U. S. Geol. Survey add

DIVISION OF HYDROGRAPHY.
Circular No. 5.

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY.

HYDROGRAPHIC SURVEYS.

This circular is intended to answer questions asked by correspondents regarding the progress and character of the work of the "Irrigation Survey" and of related investigations being carried on by the Division of Hydrography of the United States Geological Survey. It also gives a review of the legislation authorizing this work, together with a list of publications of the Geological Survey showing the results accomplished.

In brief, the work consists of a systematic examination of the water resources of the United States, especially as these have to do with the question of supplies for irrigation, water power, and domestic uses.

CHARACTER OF THE INVESTIGATION.

The investigation consists of three distinct yet closely related classes of work. The first comprises the measurement of the streams and determination of the surface supplies in lakes and rivers. This necessitates operations carried on at intervals through several years and at widely separated points. It also includes the examination of reservoir sites, especially upon the public lands, and the feasibility of using these for increasing the water supply.

The second class of investigations is the examination of underground currents and artesian wells. This requires a close detailed study of contiguous areas and a thorough knowledge of the structure of the country. It is mainly geologic in character, as distinguished from the engineering surveys first mentioned. The third class of work consists in the preparation of short popular reports giving the results of the measurement of the streams and describing the methods of utilizing the water resources, particularly for irrigation.

The connection of the Geological Survey with investigations of this character dates from its inception. In the course of "the classification of public lands and the examination of the geological structure, mineral resources and products of the national domain" the fact has been brought out clearly that over vast areas of fertile land the only "mineral" resource is water. Owing to arid or semi-arid climatic conditions the question of water supply is vital for a

considerable portion of the United States. Water is the foundation of land values, and the determination of the possibility of obtaining a sufficient quantity for agricultural purposes, including stock raising, either from surface streams, from underground sources, or by storage, has an importance as great as, if not greater than, that of the study of the occurrence elsewhere of the precious metals. The field parties of this Survey, whether engaged in topographic or in geologic mapping, have had constantly before them questions of water supply. Attention was early called to the practicability of irrigation in the writings of various members of this Survey, notably in those of the former Director, Maj. J. W. Powell.

With the gradual expansion of the surveys of this organization phases of the question of water supply other than relating to irrigation have become prominent, water power and the possibilities of its development being of especial importance in the East. The problem of securing potable waters for municipal and domestic supply has also been brought forward from regions where surface sources are contaminated and the probabilities of obtaining a pure supply from deep-seated rocks can be determined only by thorough knowledge of the geology of the region. Upon the authorization of the Irrigation Survey in 1888 the Division of Hydrography was created, in order to better systematize the work relating to water resources. This work, continued through eight years, has assumed a definite character. Men have been trained in its operations and instruments have been devised and tested.

PRESENT OPERATIONS.

The measurement of streams on the Atlantic seaboard is confined mainly to the head waters of rivers like the Potomac, James, Roanoke, Cape Fear, Yadkin, Catawba, Ocmulgee, and Chattahoochee, where with rapid fall a considerable water power is available. In addition, investigations are being made of the general hydrography of the streams of New England and of the water powers utilized. On the upper Ohio drainage some field work is being done on the Greenbrier, New, and French Broad.

The greater part of the river work is within the Rocky Mountain region and to the westward on streams flowing into the Pacific Ocean. Systematic measurements have been conducted for several years on the head waters of the Missouri, Yellowstone, Platte, Arkansas, and Canadian. On the Rio Grande, stations have been established near the head waters in Colorado and along the course of the stream in New Mexico and at points as far south as El Paso, Tex., where the river begins to form the international boundary.

On the head waters of the great Colorado River of the West measurements are being carried on in Wyoming, Utah, and Colorado, and the principal tributary at the south, the Gila, is being measured at points above Florence, Ariz. Within the interior basin systematic examinations have been carried on along the Truckee, Carson, Walker, and Humboldt rivers in Nevada, and on the Bear, Ogden, Weber, Provo, and other streams flowing into Great Salt Lake.

Many of the tributaries of Columbia River are being measured, notably the Snake, Boise, Payette, Weiser, and Bruneau of Idaho, the Owyhee, Malheur, and Umatilla of Oregon, and the Yakima of Washington. In California a large number of measurements are being made of streams flowing from the Sierra Nevada into the San Joaquin and Sacramento, and investigations are being conducted along the torrential rivers supplying water for southern California.

The geologic field work, having to do with the investigation of underground waters, including artesian conditions, has been expanded to cover typical localities in various regions. In the East arrangements have been made to continue the study of the artesian conditions along the Atlantic Coast, especially in localities where the surface waters are contaminated or where there is reason to believe that prevailing fevers are due to this source. In the Ohio Valley, field work is being carried on with the intention of continuing the series of reports upon the wells and the possibilities of obtaining water from this source in the States of Indiana and Ohio. In the Dakotas a continuation of the reconnaissance of 1895 is being made, and in eastern Nebraska detailed geologic examination and mapping has been begun. In southwestern Kansas a study of the underground structure is being carried on in the region to the east of that examined and mapped in previous years, and in eastern Washington field work has been undertaken. The results of the geologic study of Texas are being prepared for publication, especially as these relate to the water supply.

The greater number of the reports upon water supply and irrigation, especially those of a popular nature, are being prepared for publication as a new series of papers, and will be issued as rapidly as possible. The scope of these papers is broad, embracing subjects from the technical description of river measurements and results, intended mainly for engineers, to the general descriptions and directions for constructing irrigating plants, designed for the farmer. Arrangements have been made for papers upon the following subjects: River measurements in the East; river measurements in the Missouri drainage; river measurements west of the Rocky Mountains; the water power of

a portion of New England; the water power of the southeastern Appalachian slope; the water supply of Indiana; recent developments of artesian wells and irrigation in the Dakotas; the underground waters of eastern Nebraska; water supplies of southeastern Kansas; methods of irrigation on the Great Plains; methods of applying water in Arizona and in California; seepage waters from irrigation; water storage in Big Horn Mountains; efficiency of windmills in irrigation; sewage irrigation; artesian conditions of eastern Washington and western Idaho; water supply in the vicinity of Devils Lake, N. Dak., etc. The first paper of this series, that by H. M. Wilson upon Pumping Water for Irrigation, is now in press.

LEGISLATION.

The United States Geological Survey is concerned with the water resources of the country primarily through what is known as the organic law contained in the act of Congress of March 3, 1879. To the paragraph creating the office of Director of the Geological Survey the following proviso was attached:

> * * * That this officer shall have the direction of the Geological Survey, and the classification of the public lands and examination of the geological structure, mineral resources and products of the national domain and that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations. (Approved March 3, 1879. Stat. L., vol. 20, p. 394.)

The first requisite in the "classification of the public lands and the examination of the geological structure, mineral resources, and products of the national domain," is a topographic map for guidance and for exhibiting the results. Since the organization of the Survey, therefore, a large part of its energies has been concentrated on the preparation of such a map, showing all elevations by means of contours, also the location of streams, towns, roads, railroads, and canals for irrigation or transportation, isolated houses, and boundaries of States, counties and towns. This map exhibits the drainage area of streams, the relative elevations of catchment basins and irrigable lands, the topographic features favorable to water conservation, the Land Office lines, the slopes of valleys, and many other details of importance to the development of water powers and of irrigation or the reclamation of the arid lands.

In 1887 the Director of the Geological Survey was called upon by Congress to consider the question of Federal recognition of the irrigation subject. A resolution was passed requiring the Secretary of the Interior, by means of the Director of the Geological Survey, to make an investigation of that portion of the arid region

of the United States where agriculture is carried on by means of irrigation. The resolution reads as follows:

Whereas a large portion of the unoccupied public lands of the United States is located within what is known as the arid region, and now utilized only for grazing purposes, but much of which, by means of irrigation, may be rendered as fertile and productive as any land in the world, capable of supporting a large population thereby adding to the national wealth and prosperity;

Whereas all the water flowing during the summer months in many of the streams of the Rocky Mountains, upon which chiefly the husbandman of the plains and the mountain valleys chiefly depends for moisture for his crops, has been appropriated and is used for the irrigation of lands contiguous thereto, whereby a comparatively small area has been reclaimed; and

Whereas there are many natural depressions near the sources and along the courses of these streams which may be converted into reservoirs for the storage of the surplus water which during the winter and spring seasons flows through the streams; from which reservoirs the water there stored can be drawn and conducted through properly constructed canals, at the proper season, thus bringing large areas of land into cultivation, and making desirable much of the public land for which there is now no demand; therefore be it

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior by means of the Director of the Geological Survey be, and he is hereby, directed to make an examination of that portion of the arid regions of the United States where agriculture is carried on by means of irrigation, as to the natural advantages for the storage of water for irrigating purposes with the practicability of constructing reservoirs, together with the capacity of the streams and the cost of construction and capacity of reservoirs, and such other facts as bear on the question of storage of water for irrigating purposes; and that he be further directed to report to Congress as soon as practicable the result of such investigation. (Approved March 20, 1888. Stat. L., vol. 25, pp. 618, 619.)

This was followed by the passage of an act containing an appropriation of $100,000 for the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation. This act is as follows:

For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation, and the segregation of the irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and the prevention of floods and overflows, and to make the necessary maps, including the pay of employees in field and in office, the cost of all instruments, apparatus, and materials, and all other necessary expenses connected therewith, the work to be performed by the Geological Survey, under the direction of the Secretary of the Interior, the sum of one hundred thousand dollars or so much thereof as may be necessary. And the Director of the Geological Survey under the supervision of the Secretary of the Interior shall make a report to Congress on the first Monday in December of each year, showing in detail how the said money has been expended, the amount used for actual survey and engineer work in the field in locating sites for reservoirs and an itemized account of the expenditure under this appropriation. And all the lands which may hereafter be designated or selected by such United States surveys for sites for reservoirs, ditches or canals for irrigation purposes and all the lands made susceptible of irrigation by such reservoirs, ditches or canals are from this time henceforth hereby reserved from sale as the property of the United States, and shall not be subject after the passage of this act, to entry, settlement or occupation until further provided by law:

Provided, That the President may at any time in his discretion by proclamation open any portion or all of the lands reserved by this provision to settlement under the homestead laws. (Approved October 2, 1888. Stat. L., vol. 25, pp. 526, 527.)

In the following year $250,000 was appropriated for continuing the work. (Approved March 2, 1889, Stat. L., vol. 25, p. 960.)

A portion of the law passed October 2, 1888, was repealed by the following provision in the act approved August 30, 1890 (Stat. L., vol. 26, p. 391), and no appropriation was made for irrigation work as such:

For topographic surveys in various portions of the United States, three hundred and twenty-five thousand dollars, one half of which sum shall be expended west of the one hundredth meridian; and so much of the act of October second, eighteen hundred and eighty-eight, entitled "An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and eighty-nine, and for other purposes," as provides for the withdrawal of the public lands from entry, occupation and settlement, is hereby repealed, and all entries made or claims initiated in good faith and valid but for said act, shall be recognized and may be perfected in the same manner as if said law had not been enacted, except that reservoir sites heretofore located or selected shall remain segregated and reserved from entry or settlement as provided by said act, until otherwise provided by law, and reservoir sites hereafter located or selected on public lands shall in like manner be reserved from the date of the location or selection thereof.

No person who shall after the passage of this act, enter upon any of the public lands with a view to occupation, entry or settlement under any of the land laws shall be permitted to acquire title to more than three hundred and twenty acres in the aggregate, under all of said laws, but this limitation shall not operate to curtail the right of any person who has heretofore made entry or settlement on the public lands, or whose occupation, entry or settlement is validated by this act: *Provided*, That in all patents for lands hereafter taken up under any of the land laws of the United States or on entries or claims validated by this act west of the one hundredth meridian, it shall be expressed that there is reserved from the lands in said patent described, a right of way thereon for ditches or canals constructed by the authority of the United States. (Approved August 30, 1890. Stat. L., vol. 26, p. 391.)

Under this law the Survey selected and mapped a large number of reservoir sites, which have been noted on the records of the General Land Office, and are now reserved from entry or settlement. Descriptions of these sites may be found in the Tenth, Eleventh, Twelfth, and Thirteenth Annual Reports of the Geological Survey.

From the above-cited paragraphs it appears that the portion of the original law approved October 2, 1888, which affected the withdrawal of the public lands from entry, occupation, and settlement was repealed, but that the remaining portions of the law were unaffected by the act of repeal, and that there is still on the statute books authority for making an examination of the arid region of the United States, for ascertaining the capacity of the streams, and "for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and the prevention of floods and overflows, and to make the necessary maps."

In the repealing act it was specifically provided that the reservoir sites shall remain segregated for such use, and in a law entitled "An act to repeal timber-culture laws, and for other purposes," approved March 3, 1891, it is provided:

That reservoir sites located or selected and to be located and selected under the provisions of "An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred

and eighty-nine, and for other purposes," and amendments thereto, shall be restricted to and shall contain only so much land as is actually necessary for the construction and maintenance of reservoirs; excluding so far as practicable lands occupied by actual settlers at the date of the location of said reservoirs. (Stat. L., vol. 26, p. 1101.)

Under the various laws above cited, systematic measurements of the streams of the arid regions were begun by the Division of Hydrography, and were continued after August 30, 1890, as incidental to the topographic surveys and selection of reservoir sites. By act of August 18, 1894, the following specific appropriation was made for this class of work:

For gauging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in arid and semiarid sections, twelve thousand five hundred dollars. (Approved August 18, 1894. Stat. L., vol. 28, p. 398.)

A further appropriation by act approved March 2, 1895 (Stat. L., vol. 28, p. 940), made available the sum of $20,000 for the fiscal year 1895–96, and a later act was worded as follows:

For gauging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in arid and semiarid sections, and the preparation of reports upon the best methods of utilizing the water resources of said sections, fifty thousand dollars. (Approved June 11, 1896. Stat. L., vol. 29, p. 436.)

Provision has been made for printing the reports for popular distribution by the following clause in the act last named:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. (Approved June 11, 1896. Stat. L., vol. 29, p. 453.)

PUBLICATIONS.

The results of the work of the Geological Survey in this connection are best shown by the publications relating to water resources, most of these having been prepared in the Division of Hydrography. The following list gives, in chronologic order, the more important works, beginning with 1890. The earlier works are now out of print or difficult to obtain, but reference should be made particularly to the report on the "Lands of the arid region of the United States, with a more detailed account of the lands of Utah," by J. W. Powell, published in two editions, the second being in 1879, and also to the paper on "The requisite and qualifying conditions of artesian wells," by Thomas C. Chamberlin. In this list also are included the publications of the Eleventh Census

relating to irrigation, as these were prepared largely from the results of field work of this Survey:

1890.

First Annual Report of the United States Irrigation Survey, 1890, octavo, 123 pp.

This is printed as Part II. Irrigation, of the Tenth Annual Report of the Director of the United States Geological Survey, 1888-89. It contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891, octavo, 395 pp.

This is published as Part II, Irrigation, of the Eleventh Annual Report of the Director of the United States Geological Survey, 1889-90. It contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890, also the statement of the Director of the Geological Survey to the House Committee on Irrigation and other papers, including a bibliography of irrigation literature. It is illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891, octavo, 576 pp.

This is printed as Part II of the Twelfth Annual Report of the Director of the United States Geological Survey, 1890-91. It contains a report upon the location and survey of reservoir sites during the fiscal year ending June 30, 1891, by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell, "Irrigation in India," by Herbert M. Wilson. It is illustrated by 93 plates and 190 figures.

Dictionary of altitudes in the United States, by Henry Gannett; 2d ed. Bulletin No. 76 of the United States Geological Survey, 1891, octavo, 393 pp.; price, 25 cents.

This dictionary gives the altitudes at various points in the United States, including localities in the arid and semiarid region.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell, quarto.

No. 35. Irrigation in Arizona.
No. 60. Irrigation in New Mexico.
No. 85. Irrigation in Utah.
No. 107. Irrigation in Wyoming.
No. 153. Irrigation in Montana.
No. 157. Irrigation in Idaho.
No. 163. Irrigation in Nevada.
No. 178. Irrigation in Oregon.
No. 193. Artesian Wells for Irrigation.
No. 198. Irrigation in Washington.

1892.

Irrigation of Western United States, by F. H. Newell, extra census bulletin No. 23, September 9, 1892, quarto, 22 pp.

This report contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. It is illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893, octavo, 486 pp.

This report consists of three papers, the first upon water supply for irrigation, by F. H. Newell; the second on American engineering and upon engineering results of the Irrigation Survey, by Herbert M. Wilson; and the third upon the construction of topographic maps and the selection and survey of reservoir sites, by A. H. Thompson. It is illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893, octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the eleventh census, 1890, by F. H. Newell, 1894, quarto, 283 pp.

This report consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; it also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; it then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation and discusses the physical condition and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892–93, in two parts, Part II, accompanying papers, 1894, octavo, 597 pp.

This report contains a paper upon potable waters of the Eastern United States, by W J McGee; natural mineral waters of the United States, by A. C. Peale; results of stream measurements, by F. H. Newell, illustrated by maps and diagrams.

1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895, octavo, 598 pp.

Contains a paper upon the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Washington, by George H. Eldridge, 1894, octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report on progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895, octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography.

Contains paper by Grove Karl Gilbert on the underground water of the Arkansas Valley in eastern Colorado, by Frank Leverett on the water resources of Illinois, and by Nelson Horatio Darton on a reconnaissance of the artesian areas of North and South Dakota.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896, octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

This report gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by Frederick Haynes Newell, hydrographer in charge, 1896, octavo, 356 pages. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States. It also contains a paper by J. B. Lippincott on the San Joaquin Basin, giving a description of the water supply with reference to irrigation, and a short paper by Philip E. Harroun on the irrigation of a portion of the Rio Grande Valley in New Mexico.

The Glacial Lake Agassiz, by Warren Upham. Monograph Vol. XXV, 1896, quarto, 658 pages, 38 plates; price, $1.70.

Contains in chapter 10 a description of the artesian and common wells of the Red River Valley, and in chapter 11 notes on the agricultural resources of this area.

Geology of the Denver Basin, Colorado, by S. F. Emmons, Whitman Cross, and George H. Eldridge, 1896. Monograph Vol. XXVII, quarto.

Contains a description of the artesian wells and structural conditions in the vicinity of Denver.

Correspondence relating to the publications of the Survey should be addressed to the Director of the United States Geological Survey, Washington, D. C. Monographs and bulletins can be obtained only by purchase. Money for these should be transmitted by postal or express order made payable to the *Director of the United States Geological Survey.*

F. H. NEWELL,
Hydrographer.

WASHINGTON, D. C. *September 15, 1896.*

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