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Part-2

ELEVENTH ANNUAL REPORT

OF THE

DIRECTOR

OF THE

UNITED STATES GEOLOGICAL SURVEY.

Part II—IRRIGATION.

UNITED STATES IRRIGATION SURVEY.

ABSTRACT OF SECOND ANNUAL REPORT, 1889-1890.

The work of the United States Irrigation Survey during the second year has been carried on under the appropriation of $250,000 made March 2, 1889, by the force organized and equipped during the previous year. This is pursuant to the purposes outlined in the first annual report, which explains the origin, purpose, and plan of the Survey, publishes the instructions to the chiefs of the larger divisions, and gives the report of the topographic division to the end of the first fiscal year, and the reports of the hydrographic and engineering divisions during the greater part of the calendar year 1889.

This second annual report contains in condensed form the results of the work of the divisions of hydrography and engineering up to June 30, 1890. It is followed by the detailed statement before the Committee on Irrigation of the House of Representatives, which comprises a general discussion of the problems of irrigation in the arid lands of the United States, the work of the Irrigation Survey, and a résumé of the larger aspects of the problem, as well as other facts of general interest. This is followed by the report of the topographic branch of the Irrigation Survey and the abstract of disbursements, showing that $239,318.24 had been expended during the fiscal year.

In the developments of the work of this Survey no essential alteration has been made in previous plans, and the personnel of the field and office force has remained practically unchanged, the topographic work being under Prof. A. H. Thompson, and the hydrographic and engineering branches under Capt. C. E. Dutton. Work in all three divisions was rapidly pushed forward through the summer and fall of 1889 and the spring of 1890, being in full operation at the end of the fiscal year. The wisdom of thus apportioning the work of the Irrigation Survey has been demonstrated by the outcome, as investigations have been pushed forward more rapidly, and with larger results than could otherwise have been obtained.

The topographic survey has been carried on in a manner similar to that in which all such work has been conducted by the United States Geological Survey, so that the maps finally obtained are uniform in general character and appearance with those previously made, thus rendering them available for all the varied needs of scientific and engineering investigations, as well as for the irrigation examination proper. These maps not only show the lands of the arid region and the relative location of water supply and of tracts suitable for agriculture, but, by the well-known system of contours, they also exhibit the details of elevation and general slope of the ground. Thus with these maps it is possible to delineate with great exactness all of the facts essential to comprehensive irrigation schemes, and also to obtain with accuracy the area of catchment of every stream above any given point, as that of a reservoir site or a diverting dam. In short, these maps form a basis for the intelligent discussion of the whole problem of irrigation development.

IRRIGATION SURVEY—SECOND ANNUAL REPORT.

By J. W. POWELL, DIRECTOR.

HYDROGRAPHY.

SCOPE OF WORK.

Any discussion of the extent to which the lands of the arid region can be redeemed by irrigation, or of the engineering problems involved, requires a comprehensive knowledge of the distribution of water in each catchment basin and the amount available at various points in that basin. As this amount is never the same from day to day and varies greatly from year to year, it becomes necessary to continue investigations through a series of years, and from these obtain certain averages and extremes concerning flood and drought. The longer the measurements are continued the more valuable the results become—the more nearly do they represent the actual range of conditions, and hence the greater the reliance that can be placed upon them in making predictions for the future.

The water supply and the amount available at any one point are resultants of many and varied forces, most of which are beyond the control of man. In each drainage basin the relative effect of these differs in some greater or less degree, so that the results of investigations made in one locality apply only in a modified degree to any other place.

In the general subject of water control the great mass of information collected by other investigators relates mainly to localities far removed, both geographically and climatically, from the arid region, to lands where the object is oftener the disposal of excess of water than the conservation of a defi-

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near an abandoned smelter. Observations were begun August 26, 1889, and continued through the succeeding year, the floods, however, were unusually low, and the results given in the tables are probably far less than the average discharge for several years.

SALT.

This river, though considered as a tributary of the Gila, is in fact larger both in catchment area and discharge, and might properly be considered the main stream. It receives the drainage from central Arizona, its principal tributary, the Verde, flowing southeasterly and south from the mountains and table-lands south of the Colorado River There is a little irrigation along the upper waters of the Verde and in the Tonto Basin, but the diversions of water are too small to be noticeable on the main stream.

The Verde Valley is situated in Yavapai County, on the headwaters of the stream, and extends from a canyon above Camp Verde to a point 10 miles below the fort, where a branch of the Mogollon Mountains on the east and another of the Verde Mountains on the west approach the river. About 3,000 acres of land in this valley are under cultivation, and large crops of alfalfa, small grain, corn, and potatoes are raised, as well as fruits in great variety and perfection. The military reservation comprises about 1,000 acres of farming land, much of it capable of irrigation.

About a mile below the junction of the Verde, and 30 miles above Phœnix, the river begins to enter upon the plains of the Gila Valley. At this point the Arizona Canal Company have built a dam or weir across the river to raise the water and turn it into their canal. The engineer of this company, Mr. Samuel A. Davidson, has calculated the daily discharge over this weir for a number of years, and with his permission these results are given herewith, as they show in a general way the character and range for nearly three years of the rivers of this portion of the arid region While these calculations, being based on weir formulæ, may be in error to a considerable degreè, yet they are comparable among themselves, and

show the sudden fluctuations and the relative size of the stream.

Attempts have been made to establish gauging stations on the Verde and Salt above their junctions, but great difficulties have been encountered, and, after moving the stations, that on the Verde was finally abandoned and work on the Upper Salt suspended during the winter of 1889–'90. The measurements on the Salt, made at about a half mile above the junction of the Verde, are as follows:

Discharge.	Sec. ft.
June 27, 1889	251
July 10, 1889	195
July 17, 1889	272
August 16, 1889	213
August 30, 1889	216
September 16, 1889	212
September 22, 1889	306
September 26, 1889	225
September 30, 1889	212

In the spring of 1890 a new station was located at a more favorable though remote place up in the canyons about 50 miles above Phœnix. The mean discharges in second feet are: For May, 500; for June, 298; for July, 21.

The measurements on the Verde, made at a place a mile above the Salt, are as follows:

Discharge.	Sec. ft.
June 26, 1889	127
July 11, 1889	234
July 20, 1889	436
August, mean, 1889	200
September, mean, 1889	192

Besides the Arizona Canal Company, at whose headworks the estimates of daily discharge have been made, there are below it a dozen other canals taking water from the Salt River. These vary in length from 3 to 22 miles, and cover in the aggregate 300,000 acres of land, of which about 35,000 are annually cultivated. All the water in Salt River has been utilized and little more can be done in the way of land reclamation without the construction of storage reservoirs. If this

were done it is estimated that sufficient water could be impounded during the storm floods to reclaim many times the area now under cultivation. The soil is very productive, large crops of wheat, barley, and alfalfa are grown, and fruits of all descriptions flourish and yield bountifully.

TRUCKEE AND CARSON BASINS.

These rivers rise in the Sierras, receiving drainage from mountains 7,000 to 10,000 feet high, and, flowing easterly, lose their waters in the sinks of the interior basin. The catchment areas, though small, yield a considerable amount of water, owing to the steepness of the slopes and the general elevation of the basin. In the drainage of the Truckee is Lake Tahoe, the highest lake of its size in the country. From its elevated position, however, the catchment area of the lake is very restricted, being only 522 square miles, less than four times that of the water surface, which is 195 square miles As a consequence the run-off from the lake is comparatively small.

The situation of this basin in regard to political divisions is somewhat peculiar The line between California and Nevada, running through Lake Tahoe, cuts the catchment area into two portions, of which 793 square miles are in California and 283 square miles in Nevada, measuring the drainage above Reno. The water is most largely utilized in Nevada, but any comprehensive system of water conservation for the further benefit of these desert tracts is rendered complex by questions arising from differences in jurisdiction and in water privileges in the two States.

Measurements were begun in the Truckee Basin in the latter part of May, 1889. The high water of that year came very late on account of light fall of snow during the preceding winter. There was a very heavy snow storm about the middle of May, followed by warm weather, causing floods of short duration, which were followed by unusually low water during the summer and fall.

The results obtained are here given, beginning at the outlet of Lake Tahoe and taking the various tributaries in succession.