," as given in the preceding table, are not strictly comparable.

Cascade Power Reports.

Through cooperative arrangements with the State Board of Geological Survey in 1909, the Federal Survey adopted its first comprehensive plan for giving the public accurate data concerning water power resources. More recently similar work has been instituted in Oregon. Progress has been hampered considerably due to lack of sufficient base data and need of continuing stream flow observations over a series of years in order to insure dependable estimates of water supply. Surveys have been run along portions of the larger streams in the Cascade Range. Reservoir sites which appear to offer favorable storage opportunities for increasing low water flow have been surveyed and a large mass of information bearing upon feasibility of hydro-electric projects has been collected.

The scheme followed in analyzing power resources of the Cascades consists of assembling estimates for a group of streams within a relatively small section of the range. It is proposed to publish the estimates in a series of seven reports as water supply papers of the United States Geological Survey.

The first report is Water Supply Paper 253 and is entitled "Water Powers of the Cascade Range, Part I, Southern Washington." The power possibilities of Klickitat, White Salmon, Little White Salmon, Lewis and Tontle rivers are summarized.

The second report is Water Supply Paper 313 and is entitled "Water Powers of the Cascade Range, Part II." The power possibilities of Cowlitz, Nisqually, Puyallup, White, Cedar and Green rivers are summarized. This report also includes a discussion of hydro-electric market conditions in Puget Sound region.

The third report is Water Supply Paper 369 and is entitled "Water Powers of the Cascade Range, Part III, Yakima Basin." The summaries were more difficult to compile than for any of the series on account of the necessity of taking into consideration ultimate use of stored water for irrigation in Yakima Valley.

The fourth report is Water Supply Paper 486 and is entitled "Water Power of the Cascade Range, Part IV, Wenatchee and Entiat Basins." The water power resources in Wenatchee basin with and without the proposed Quincy Valley irrigation scheme in operation are discussed and water supply available for the Quincy project, through utilizing storage in Wenatchee Lake reservoir, is shown.

The fifth report, not finished, will be published as Water Supply Paper 487, and will be entitled "Water Power of the Cascade Range, Part V, Chelan, Methow and Similkameen Basins."

All of the field data have been collected for the fifth unit and considerable work has been done toward compiling the data.

Practically all of the surveys have been completed for the sixth and seventh units, and most of the field reconnaissance for the sixth unit has been finished. Gaging stations are being maintained in each to determine the available water supply.

GEOLOGICAL SURVEYS.

MINERAL SURVEY OF STEVENS COUNTY. During the field season of 1917 a complete mineral survey of Stevens County was made by Dr. Charles E. Weaver and two assistants. A geological map of the county was made and the mineral deposits carefully investigated and described. Besides the promising ore bodies which are now producing copper, lead, silver and gold, particular attention was given to the deposits of magnesite which are among the largest and most important to be found within the United States. The area underlain by magnesite was mapped and an investigation made of the quantity and value.

This report on Stevens County was prepared during the previous biennium but was not printed until the summer of 1919. It is known as Bulletin 20, and it is proposed to follow this report with other bulletins, using the county as a unit for similar investigations and reports.

MINERAL RESOURCES OF WASHINGTON, WITH STATISTICS FOR 1919.—The members of the Survey cooperated in compiling this report, (Bulletin 21) which will serve as a complete and accurate directory of the known mineral resources of the state. The bulletin is divided into four parts, viz: Fuels, Metals, Non-metals, and Structural Materials. The numerous economic minerals falling under these various headings are discussed separately on the basis of present production, occurrence, extent of the local products, economic factors governing their development, and finally, whenever possible, suggestions are made for the more extensive utilization of the state's mineral wealth. The value of the data is increased by including tables and graphs to show the various production figures for the period, 1910 to 1919, inclusive. The subject matter is complete up to the close of 1920. The bulletin is accompanied by an outline map of the state wherein, by a system of symbols and colors, all varieties of mineral products are shown in the localities where they are obtained.

THE METAL MINES OF WASHINGTON. For the past several years there has been felt a marked need for an authentic report that would bring up to date the information on the metal mines of Washington and consolidate that information under one cover. This investigation was undertaken by Ernest N. Patty, who spent four months during the summer of 1919 and one and one-half months during 1920 in examining about one hundred active mining properties in various degrees of development. The field work was begun in Pend Oreille County and then carried westward to include the mining district of Stevens, Ferry, Okanogan, Chelan, and Kittitas counties, east of the Cascades, and King, Snohomish, Pierce, Whatcom, and Mason counties in western Washington.

One of the greatest tangible benefits to the prospector and small mine operator, from work such as this, comes from the personal contact with these men in the field where their problems can be talked over informally and, as far as possible, solutions suggested. In this way, before the report appears in print, suggestions were made which have resulted in the opening up of new ore bodies, and in certain other instances, further development discouraged where properties were found to be lacking in merit.

The ore bodies and associated formations have been carefully studied. Type samples of these were brought into the laboratory for close study and finally a report written (Bulletin 23) describing the controlling geologic

features of each district and individual property visited. The subject matter is treated from a practical standpoint and is intended to be intelligible to the average mining man. The field work also permitted a systematic classification of the ore deposits of the state by means of which it is possible to correlate the mines of any certain district with those of similar areas in the Northwest.

CLAYS AND SHALES OF WASHINGTON. This report, by Sheldon L. Glover, was begun in the summer of 1919, to determine the type, location, and extent of clays and shales in the state and their availability for ceramic purposes. Samples were taken during the field season from each deposit visited, and the winter months were spent in studying and classifying the various clays. Physical tests were made of the samples by the Ceramic Department of the University of Washington, under the supervision of Hewitt Wilson, Professor of Ceramics, the procedure outlined by the American Ceramic Society being closely followed. The work was continued in 1920 along the same lines and is now reaching completion. When printed this bulletin will be Number 24.

Washington is abundantly supplied with a great variety of clays; in fact they constitute one of our most important resources. The lack of accurate data concerning these clays, and the prevailing scant knowledge as to the suitability of different clays for particular purposes, has led to erratic development and much loss of money in the past. It is the intention of this report to supply pertinent information in as concise and applicable a form as possible for both operator and general public.

THE MAGNESITE DEPOSITS OF WASHINGTON. This is a report by G. E. Whitwell and Ernest N. Patty covering the extensive bodies of magnesite in Stevens County. These were first developed on a large scale in 1916 and now rank as the largest deposits of magnesite on the Continent. At the present time they supply approximately 85 per cent of the magnesite going into the manufacture of refractories in the United States.

To assist the local producers, Mr. Whitwell, Instructor in Industrial Chemistry at the University of Washington, was engaged to undertake an investigation of the chemical and physical properties of the various magnesite products in an effort to evolve more extended commercial uses for the material. Mr. Patty, of the Survey, examined the various deposits and prepared a report on the geology, methods of mining and transportation, cost data, general features, etc., governing the local deposits. These reports have now been completed, and will be published as Bulletin 25.

MINERAL PRODUCTION OF WASHINGTON FROM 1909 TO 1918, INCLUSIVE (a).

PRODUCTS	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
NON-METALLIC—										
Coal.....	\$0,158,909	\$0,764,465	\$8,174,170	\$8,049,871	\$9,243,137	\$6,751,511	\$5,276,200	\$6,907,498	\$11,356,357	\$14,564,445
Clay products.....	3,060,486	3,023,884	2,801,758	2,888,870	2,370,225	1,800,401	1,460,051	1,589,574	1,532,043	1,324,400
Portland cement.....	767,166	1,031,704	1,406,807	2,012,785	2,583,200	1,870,078	1,760,469	2,243,027	2,367,045	2,114,730
Granite.....	742,878	642,932	1,345,551	809,201	140,279	72,079	260,688	90,525	52,053	65,233
Basalt.....	.....	.....	.....	.....	† 632,915	1,068,042	1,452,869	764,881	328,331	154,205
Sandstone.....	335,470	438,581	301,843	344,476	560,468	450,436	33,710	27,791	.....	45,368
Limestone.....	38,269	36,186	32,475	20,370	62,913	10,585	11,550	30,338	59,229	99,992
Marble.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Lime.....	232,628	297,735	228,933	234,832	219,163	178,945	180,200	166,653	156,553	229,104
Magnesite.....	.....	.....	.....	.....	.....	.....	.....	5,302	783,188	1,050,790
Mineral waters.....	15,953	12,571	14,654	17,542	18,834	28,777	11,703	9,476	7,265	.....
Sand and gravel.....	423,425	451,569	319,760	345,289	385,896	324,628	211,480	387,337	199,565	332,141
Diatomaceous earth.....	.....	.....	.....	.....	.....	.....	.....	10,700	18,910	.....
Miscellaneous.....	.....	.....	.....	.....	.....	.....	.....	.....	67,091	129,335
Totals.....	\$14,825,308	\$15,609,657	\$14,775,954	\$14,216,236	\$16,507,081	\$12,564,572	\$10,712,624	\$12,225,192	\$16,927,630	\$20,106,803
METALLIC—										
Gold.....	\$392,051	\$788,145	\$847,677	\$690,964	\$935,275	\$537,173	\$391,419	\$577,655	\$492,324	\$304,568
Silver.....	41,334	110,886	129,204	254,326	200,068	146,468	129,709	220,510	232,632	310,093
Copper.....	33,167	11,038	39,776	179,192	147,833	103,571	178,692	650,675	600,464	474,534
Lead.....	12,414	58,180	38,186	5,732	8,909	2,555	13,875	372,550	841,913	374,299
Zinc.....	.....	.....	.....	.....	.....	.....	30,368	226,960	121,948	3,537
Totals.....	\$448,966	\$968,249	\$1,056,017	\$1,120,214	\$1,053,135	\$809,767	\$744,033	\$2,048,350	\$2,289,251	\$1,467,356
GRAND TOTALS.....	\$15,274,274	\$16,667,906	\$15,631,971	\$15,336,450	\$17,560,216	\$13,374,339	\$11,456,657	\$14,273,542	\$19,216,911	\$21,574,159

* Compiled from Mineral Resources U. S. Geological Survey.

† Herebefore included in granite totals.

‡ Included under miscellaneous to conceal figures of individual producers.

FINANCIAL STATEMENT.

TOPOGRAPHIC AND HYDROMETRIC SURVEYS.

U. S. Geological Survey:	
Allotment for cooperation 1919-21.....	\$35,000 00
Expenditures to November 30, 1920.....	30,086 29
	\$4,913 71
State Geological Survey:	
Appropriation for cooperation 1919-21.....	\$35,000 00
Expenditures to November 30, 1920.....	30,261 00
	\$4,739 00

GEOLOGICAL SURVEYS.

Investigations and Surveys:	
Appropriation for 1919-21.....	\$5,700 00
Expenditures to November 30, 1920.....	4,810 18
	\$889 82
Supplies, Materials and Service:	
Appropriation for 1919-21.....	\$7,400 00
Expenditures to November 30, 1920.....	4,644 73
	\$2,755 27
Salaries and Wages:	
Appropriation for 1919-21.....	\$6,900 00
Expenditures to November 30, 1920.....	5,875 21
	\$1,024 79

RECOMMENDATIONS.

APPROPRIATIONS REQUESTED.

For topographic and hydrometric surveys (conditioned upon a similar sum being expended in the state by the United States Geological Survey)	\$35,000
For Geological Surveys.....	20,000

TYPOGRAPHIC SURVEYS.

For some time the greatest demand for topographic surveys has come from the arid and semi-arid regions of the state where the land may be put to its greatest use only by irrigation, and where topographic maps are invaluable for engineering work of this character. Such maps are also requested in those portions of Washington where the country is being rapidly settled, and in certain mountainous areas where large water-power projects are under consideration. Urgent requests are now on file for topographic surveys of Asotin, Eatonville, Fort Simcoe, Othello, Olympia, Pomeroy, Sultan and Yakima quadrangles. In preparation for large irrigation projects now contemplated in central Washington topographic maps should at once be made of Adams, Franklin, Grant and Lincoln counties.

In the past 10 years level lines or profiles have been run along all the streams of the Cascade Mountains, except the three forks of the Nooksak River. This has been done as a necessary part of the problem of determining with accuracy the total hydro-electric power of the rivers of the Cascades. In the

next biennium the Nooksak River should be surveyed, and river profiles begun on the streams of the Olympic Mountains. When the latter are completed it will then be possible to publish detailed reports on the water power resources of the entire state.

HYDROMETRIC SURVEYS.

As indicated in the preceding pages, gaging stations are maintained on a large number of the rivers where information is very necessary as to the total amount of water available for municipal supplies, irrigation and power. The number of stations should be increased rather than diminished. Each added year of gaging at any station makes the records that much more valuable. The demand for accurate information regarding our water resources grows stronger with each biennium. It is recommended that the usual appropriation for this work be made so that cooperation with the Federal Government may be continued.

GEOLOGICAL SURVEYS.

The sum of twenty thousand dollars, the same amount as appropriated by the legislature of 1909, 1911, 1913 and 1917, is requested for geological surveys, in order that certain lines of work now under way may be completed and some important new work undertaken.

Soil Surveys.—In past years soil surveys have been made of nearly all the logged-off lands of western Washington, besides similar surveys and reports upon the Quincy Valley country, Stevens, Spokane and Franklin counties, in eastern Washington. In all soil surveys cooperation has been afforded by the United States Bureau of Soils, the Federal Bureau usually assuming about three-fifths of the expense of the field work besides all the cost of printing. The reports of the soil surveys have been in large demand from the agriculturists, commercial bodies, prospective settlers, county assessors, and all others who desire to know the facts about the soil conditions in various parts of the state. At the present time requests are on file for soil surveys in various sections of Washington where this work has not been done.

Report on Mineral Industries.—Any information bearing upon the production of different minerals in different counties and other portions of the state is always in much demand. It seems necessary to keep this information in such form that it may be given out regularly and be revised as often as desirable. At least once a year reports and maps should be issued which set forth the localities where different mineral products may be obtained, along with the names of all producers, and with accurate statistics in regard to the output of each particular mineral concerned. Such information is very greatly desired by manufacturers and others who have occasion to use in any way whatsoever those minerals that are of economic importance.

Topographical Map.—There is constant inquiry for a map which will show by a system of contours, or by a series of lines, the elevations of various portions of the state. By utilizing the base map which has already been prepared and by compiling the data regarding elevations throughout the state, it will be possible to prepare a map which will give the information most needed. Such a map should be printed in colors, the black referring to culture, the blue giving the water bodies, and a series of brown shades or tints which will give the variation in elevation from sea level to the tops of the highest mountains.

Geological Map.—More requests have come for a geological map of the state than for any other one thing. With the base map now available it is desirable that the boundaries of the different geological formations should be entered thereon and a complete geological map of the state be prepared as early as possible. This has been very generally done by other states and Washington will be one of the last to prepare such a map. The cost of preparation of such a map is not excessive, and its value to our citizens generally would repay the cost many fold.

Office Work.—The office work of the Geological Survey becomes increasingly heavy from year to year. Constant inquiries come to the office in regard to the mineral resources of every portion of the state. Prospective settlers and others are very desirous of accurate information regarding the climatic and soil conditions of those regions in which they may plan to make their homes. Manufacturers are desirous before coming to Washington of knowing the nature of the fuel supply and the variety of crude materials of a mineral character which may be obtained for manufacturing purposes. On the whole the work of the State Geological Survey is carried on at a minimum of expense because a very large part of the work, especially the office work, is done by men who do not receive any compensation for that purpose out of the funds of the Survey.

PUBLICATIONS
OF THE
WASHINGTON STATE GEOLOGICAL SURVEY

ADDRESS
STATE LIBRARIAN
OLYMPIA, WASHINGTON

Volume 1.—Annual Report for 1901. Part 1, Creation of the State Geological Survey, and An Outline of the Geology of Washington, by Henry Landes; part 2, The Metalliferous Resources of Washington, Except Iron, by Henry Landes, William S. Thyng, D. A. Lyon and Milnor Roberts; part 3, The Non-Metalliferous Resources of Washington, Except Coal, by Henry Landes; part 4, The Iron Ores of Washington, by S. Shedd, and the Coal Deposits of Washington, by Henry Landes; part 5, The Water Resources of Washington, by H. G. Byers, C. A. Ruddy and R. E. Heine; part 6, Bibliography of the Literature Referring to the Geology of Washington by Ralph Arnold. Out of print.

Volume 2.—Annual Report for 1902. Part 1, The Building and Ornamental Stones of Washington, by S. Shedd; part 2, The Coal Deposits of Washington, by Henry Landes and C. A. Ruddy. Out of print.

Bulletin 1.—Geology and Ore Deposits of Republic Mining District, by Joseph B. Umpleby. Bound in cloth; price, 35 cents.

Bulletin 2.—The Road Materials of Washington, by Henry Landes. Bound in cloth; price, 60 cents.

Bulletin 3.—The Coal Fields of King County, by Geo. W. Evans. Bound in cloth; price, 75 cents.

Bulletin 4.—The Cement Materials of Washington, by S. Shedd. Bound in cloth; price, 75 cents. Paper cover; price, 40 cents.

Bulletin 5.—Geology and Ore Deposits of the Myers Creek and Oroville-Nighthawk Districts, by Joseph B. Umpleby. Bound in cloth; price, 50 cents.

Bulletin 6.—Geology and Ore Deposits of the Blewett Mining District, by Charles E. Weaver. Bound in cloth; price, 50 cents.

Bulletin 7.—Geology and Ore Deposits of the Index Mining District, by Charles E. Weaver. Bound in cloth; price, 50 cents.

Bulletin 8.—Glaciation of the Puget Sound Region, by J. Harlen Bretz. Bound in cloth; price, 60 cents. Paper cover; price, 35 cents.

Bulletin 9.—The Coal Fields of Kittitas County, by E. J. Saunders. Paper cover; price, 40 cents.

Bulletin 10.—The Coal Fields of Pierce County, by Joseph Daniels. Bound in cloth; price, 60 cents. Paper cover; price, 40 cents.

Bulletin 11.—The Mineral Resources of Washington, with Statistics for 1912, by Henry Landes. Paper cover; price, 25 cents.

Bulletin 12.—Bibliography of Washington Geology and Geography, by Gretchen O'Donnell. Paper cover; price, 25 cents.

Bulletin 13.—The Tertiary Formations of Western Washington, by Charles E. Weaver. Paper cover; price, 40 cents.

Bulletin 14.—The Quincy Valley Irrigation Project, by Henry Landes, A. W. Mangum, H. K. Benson, E. J. Saunders, and Joseph Jacobs. Paper cover; price, 20 cents. Out of print.

Bulletin 15.—A Preliminary Report on the Tertiary Paleontology of Western Washington, by Charles E. Weaver. Paper cover; price, 20 cents.

Bulletin 16.—Geology and Ore Deposits of the Covada Mining District, by Charles E. Weaver. Paper cover; price, 25 cents.

Bulletin 17.—A Geographic Dictionary of Washington, by Henry Landes. Paper cover; price, 75 cents.

Bulletin 18.—The Country About Camp Lewis, by Morris M. Leighton. Paper cover; price, 50 cents.

Bulletin 19.—The Coal Fields of Southwestern Washington, by Harold E. Culver. Paper cover; price, 75 cents.

Bulletin 20.—The Mineral Resources of Stevens County, by Charles E. Weaver. Paper cover; price, one dollar.

Bulletin 21.—The Mineral Resources of Washington, with Statistics for 1919, by Henry Landes. Paper cover; price, 50 cents. In preparation.

Bulletin 22.—The Sand and Gravel Deposits of Washington Suitable for Road Building, by Morris M. Leighton. Paper cover; price, 75 cents.

Bulletin 23.—The Metal Mines of Washington, by Ernest N. Patty. In preparation.

Bulletin 24.—The Clays and Shales of Washington, by Sheldon L. Glover. In preparation.

Bulletin 25.—The Magnesite Deposits of Washington, by George E. Whitwell and Ernest N. Patty. In preparation.

PUBLICATIONS OF THE U. S. GEOLOGICAL SURVEY, IN COOPERATION
WITH THE WASHINGTON GEOLOGICAL SURVEY.

(For copies of these publications address the Director, U. S. Geological Survey, Washington, D. C. Water-Supply papers may also be obtained, upon request, from the U. S. Geological Survey district, 406 Federal Building, Tacoma, Washington.)

Topographic Maps of the Following Quadrangles.

Arlington, Beverly, Cedar Lake, Chehalis, Connell, Coyote Rapids, Hoquiam, Lake Crescent, Malaga, Moses Lake, Mount Vernon, Ocosta, Pasco, Port Angeles, Port Crescent, Priest Rapids, Prosser, Pysht, Quincy, Red Rock, Samish Lake, Van Zandt, Walla Walla, Wallula, Wenatchee, Wickersham, Winchester.

Power Reports.

Water-Supply Paper No. 253: Water Powers of the Cascade Range, Part I, Southern Washington.

Water-Supply Paper No. 313: Water Powers of the Cascade Range, Part II, Southwestern Washington, Puget Sound Region.

Water Supply Paper No. 369: Water Powers of the Cascade Range, Part III, Yakima basin.

Water-Supply Paper No. 486: Water Powers of the Cascade Range, Part IV, Wenatchee and Entiat basins.

Water-Supply Paper No. 487: Water Powers of the Cascade Range, Part V, Chelan, Methow and Similkameen basins. In preparation.

Water-Supply Paper No. 488: Water Powers of the Cascade Range, Part VI, Snoqualmie, Skykomish, and Stilaguamish basins. In preparation.

River Profiles.

Water-Supply Paper No. 346: Profile Surveys of Clark Fork of Columbia River.

Water Supply Paper No. 366: Profile Surveys of Snoqualmie, Sultan and Skykomish rivers.

Water-Supply Paper No. 368: Profile Surveys of Wenatchee River and tributaries.

Water-Supply Paper No. 376: Profile Surveys, Chelan and Methow basins.

Water-Supply Paper No. 377: Profile Surveys, Spokane and John Day basins.

Water-Supply Paper No. 419: Profile Surveys in Skagit River Basin.

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Reconnaissance Soil Survey of Stevens County.

Reconnaissance Soil Survey of Franklin County.

Reconnaissance Soil Survey of Spokane County.