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SURFACE WATER SUPPLY OF THE UNITED STATES

1909

PART VII. LOWER MISSISSIPPI BASIN

PREPARED UNDER THE DIRECTION OF M. O. LEIGHTON

BY

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CONTENTS.

ILLUSTRATIONS.

SURFACE WATER SUPPLY OF THE LOWER MISSISSIPPI BASIN, 1909.

By W. B. Freeman and R. H. Bolster.

INTRODUCTION.

AUTHORITY FOR INVESTIGATIONS.

This volume contains results of flow measurements made on certain streams in the United States. The work was performed by the water-resources branch of the United States Geological Survey, either independently or in cooperation with organizations mentioned herein. These investigations are authorized by the organic law of the Geological Survey (Stat. L., vol. 20, p. 394), which provides, among other things, as follows:

Provided that this officer [the Director] shall have the direction of the Geological Survey and the classification of public lands and examination of the geological structure, mineral resources, and products of the national domain.

Inasmuch as water is the most abundant and most valuable mineral in nature, the investigation of water resources is included under the above provisions for investigating mineral resources. The work has been supported since the fiscal year ending June 30, 1895, by appropriations in successive sundry civil bills passed by Congress under the following item:

For gaging the streams and determining the water supply of the United States, and for the investigation of underground currents and artesian wells, and for the preparation of reports upon the best methods of utilizing the water resources.

The various appropriations that have been made for this purpose are as follows:

Annual appropriations for the fiscal year ending June 30—

1895	$12,500
1896	20,000
1897 to 1900, inclusive	50,000
1901 to 1902, inclusive	100,000
1903 to 1906, inclusive	200,000
1907	150,000
1908 to 1910, inclusive	100,000
1911	150,000

SCOPE OF INVESTIGATIONS.

These investigations of stream flow are not complete nor do they include all the river systems or parts thereof that might purposefully be studied. The scope of the work is limited by the appropriations available. The field covered is the widest and the character of the work is believed to be the best possible under the controlling conditions. The work would undoubtedly have greater scientific importance and ultimately be of more practical value if the money now expended for wide areas were concentrated on a few small drainage basins; but such a course is impossible because general appropriations made by Congress are applicable to all parts of the country. Each part demands its proportionate share of the benefits.

It is essential that records of stream flow shall be kept during a period of years long enough to determine within reasonable limits the entire range of flow from the absolute maximum to the absolute minimum. The length of such a period manifestly differs for different streams. Experience has shown that the records for some streams should cover from five to ten years, and for other streams twenty years or even more, the limit being determined by the relative importance of the stream and the interdependence of the results with other long-time records on adjacent streams.

In the performance of this work an effort is made to reach the highest degree of precision possible with a rational expenditure of time and a judicious expenditure of a small amount of money. In all engineering work there is a point beyond which refinement is needless and wasteful, and this statement applies with especial force to stream-flow measurements. It is confidently believed that the stream-flow data presented in the publications of the Survey are in general sufficiently accurate for all practical purposes. Many of the records are, however, of insufficient length, owing to the unforeseen reduction of appropriations and consequent abandonment of stations. All persons are cautioned to exercise the greatest care in using such incomplete records.

Records have been obtained at more than 1,550 different points in the United States, and in addition the surface water supply of small areas in Seward Peninsula and the Yukon-Tanana region, Alaska, has been investigated. During 1909 regular gaging stations were maintained by the Survey and cooperating organizations at about 850 points in the United States, and many miscellaneous measurements were made at other points. Data were also obtained in regard to precipitation, evaporation, storage, reservoirs, river profiles, and water power in many sections of the country and will be made available in the regular surface water-supply papers and in special papers from time to time.

PURPOSES OF THE WORK.

The results contained in this volume are requisite to meet the immediate demands of many public interests, including navigation, irrigation, domestic water supply, water power, swamp and overflow land drainage, and flood prevention.

Navigation.—The Federal Government has expended more than $250,000,000 for the improvement of inland navigation, and prospective expenditures will approximate several times this amount. It is obvious that the determination of stream flow is necessary to the intelligent solution of the many problems involved.

Irrigation.—The United States is now expending $51,000,000 on federal irrigation systems, and this amount is far exceeded by the private expenditures of this nature in the arid West. The integrity of any irrigation system depends absolutely on the amount of water available. Therefore investigations of stream flow in that portion of the country are not only of first importance in the redemption of the lands, but constitute an insurance of federal and private investments.

Domestic water supply.—The highest use of water is for domestic supply, and although this branch of the subject is of less direct federal interest than the branches already named, it nevertheless has so broad a significance with respect to the general welfare that the Federal Government is ultimately and intimately concerned.

Water power.—The development of the water power of the country is an economic necessity. Our stock of coal is being rapidly depleted and the cost of steam power is increasing accordingly. Industrial growth, and as a consequence the progress of the United States as a nation, will cease if cheap power is not available. Water power affords the only avenue now open. When the electric transmission of power was accomplished the relation of our water powers to national economy changed entirely. Before the day of electric transmission water power was important only at the locality at which it was generated, but it has now become a public utility in which the individual citizen is vitally interested. Inasmuch as the amount of water power that may be made available depends on the flow of rivers, the investigation of flow becomes a prerequisite in the judicious management of this source of energy.

Drainage of swamp and overflowed lands.—More than 70,000,000 acres of the richest land in this country are now practically worthless or of precarious value by reason of overflow and swamp conditions. When this land is drained it becomes exceedingly productive and its value increases many fold. Such reclamation would add to the national assets at least $700,000,000. The study of run-off is the first consideration in connection with drainage projects. If by the drainage of a large area into any particular channel that channel becomes so gorged with water which it had not hitherto been called upon to convey that overflow conditions are created in places where previously the land was not subject to inundation, then drainage results merely in an exchange of land values. This is not the purpose of drainage improvement.

Flood prevention.—The damage from floods in the United States probably exceeds on the average $100,000,000 annually, and in the year 1908, according to estimates based on reliable data, the aggregate damage approximated $250,000,000. Such an annual tax on the property of great regions should be reduced in the orderly progress of government. It goes without saying that any consideration of flood prevention must be based on a thorough knowledge of stream flow, both in the contributing areas which furnish the water and along the great lowland rivers.

PUBLICATIONS.

The data on stream flow collected by the United States Geological Survey since its inception have appeared in the annual reports, bulletins, and water-supply papers. Owing to natural processes of evolution and to changes in governmental requirements, the character of the work and the territory covered by these different publications has varied greatly. For the purpose of uniformity in the presentation of reports a general plan has been agreed upon by the United States Reclamation Service, the United States Forest Service, the United States Weather Bureau, and the United States Geological Survey, according to which the area of the United States has been divided into twelve parts, whose boundaries coincide with certain natural drainage lines. The areas so described are indicated by the following list of papers on surface water supply for 1909. The dividing line between the North Atlantic and South Atlantic drainage areas lies between York and James rivers.

Papers on surface water supply of the United States, 1909.

Part.	No.	Title.	Part.	No.	Title.
I	261	North Atlantic coast.	VI	266	Missouri River basin.
II	262	South Atlantic coast and eastern Gulf of Mexico.	VII	267	Lower Mississippi River basin.
			VIII	268	Western Gulf of Mexico.
III	263	Ohio River basin.	IX	269	Colorado River basin.
IV	264	St. Lawrence River basin.	X	270	Great Basin.
V	265	Upper Mississippi River and Hudson Bay basin.	XI	271	California.
			XII	272	North Pacific coast.

The following table gives the character of data regarding stream flow at regular stations to be found in the various publications of the United States Geological Survey exclusive of all special papers. Numbers of reports are inclusive and dates also are inclusive so far as the data are available.

Stream-flow data in reports of the United States Geological Survey.

[Ann.=Annual Report; B.=Bulletin; W. S.=Water-Supply Paper.]

Report.	Character of data.	Year.
10th Ann., pt. 2	Descriptive information only	
11th Ann., pt. 2	Monthly discharge	1884 to Sept., 1890.
12th Ann., pt. 2	....do	1884 to June 30, 1891.
13th Ann., pt. 3	Mean discharge in second-feet	1884 to Dec. 31, 1892.
14th Ann., pt. 2	Monthly discharge (long-time records, 1871 to 1893)	1888 to Dec. 31, 1893.
B. 131	Descriptions, measurements, gage heights, and ratings	1893 and 1894.
16th Ann., pt. 2	Descriptive information only	
B. 140	Descriptions, measurements, gage heights, ratings, and monthly discharge (also many data covering earlier years).	1895.
W. S. 11	Gage heights (also gage heights for earlier years)	1896.
18th Ann., pt. 4	Descriptions, measurements, ratings, and monthly discharge (also similar data for earlier years).	1895 and 1896.
W. S. 15	Descriptions, measurements, and gage heights, eastern United States, eastern Mississippi River, and Missouri River above junction with Kansas.	1897.
W. S. 16	Descriptions, measurements, and gage heights, western Mississippi River below junction of Missouri and Platte, and western United States.	1897.
19th Ann., pt. 4	Descriptions, measurements, ratings, and monthly discharge (also some long-time records).	1897.
W. S. 27	Measurements, ratings, and gage heights, eastern United States, eastern Mississippi River, and Missouri River.	1898.
W. S. 28	Measurements, ratings, and gage heights, Arkansas River and western United States.	1898.
20th Ann., pt. 4	Monthly discharge (also for many earlier years)	1898.
W. S. 35 to 39	Descriptions, measurements, gage heights, and ratings	1899.
21st Ann., pt. 4	Monthly discharge	1899.
W. S. 47 to 52	Descriptions, measurements, gage heights, and ratings	1900.
22d Ann., pt. 4	Monthly discharge	1900.
W. S. 65, 66	Descriptions, measurements, gage heights, and ratings	1901.
W. S. 75	Monthly discharge	1901.
W. S. 82 to 85	Complete data	1902.
W. S. 97 to 100	....do	1903.
W. S. 124 to 135	....do	1904.
W. S. 165 to 178	....do	1905.
W. S. 201 to 214	Complete data, except descriptions	1906.
W. S. 241 to 252	Complete data	1907–8.
W. S. 261 to 272	....do	1909.

NOTE.—No data regarding stream flow are given in the 15th and 17th annual reports.

The records at most of the stations discussed in these reports extend over a series of years. An index of the reports containing records prior to 1904 has been published in Water-Supply Paper 119. The first table which follows gives, by years and drainage basins, the numbers of the papers on surface water supply published from 1899 to 1909. Wherever the data for a drainage basin appear in two papers the number of one is placed in parentheses and the portion of the basin covered by that paper is indicated in the second table. For example, in 1904 the data for Missouri River were published in Water-Supply Papers 130 and 131, and the portion of the records contained in Water-Supply Paper 131, as indicated by the second table, is that relating to Platte and Kansas rivers.

Numbers of water-supply papers containing results of stream measurements, 1899–1909.

	1899.[a]	1900.[b]	1901.	1902.	1903.	1904.	1905.	1906.	1907–8.	1909.
Atlantic coast and eastern Gulf of Mexico:										
New England rivers..	35	47	65, 75	82	97	124	165	201	241	261
Hudson River to Delaware River, inclusive..........	35	47, (48)	65, 75	82	97	125	166	202	241	261
Susquehanna River to York River, inclusive............	35	48	65, 75	82	97	126	167	203	241	261
James River to Yadkin River, inclusive................	(35).36	48	65, 75	(82), 83	(97), 98	126	167	203	242	262
Santee River to Pearl River, inclusive....	36	48	65, 75	83	98	127	168	204	242	262
St. Lawrence River......	36	49	65, 75	(82), 83	97	129	170	206	244	264
Hudson Bay..............	....	....	66, 75	85	100	130	171	207	245	265
Mississippi River:										
Ohio River..........	36	48, (49)	65, 75	83	98	128	169	205	243	263
Upper Mississippi River..............	36	49	65, 75	83	98, (99)	128, (130)	171	207	245	265
Missouri River.......	(36), 37	49, (50)	66, 75	84	99	130, (131)	172	208	246	266
Lower Mississippi River..............	37	50	(65), 65, 75	(83), 84	(98), 99	(128) 131	(169), 173	(205), 209	247	267
Western Gulf of Mexico..	37	50	66, 75	84	99	132	174	210	248	268
Pacific coast and Great Basin:										
Colorado River.......	(37), 38	50	66, 75	85	100	133, (134)	175, (177)	211, (213)	249, (251)	269, (271)
Great Basin..........	38, (39)	51	66, 75	85	100	133, (134)	176, (177)	212, (213)	250, (251)	270, (271)
South Pacific coast to Klamath River, inclusive...........	(38), 39	51	66, 75	85	100	134	177	213	251	271
North Pacific coast...	38	51	66, 75	85	100	135	(177), 178	214	252	272

[a] Rating tables and index to Water-Supply Papers 35–39 contained in Water-Supply Paper 39.
[b] Rating tables and index to Water-Supply Papers 47–52 and data on precipitation, wells, and irrigation in California and Utah contained in Water-Supply Paper 52.

Numbers of water-supply papers containing data covering portions of drainage basins.

No.	River basin	Tributaries included.
35	James..................................	
36	Missouri...............................	Gallatin.
37	Colorado...............................	Green, Gunnison, Grand above junction with Gunnison.
38	Sacramento............................	Except Kings and Kern.
39	Great Basin...........................	Mohave.
48	Delaware..............................	Wissahickon and Schuylkill.
49	Ohio..................................	Scioto.
50	Missouri...............................	Loup and Platte near Columbus, Nebr. All tributaries below junction with Platte.
65	Lower Mississippi.................	Yazoo.
82	James..................................	
	St. Lawrence.........................	Lake Ontario, tributaries to St. Lawrence River proper.
83	Lower Mississippi.................	Yazoo.
97	James..................................	
98	Lower Mississippi.................	Do.
99	Upper Mississippi.................	Tributaries from the west.
128	Lower Mississippi.................	Yazoo.
130	Upper Mississippi.................	Tributaries from the west.
131	Missouri...............................	Platte, Kansas.
134	Colorado...............................	Data near Yuma, Ariz., repeated.
	Great Basin...........................	Susan, Owens, Mohave.
169	Lower Mississippi.................	Yazoo.
177	Colorado...............................	Below junction with Gila.
	Great Basin...........................	Susan repeated, Owens, Mohave.
	North Pacific coast................	Rogue, Umpqua, Siletz.
205	Lower Mississippi.................	Yazoo, Homochitto.
213	Colorado...............................	Data at Hardyville repeated; at Yuma, Salton Sea.
	Great Basin...........................	Owens, Mohave.
251	Colorado...............................	Yuma and Salton Sea stations repeated.
271	Great Basin...........................	Owens River basin.

The order of treatment of stations in any basin in these papers is downstream. The main stem of any river is determined on the basis of drainage area, local changes in name and lake surface being disregarded. After all stations from the source to the mouth of the main stem of the river have been given, the tributaries are taken up in regular order from source to mouth. The tributaries are treated the same as the main stream, all stations in each tributary basin being given before taking up the next one below.

The exceptions to this rule occur in the records for Mississippi River, which are given in four parts, as indicated above, and in the records for large lakes, where it is often clearer to take up the streams in regular order around the rim of the lake than to cross back and forth over the lake surface.

DEFINITION OF TERMS.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups: (1) Those which represent a rate of flow, as second-feet, gallons per minute, miner's inches, and run-off in second-feet per square mile, and (2) those which represent the actual quantity of water, as run-off in depth in inches and acre-feet. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed by the use of the factors given in the following table of equivalents.

"Gallons per minute" is generally used in connection with pumping and city water supply.

The "miner's inch" is the rate of discharge of water that passes through an orifice 1 inch square under a head which varies locally. It is commonly used by miners and irrigators throughout the West, and is defined by statute in each State in which it is used.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off, depth in inches on drainage area," is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage for irrigation work.

CONVENIENT EQUIVALENTS.

The following is a list of convenient equivalents for use in hydraulic computations:

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,272 gallons for one day.
1 second-foot equals 6.23 British imperial gallons per second.
1 second-foot for one year covers 1 square mile 1.131 feet or 13.572 inches deep.
1 second-foot for one year equals 31,536,000 cubic feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one day covers 1 square mile 0.03719 inch deep.
1 second-foot for one 28-day month covers 1 square mile 1.041 inches deep.
1 second-foot for one 29-day month covers 1 square mile 1.079 inches deep.
1 second-foot for one 30-day month covers 1 square mile 1.116 inches deep.
1 second-foot for one 31-day month covers 1 square mile 1.153 inches deep.
1 second-foot for one day equals 1.983 acre-feet.
1 second-foot for one 28-day month equals 55.54 acre-feet.
1 second-foot for one 29-day month equals 57.52 acre-feet.
1 second-foot for one 30-day month equals 59.50 acre-feet.
1 second-foot for one 31-day month equals 61.49 acre-feet.
100 California miner's inches equal 18.7 United States gallons per second.
100 California miner's inches equal 96.0 Colorado miner's inches.
100 California miner's inches for one day equal 4.96 acre-feet.
100 Colorado miner's inches equal 2.60 second-feet.
100 Colorado miner's inches equal 19.5 United States gallons per second.
100 Colorado miner's inches equal 104 California miner's inches.
100 Colorado miner's inches for one day equal 5.17 acre-feet.
100 United States gallons per minute equal 0.223 second-foot.
100 United States gallons per minute for one day equal 0.442 acre-foot.
1,000,000 United States gallons per day equal 1.55 second-feet.
1,000,000 United States gallons equal 3.07 acre-feet.
1,000,000 cubic feet equal 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 foot equals 0.3048 meter.
1 mile equals 1.60935 kilometers.
1 mile equals 5,280 feet.
1 acre equals 0.4047 hectare.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square, nearly.
1 square mile equals 2.59 square kilometers.
1 cubic foot equals 0.0283 cubic meter.
1 cubic foot equals 7.48 gallons.
1 cubic foot of water weighs 62.5 pounds.
1 cubic meter per minute equals 0.5886 second-foot.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 76.0 kilogram-meters per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
1⅓ horsepower equal about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = net horsepower on water wheel realizing 80 per cent of theoretical power.

EXPLANATION OF TABLES.

For each drainage basin there is given a brief description of general conditions covering such features as area, source, tributaries, topography, geology, conditions of forestation, rainfall, ice conditions, irrigation, storage, power possibilities, and other special features of importance or interest.

For each regular current-meter gaging station are given in general, and so far as available, the following data: Description of station, list of discharge measurements, table of daily gage heights, table of daily discharges, table of monthly and yearly discharges and run-off. For stations located at weirs or dams the gage-height table is omitted.

In addition to statements regarding the location and installation of current-meter stations the descriptions give information in regard to any conditions which may affect the constancy of the relation of gage height to discharge, covering such points as ice, logging, shifting conditions of flow, and backwater; also information regarding diversions which decrease the total flow at the measuring section. Statements are also made regarding the accuracy and reliability of the data.

The discharge-measurement table gives the results of the discharge measurements made during the year, including the date, name of hydrographer, width and area of cross section, gage height, and discharge in second-feet.

The table of daily gage heights gives the daily fluctuations of the surface of the river as found from the mean of the gage readings taken each day. At most stations the gage is read in the morning and in the evening. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. All gage heights during ice conditions, backwater from obstructions, etc., are published as recorded, with suitable footnotes. The rating is not applicable for such periods unless the proper corrections to the gage heights are known and applied. Attention is called to the fact that the zero of the gage is placed at an arbitrary datum and has no relation to zero flow or the bottom of the river. In general, the zero is located somewhat below the lowest known flow, so that negative readings shall not occur.

The discharge measurements and gage heights are the base data from which rating tables, daily discharge tables, and monthly discharge tables are computed.

The rating table gives, either directly or by interpolation, the discharge in second-feet corresponding to every stage of the river recorded during the period for which it is applicable. It is not published in this report but can be determined from the daily gage heights and daily discharges for the purposes of verifying the published results as follows.

First plot the discharge measurements for the current and earlier years on cross-section paper with gage heights in feet as ordinates and discharge in second-feet as abscissæ. Then tabulate a number of gage heights taken from the daily gage-height table for the complete range of stage given and the corresponding discharges for the days selected from the daily discharge table and plot the values on cross-section paper. The last points plotted will define the rating curve used and will lie among the plotted discharge measurements. After drawing the rating curve, a table can be developed by scaling off the discharge in second-feet for each tenth foot of gage height. These values should be so adjusted that the first differences shall always be increasing or constant, except for known backwater conditions.

The table of daily discharges gives the discharges in second-feet corresponding to the observed gage heights as determined from the rating tables.

In the table of monthly discharge the column headed "Maximum" gives the mean flow, as determined from the rating table, for the day when the mean gage height was highest. As the gage height is the mean for the day, it does not indicate correctly the stage when the water surface was at crest height and the corresponding discharge consequently larger than given in the "Maximum" column. Likewise, in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow in cubic feet for each second during the month. On this the computations for the remaining columns, which are defined on page 13, are based.

FIELD METHODS OF MEASURING STREAM FLOW.

There are three distinct methods of determining the flow of open-channel streams: (1) By measurements of slope and cross section and the use of Chezy's and Kutter's formulas; (2) by means of a weir or dam; (3) by measurements of the velocity of the current and of the area of the cross section. The method chosen depends on the local physical conditions, the degree of accuracy desired, the funds available, and the length of time that the record is to be continued.

Slope method.—Much information has been collected relative to the coefficients to be used in the Chezy formula, $v=c\sqrt{Rs}$. This has been utilized by Kutter, both in developing his formula for c and in determining the values of the coefficient n which appear therein. The results obtained by the slope method are in general only roughly approximate, owing to the difficulty in obtaining accurate data and the uncertainty of the value for n to be used in Kutter's formula. The most common use of this method is in estimating the flood discharge of a stream when the only data available are the cross section, the slope as shown by marks along the bank, and a knowledge of the general conditions. It is seldom used by the United States Geological Survey.[a]

Weir method.—Relatively few stations are maintained at weirs or dams by the United States Geological Survey. Standard types of sharp-crested and broad-crested weirs within the limits for which accurate coefficients have been experimentally obtained give very accurate records of discharge if properly maintained. At practically all broad-crested weirs, however, there is a diversion of water either through or around the dam, usually for the purpose of development of water power. The flow is often complicated and the records are subject to errors from such sources as leakage through the dam, backwater at high stages, uncertainty regarding coefficient, irregularity of crest, obstructions from logs or ice, use of flashboards, old turbines with imperfect ratings, and many others depending on the type of development and the uses of the diverted water.

In general records of discharge at dams are usually accurate enough for practical use if no others are available. It has been the general experience of the United States Geological Survey, however, that records at current-meter gaging stations under unobstructed channel conditions are more accurate than those collected at dams, and where the conditions are reasonably favorable are practically as good as those obtained at sharp-crested weirs.[b]

Velocity method.—Streams in general present throughout their courses to a greater or less extent all conditions of permanent, semipermanent, and varying conditions of flow. In accordance with the location of the measuring section with respect to these physical conditions, current-meter gaging stations may in general be divided into four classes—(1) those with permanent conditions of flow; (2) those with beds which change only during extreme high water; (3) those with beds which change frequently, but which do not cause a variation of more than about 5 per cent of the discharge curves from year to year; and (4) those with constantly shifting beds. In determining the daily flow different office methods are necessary for each class. The field data on which the determinations are based and the methods of collecting them are, however, in general the same.

Great care is taken in the selection and equipment of gaging stations for determining discharge by velocity measurements, in

[a] Full information regarding this method is given in text-books on hydraulics.

[b] The determination of discharge over the different types of weirs and dams is treated fully in "Weir experiments, coefficients, and formulas" (Water-Supply Paper 200) and in the various textbooks on hydraulics. "Turbine water-wheel tests and power tables" (Water-Supply Paper 180) treats of the discharge through turbines when used as meters. The edition of the latter water-supply paper is nearly exhausted. It can, however, be consulted at most of the larger libraries of the country or it can be obtained from the superintendent of documents, Washington, D. C., at a cost of 20 cents.

order that the data may have the required degree of accuracy. They are located, as far as possible, at such points that the relation between gage height and discharge will always remain constant for any given stage. The experience of engineers of the Geological Survey has been that permanency of conditions of flow is the prime requisite of any current-meter gaging station when maintained for several years unless funds are available to cover all changes in conditions of flow. A straight, smooth section without cross currents, backwater, boils, etc., at any stage is highly desirable, but on most streams is not attainable except at the cost of a cable equipment. Rough, permanent sections, if measurements are properly made by experienced engineers, taking measuring points at a distance apart of 5 per cent or less of the total width, will, within reasonable limits, yield better results for a given outlay of money than semi-permanent or shifting sections with smooth, uniform current. So far as possible stations are located where the banks are high and not subject to overflow at high stages and out of the influence of tributary streams, dams, or other artificial obstructions which might affect the relation between gage height and discharge.

A gaging station consists essentially of a gage for determining the daily fluctuations of stage of the river and some structure or apparatus from which discharge measurements are made, usually a bridge or cable.

The two factors required to determine the discharge of a stream past a section perpendicular to the mean direction of the current are the area of the cross section and the mean velocity of flow normal to that section.

In making a measurement with a current meter a number of points, called measuring points, are measured off above and in the plane of the measuring section at which observations of depth and velocity are taken. (See Pl. I, *A*.) These points are spaced equally for those parts of the section where the flow is uniform and smooth and are spaced unequally for other parts according to the discretion and judgment of the engineer. In general the points should not be spaced farther apart than 5 per cent of the channel width, nor farther apart than the approximate mean depth of the section at the time of measurement.

The measuring points divide the total cross section into elementary strips at each end of which observations of depth and velocity are made. The discharge of any elementary strip is the product of the average of the depths at the two ends times the width of the strip times the average of the mean velocities at the two ends of the strip. The sum of the discharges of the elementary strips is the total discharge of the stream.[a]

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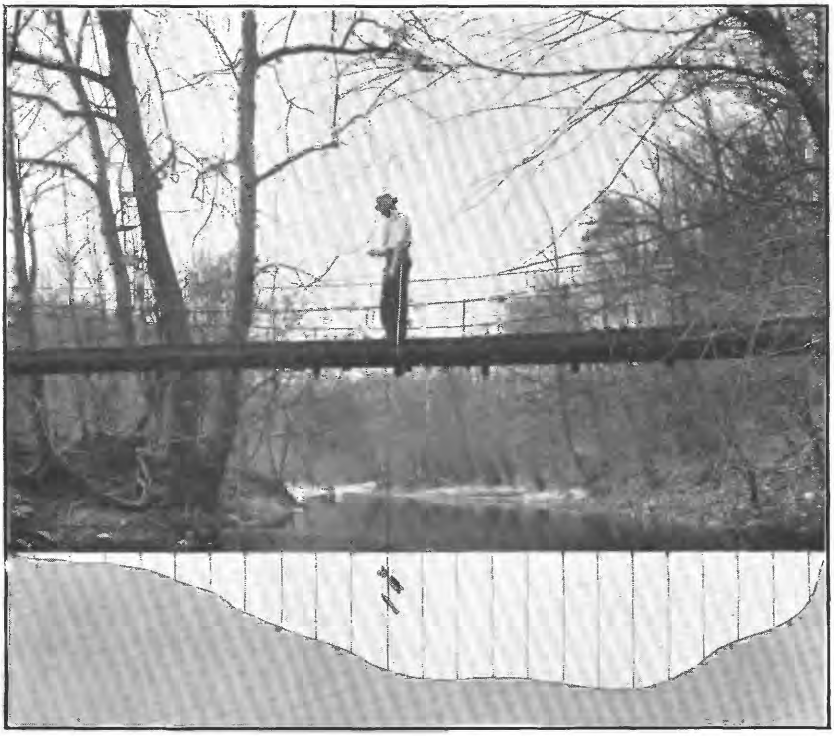
[a] For a discussion of methods of computing the discharge of a stream see Engineering News, June 25, 1908.



A. FOR BRIDGE MEASUREMENT.

B. FOR WADING MEASUREMENT.

TYPICAL GAGING STATIONS.

Depths for the determination of the area are usually obtained by sounding with the current meter and cable. In rough sections or swift current an ordinary weight and cable are used, particular care being taken that all observations shall be in the plane of the cross section.

Two methods of determining the velocity of flow of a stream are in general use—the float method and the current-meter mothod.

The float method, with its various modifications of surface, subsurface, and tube or rod floats, is now considered obsolete in the ordinary practice of the United States Geological Survey. The use of this method is limited to special conditions where it is impracticable to use the current meter, such as in places where large quantities of ice or débris which may damage the meter are flowing with the current, and for miscellaneous measurements or other work where a high degree of accuracy is not necessary. Tube floats are very satisfactory for use in canals with regular bottoms and even flow of current. Measurements by the float method are made as follows: The velocity of flow of the stream is obtained by observing the time which it takes floats set free at different points across the stream to pass between two range lines about 200 feet apart. The area used is the mean value obtained from several cross sectioms neasured between the two range lines. The chief disadvantages of this method are difficulty in obtaining the correct value of mean area for the course used and uncertainty regarding the proper coefficient to apply to the observed velocity.[a]

The Price current meter is now used almost to the exclusion of other types of meters by the United States Geological Survey in the determination of the velocity of flow of water in open channels, a use for which it is adapted under practically all conditions.[b]

Plate II shows in the center the new type of penta-recording current meter equipped for measurements at bridge and cable stations; on the left the same type of meter is shown equipped for wading measurements, to record by the acoustic method; on the right the meter is shown equipped to record electrically. (See Pl. I, *B*.) Briefly, the meter consists of six cups attached to a vertical shaft which revolves on a conical hardened steel point when immersed in moving water. The revolutions are indicated electrically. The rating, or relation between the velocity of moving water and the revolutions of the wheel, is determined for each meter by drawing it through still water for a given distance at different speeds and noting the number of revolutions for each run. From these data a rating table

[a] Further information regarding the float method is given in Water-Supply Paper 95 and the various textbooks on stream flow.

[b] See Hoyt, J. C., and others, Use and care of the current meter as practiced by the U. S. Geological Survey: Trans. Am. Soc. Civil Eng., vol. 66, 1910, p. 70.

is prepared which gives the velocity per second of moving water for any number of revolutions in a given time interval. The ratio of revolutions per second to velocity of flow in feet per second is very nearly a constant for all speeds and is approximately 0.45.

Three classes of methods of measuring velocity with current meters are in general use—multiple-point, single-point, and integration.

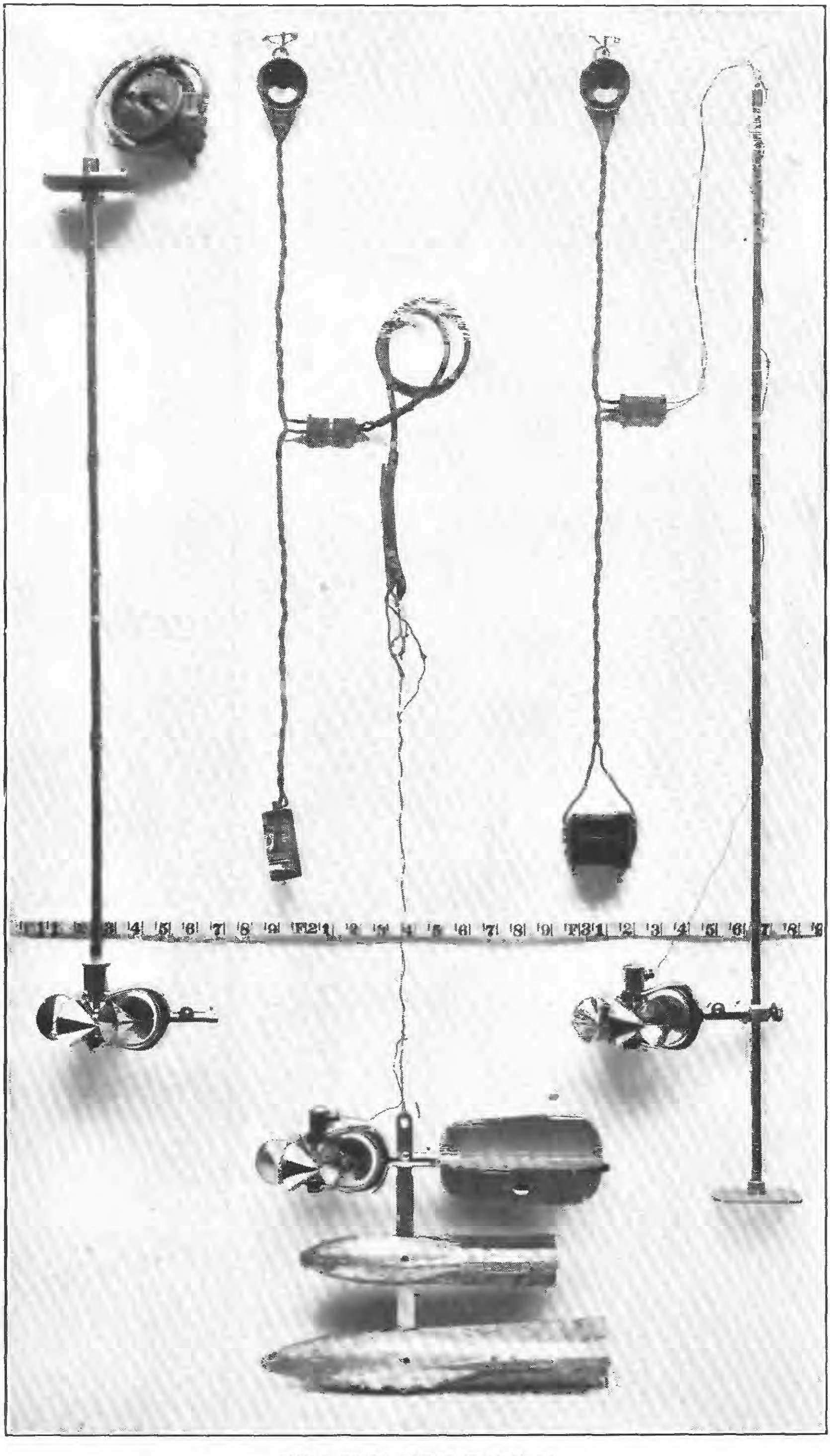
The two principal multiple-point methods in general use are the vertical velocity curve and 0.2 and 0.8 depth.

In the vertical velocity curve method a series of velocity determinations is made in each vertical at regular intervals, usually about 10 to 20 per cent of the depth apart. By plotting these velocities as abscissas and their depths as ordinates and drawing a smooth curve among the resulting points, the vertical velocity curve is developed. This curve shows graphically the magnitude and changes in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the area bounded by this velocity curve and its axis by the depth. This method of obtaining the mean velocity in the vertical is probably the best known, but on account of the length of time required to make a complete measurement its use is largely limited to the determination of coefficients for purposes of comparison and to measurements under ice.

In the second multiple-point method the meter is held successively at 0.2 and 0.8 depth, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. (See Pl. I, *A*.) On the assumption that the vertical velocity curve is a common parabola with horizontal axis, the mean of the velocities at 0.22 and 0.79 depth will give (closely) the mean velocity in the vertical. Actual observations under a wide range of conditions show that this multiple-point method gives the mean velocity very closely for open-water conditions and that in a completed measurement it seldom varies as much as 1 per cent from the value given by the vertical velocity curve method. Moreover, the indications are that it holds nearly as well for ice-covered rivers. It is very extensively used in the regular practice of the United States Geological Survey.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity or at an arbitrary depth for which the coefficient for reducing to mean velocity has been determined or must be assumed.

Extensive experiments by means of vertical velocity curves show that the thread of mean velocity generally occurs between 0.5 and 0.7 total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, and at this point the meter is held in most of the measurements made by the single-point method. A large number of vertical velocity curve measurements, taken on many streams and under varying conditions, show that the average



SMALL PRICE CURRENT METERS.

coefficient for reducing the velocity obtained at 0.6 depth to mean velocity is practically unity. The variation of the coefficient from unity in individual cases is, however, greater than in the 0.2 and 0.8 method and the general results are not as satisfactory.

In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the effect of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocity taken at the subsurface to the mean has been found to be in general from about 0.85 to 0.95, depending on the stage, velocity, and channel conditions. The higher the stage the larger the coefficient. This method is especially adapted for flood measurements, or when the velocity is so great that the meter can not be kept in the correct position for the other methods.

The vertical integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface and noting the number of revolutions and the time taken in the operation. This method has the advantage that the velocity at each point of the vertical is measured twice. It is useful as a check on the point methods. In using the Price meter great care should be taken that the vertical movement of the meter is not rapid enough to vitiate the accuracy of the resulting velocity.

The determination of the flow of an ice-covered stream is difficult, owing to diversity and instability of conditions during the winter period and also to lack of definite information in regard to the laws of flow of water under ice. The method now employed is to make frequent discharge measurements during the frozen periods by the 0.2 and 0.8 and the vertical velocity curve methods, and to keep an accurate record of the conditions, such as the gage height to the surface of the water as it rises in a hole cut in the ice, and the thickness and character of the ice. From these data an approximate estimate of the daily flow can be made by constructing a rating curve (really a series of curves) similar to that used for open channels, but considering, in addition to gage heights and discharge, the varying thickness of ice.[a]

OFFICE METHODS OF COMPUTING AND STUDYING DISCHARGE AND RUN-OFF.

At the end of each year the field or base data for current-meter gaging stations, consisting of daily gage heights, discharge measurements, and full notes, are assembled. The measurements are plotted on cross-section paper and rating curves are drawn wherever feasible. The rating tables prepared from these curves are then applied to

[a] For information in regard to flow under ice cover see Water-Supply Paper U. S. Geol. Survey No. 187.

the tables of daily gage heights to obtain the daily discharges, and from these applications the tables of monthly discharge and run-off are computed.

Rating curves are drawn and studied with special reference to the class of channel conditions which they represent. (See p. 17.) The discharge measurements for all classes of stations when plotted with gage heights in feet as ordinates and discharges in second-feet as abscissas define rating curves which are generally more or less parabolic in form. In many cases curves of area in square feet and mean velocity in feet per second are also constructed to the same scale of ordinates as the discharge curve. These are used mainly to extend the discharge curves beyond the limits of the plotted discharge measurements, and for checking purposes to avoid errors in the form of the discharge curve and to determine and eliminate erroneous measurements.

For every rating table the following assumptions are made for the period of application of the table: (*a*) That the discharge is a function of and increases gradually with the stage; (*b*) that the discharge is the same whenever the stream is at a given stage, and hence such changes in conditions of flow as may have occurred during the period of application are either compensating or negligible, except that the rating is not applicable for known conditions of ice, log jams, or other similar obstructions; (*c*) that the increased and decreased discharge due to change of slope on rising and falling stages is either negligible or compensating.

As already stated, the gaging stations may be divided into several classes, as indicated in the following paragraphs:

The stations of class 1 represent the most favorable conditions for an accurate rating and are also the most economical to maintain. The bed of the stream is usually composed of rock, and is not subject to the deposit of sediment and loose material. This class includes also many stations located in a pool below which is a permanent rocky riffle that controls the flow like a weir. Provided the control is sufficiently high and close to the gage to prevent cut and fill at the gaging point from materially affecting the slope of the water surface, the gage height will for all practical purposes be a true index of the discharge. Discharge measurements made at such stations usually plot within 2 or 3 per cent of the mean-discharge curve, and the rating developed from that curve represents a very high degree of accuracy. For examples of this class see stations of the north Atlantic coast drainage basins.

Class 2 is confined mainly to stations on rough, mountainous streams with steep slopes. The beds of such streams are as a rule comparatively permanent during low and medium stages, and when the flow is sufficiently well defined by an adequate number of discharge measurements before and after each flood the stations of this class give nearly as good results as those of class 1. As it is seldom possible to make measurements covering the time of change at flood stage, the assumption is often made that the curves before and after the flood converged to a common point at the highest gage height recorded during the flood. Hence the only uncertain period occurs during the few days of highest gage heights covering the period of actual change in conditions of flow. For examples of this class see stations in the upper Missouri River basin.

Class 3 includes most of the current-meter gaging stations maintained by the United States Geological Survey. If sufficient measurements could be made at stations of this class, results would be obtained nearly equaling those of class 1, but owing to the limited funds at the disposal of the Survey this is manifestly impossible, nor is it necessary for the uses to which discharge data are applied. The critical points are, as a rule, at relatively high or low stages. The percentage error, however, is greater at low stages. No absolute rule can be laid down for stations of this class. Each rating curve must be constructed mainly on the basis of the measurements of the current year, the engineer being guided largely by the past history of the station and the following general law: If all measurements ever made at a station of this class are plotted on cross-section paper, they will define a mean curve which may be called a standard curve. It has been found in practice that if after a change caused by high stage a relatively constant condition of flow occurs at medium and low stages, all measurements made after the change will plot on a smooth curve which is practically parallel to the standard curve with respect to ordinates or gage heights. This law of the parallelism of ratings is the fundamental basis of all ratings and estimates at stations with semipermanent and shifting channels. It is not absolutely correct, but, with few exceptions, answers all the practical requirements of estimates made at low and medium stages after a change at a high stage. This law appears to hold equally true whether the change occurs at the measuring section or at some controlling point below. The change is, of course, fundamentally due to change in the channel caused by cut or fill, or both, at or near the measuring section. For all except small streams the changes in section usually occur at the bottom. The following simple but typical examples illustrate this law:

(*a*) If 0.5 foot of planking were to be nailed on the bottom of a well-rated wooden flume of rectangular section, there would result, other conditions of flow being equal, new curves of discharge, area, and velocity, each plotting 0.5 foot above the original curves when referred to the original gage. In other words, this condition would be analogous to a uniform fill or cut in a river channel which either reduces or increases all three values of discharge, area, and velocity for any gage height. In practice, however, such ideal conditions rarely exist.

(*b*) In the case of a cut or fill at the measuring section, there is a marked tendency toward decrease or increase, respectively, of the velocity. In other words, the velocity has a compensating effect, and if the compensation is exact at all stages the discharge at a given stage will be the same under both the new and the old conditions.

(*c*) In the case of uniform change along the crest of a weir or rocky control, the area curve will remain the same as before the change, and it can be shown that here again the change in velocity curve is such that it will produce a new discharge curve essentially parallel to the original discharge curve with respect to their ordinates.

Of course in actual practice such simple changes of section do not occur. The changes are complicated and lack uniformity, a cut at one place being largely offset by a fill at another, and vice versa. If these changes are very radical and involve large percentages of the total area—as, for example, on small streams—there may result a wide departure from the law of parallelism of ratings. In complicated changes of section the corresponding changes in velocity which tend to produce a new parallel discharge curve may interfere with each other materially, causing eddies, boils, backwater, and radical changes in slope. In such extreme conditions, however, the measuring section would more properly fall under class 4 and would require very frequent measurements of discharge. Special stress is laid on the fact that in the lack of other data to the contrary the utilization of this law will yield the most probable results.

Slight changes at low or medium stages of an oscillating character are usually averaged by a mean curve drawn among them parallel to the standard curve, and if the individual measurements do not vary more than 5 per cent from the rating curve the results are considered good for stations of this class.

For examples of stations of this class see stations of the south Atlantic coast and eastern Gulf of Mexico drainage basins.

Class 4 comprises stations that have soft, muddy, or sandy beds. Good results can be obtained from such sections only by frequent discharge measurements, the frequency varying from a measurement every two or three weeks to a measurement every day, according to the rate of diurnal change in conditions of flow. The following graphic method of determining the daily discharge of streams of this class is now used by the engineers of the United States Geological Survey almost exclusively, owing to the rapidity with which the computations can be made, the clearness with which changes in conditions of flow can be followed, and the accuracy of the results obtained.

In the graphic method of determining the daily discharge of streams with changeable beds, which was devised by R. H. Bolster, the discharge measurements for the entire year are first plotted with discharges as abscissas and gage heights as ordinates. The points so plotted are considered chronologically and, even though scattered, will usually locate one or more fairly well-defined curves, called standard curves. (See fig. 1.) In general the number and position of these standard curves is determined by the radical changes in the stream bed due to floods.

When stream beds change very rapidly it is necessary to change the position of the rating curve daily, making a new curve for each day. This daily curve is of the same form as the standard curve and is parallel to it with respect to ordinates. The rating curve for a day when a measurement is made passes through such plotted measurement, the discharge for that day being read off from the scale of discharge in second-feet, at the point of intersection of the curve and the mean gage height for the day. In order to locate the rating curve for other days, lines are drawn connecting consecutive measurements. These lines are called correction curves and should have the same curvature as that portion of the standard curve which lies vertically above or below them. These lines are divided into as many equal parts as there are days intervening between the measurements, on the assumption that the change in conditions of flow between any two consecutive measurements is uniform from day to day. The daily rating curve will then pass through these points of division, and the discharge is read directly from these curves at their point of intersection with the observed daily gage heights.

To facilitate the use of the method and obviate the use of daily rating curves, and to make it as rapid in application as the common method for permanent stations, the standard curve or curves, together with a vertical line of reference, should be transferred from the original station sheet to tracing cloth, which can be readily shifted vertically to any desired position by always keeping the two vertical reference lines in coincidence. Thus the daily rating curve, which is merely the standard curve transferred, can be placed in any desired position.

Another way of simplifying the work of applying this method is to use dividers. Always keep one point of the dividers coincident with the standard curve and always keep both points on the same vertical line of discharge. By spreading the points, the point which is not coincident with the standard curve can be made to trace any daily rating curve desired.

In applying and modifying this method, judgment must be used for long-time intervals of no measurements or for radical changes in the stream bed caused by sudden floods. The following tables and figure 1 illustrate the Bolster or graphic method of obtaining daily discharge:

List of measurements to illustrate graphic method of determining daily discharge.

No.	Date.	Gage height.	Discharge.	No.	Date.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
1	June 1	2.55	3,700	6	July 18	3.8	6,460
2	June 6	.55	500	7	July 20	2.2	2,330
3	June 14	1.4	1,200	8	July 22	.4	200
4	June 22	1.2	600	9	July 31	.9	150
5	July 2	1.5	500				

Daily gage heights and discharges to illustrate graphic method of determining daily discharge.

Day.	June.		July.		Day.	June.		July.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*		*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	3.0	4,870	1.5	530	16	1.1	760	3.5	5,370
2	2.5	3,580	1.5	500	17	1.0	620	3.2	4,610
3	2.0	2,490	1.5	570	18	1.0	580	3.7	6,150
4	1.5	1,610	1.6	730	19	1.1	640	4.0	7,080
5	1.0	930	1.6	780	20	1.2	690	3.0	4,160
6	.4	390	1.8	1,050	21	1.2	650	1.8	1,640
7	.6	510	1.7	970	22	1.3	690	.8	480
8	.6	490	1.7	1,020	23	1.5	850	.3	120
9	.7	550	1.9	1,320	24	1.8	1,170	.3	100
10	.8	620	2.0	1,510	25	1.7	990	.4	110
11	1.0	800	2.2	1,890	26	1.6	830	.4	90
12	1.5	1,400	2.6	2,720	27	1.6	780	.6	130
13	1.4	1,240	3.0	3,700	28	1.6	740	.7	150
14	1.4	1,200	3.6	5,440	29	1.6	700	.8	170
15	1.3	1,020	3.7	5,850	30	1.6	660	.9	180
					31			1.0	200

The computations have, as a rule, been carried to three significant figures. Computation machines, Crelle's tables, and the 20-inch slide rule have been generally used. All computations are carefully checked.

After the computations have been completed they are entered in tables and carefully studied and intercompared to eliminate or account for all gross errors so far as possible. Missing periods are filled in, so far as feasible, by means of comparison with adjacent streams. The attempt is made to complete years or periods of discharge, thus eliminating fragmentary and disjointed records. Full notes accompanying such estimates follow the monthly discharge tables.

For most of the northern stations estimates have been made of the monthly discharge during frozen periods. These are based on measurements under ice conditions whenever available, daily records of temperature and precipitation obtained from the United States Weather Bureau climate and crop reports, observers' notes of con-

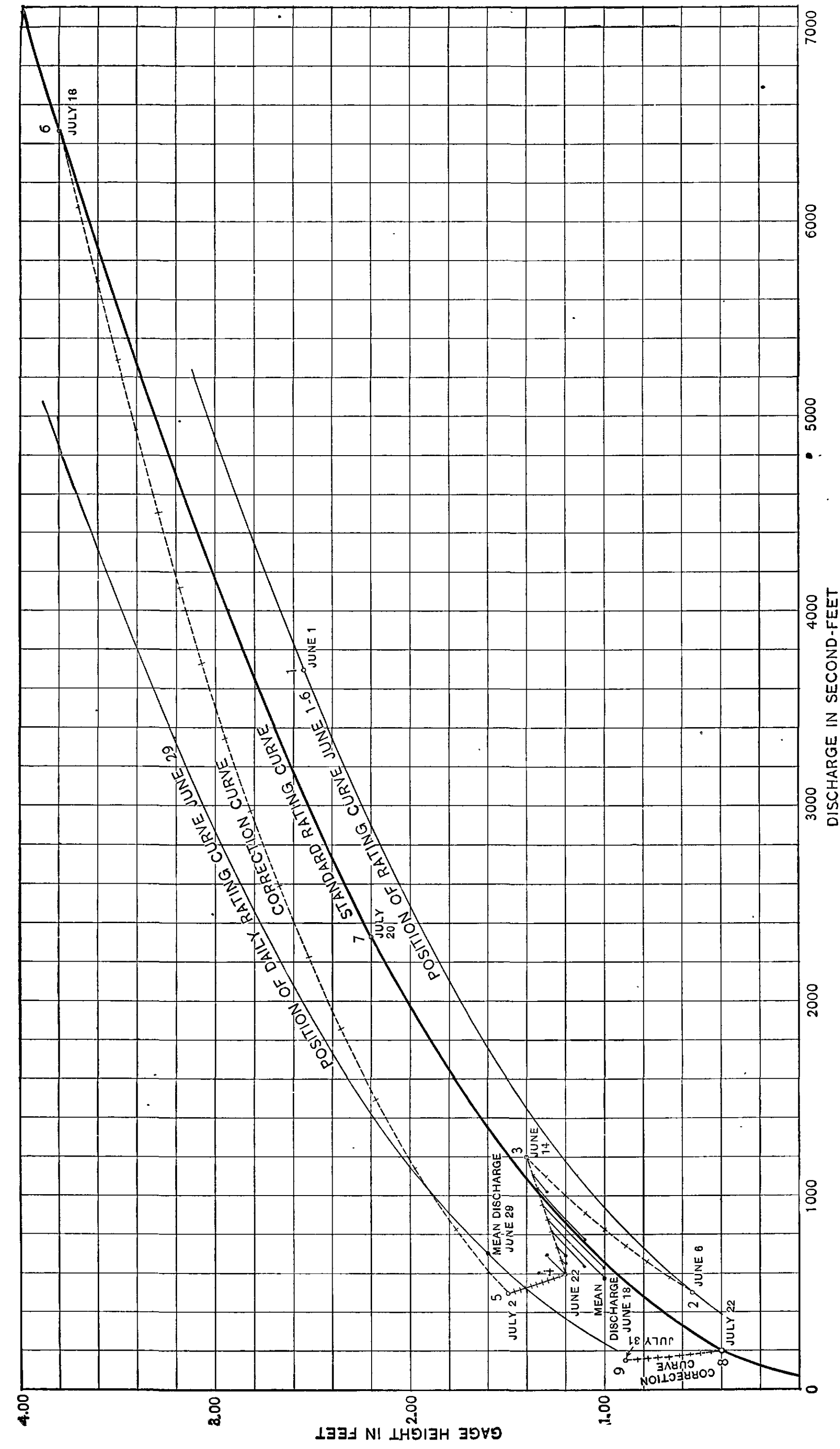


FIGURE 1.—Graphic method of determining daily discharge of streams with changeable beds.

ditions, and a careful and thorough intercomparison of results with adjacent streams. Although every care possible is used in making these estimates, they are often very rough, the data for some of them being so poor that the estimates are liable to as much as 25 to 50 per cent error. It is believed, however, that estimates of this character are better than none at all, and serve the purpose of indicating in a relative way the proportionate amount of flow during the frozen period. These estimates are, as a rule, included in the annual discharge. The large error of the individual months has a relatively small effect on the annual total, and it is for many purposes desirable to have the yearly discharge computed even though some error is involved in doing so.

ACCURACY AND RELIABILITY OF FIELD DATA AND COMPARATIVE RESULTS.

Practically all discharge measurements made under fair conditions are well within 5 per cent of the true discharge at the time of observation. Inasmuch as the errors of meter measurements are largely compensating, the mean rating curve, when well defined, is much more accurate than the individual measurements. Numerous tests and experiments have been made to test the accuracy of current-meter work. These show that it compares very favorably with the results from standard weirs, and, owing to simplicity of methods, usually give results that are much more reliable than those from stations at dams, where uncertainty regarding the coefficient and complicated conditions of flow prevail.

The work is, of course, dependent on the reliability of the observers. With relatively few exceptions, the observers perform their work honestly. Care is taken, however, to watch them closely and to inquire into any discrepancies. It is, of course, obvious that one gage reading a day does not always give the mean height for that day. As an almost invariable rule, however, errors from this source are compensating and virtually negligible in a period of one month, although a single day's reading may, when taken by itself, be considerably in error.

The effort is made to visit every station at least once each year for the purpose of making a measurement to determine the constancy of conditions of flow since the last measurement made during the preceding year, and also to check the elevation of the gage. On account of lack of funds or for other causes, some stations were not visited during the current year. If conditions of flow have been reasonably permanent up to the time of the last preceding measurement, it is considered best to publish values of discharge on the basis of the latest verified rating curve rather than to omit them altogether, although it should be distinctly understood that such records are at times subject to considerable error. This is also true, although to a less degree, of the period of records since the date of the last measurement of the current year. As a rule the accuracy notes are based on the assumption that the rating curve used is strictly applicable to the current year.

In order to give engineers and others information regarding the probable accuracy of the computed results, footnotes are added to the daily discharge tables, stating the probable accuracy of the rating tables used, and an accuracy column in inserted in the monthly discharge table. For the rating tables "well defined" indicates in general that the rating is probably accurate within 5 per cent; "fairly well defined," within 10 per cent; "poorly defined" or "approximate," within 15 to 25 per cent. These notes are very general and are based on the plotting of the individual measurements with reference to the mean rating curve.

The accuracy column in the monthly discharge table does not apply to the maximum or minimum nor to any individual day, but to the monthly mean. It is based on the accuracy of the rating, the probable reliability of the observer, and knowledge of local conditions. In this column, A indicates that the mean monthly flow is probably accurate within 5 per cent; B, within 10 per cent; C, within 15 per cent; D, within 25 per cent. Special conditions are covered by footnotes.

USE OF THE DATA.

In general the policy is followed of making available for the public the base data which are collected in the field each year by the survey engineers. This is done to comply with the law, but also for the express purpose of giving to any engineer the opportunity of examining the computed results and of changing and adjusting them as may seem best to him. Although it is believed that the rating tables and computed monthly discharges are as good as the base data up to and including the current year will warrant, it should always be borne in mind that the additional data collected at each station from year to year nearly always throw new light on data already collected and published, and hence allow more or less improvement in the computed results of earlier years. It is therefore expected that the engineer who makes serious use of the data given in these papers will verify all ratings and make such adjustments in earlier years as may seem necessary. The work of compiling, studying, revising, and republishing data for different drainage basins for five or ten year periods or more is carried on by the United States Geological Survey so far as the funds for such work are available.

The values in the table of monthly discharge are so arranged as to give only a general idea of the conditions of flow at the station, and it is not expected that they will be used for other than preliminary estimates.

The daily discharges are published to allow a more detailed study of the variation in flow and to determine the periods of deficient flow.

COOPERATIVE DATA.

Cooperative data of various kinds and also data regarding the run-off at many stations maintained wholly by private funds are incorporated in the surface water-supply reports of the United States Geological Survey.

Many stations throughout the country are maintained for specific purposes by private parties who supply the records gratuitously to the United States Geological Survey for publication. When such records are supplied by responsible parties and appear to be reasonably accurate they are verified, so far as possible, and estimated values of accuracy are given. Records clearly known to be worthless or misleading are not published. As it is, however, impossible to completely verify all such records furnished—because of lack of funds or for other causes—they are published for what they are worth, as they are of value as a matter of record and afford at least approximate information regarding stream flow at the particular localities. The Survey does not, however, assume any responsibility for inaccuracies found in such records, although most of them are believed to be reasonably good.

COOPERATION AND ACKNOWLEDGMENTS.

Special acknowledgments are due the following parties for cooperative assistance:

The State engineer of Colorado, Charles W. Comstock, paid the expenses of the hydrographers and the salaries of the observers at a number of stations in this drainage basin. He has also assisted in the work in other ways and has furnished some data which he procured independently for publication in this paper.

The Territorial engineer of New Mexico, Vernon T. Sullivan, has taken special interest in cooperative work and has borne more than half the expense of the New Mexico work from the $2,500 appropriated by the legislature for the whole Territory and from other funds pertaining to his office.

The Atchison, Topeka & Santa Fe Railway Company donated $1,000 to New Mexico, to be spent in cooperation with the United States Geological Survey in the Territory during 1909.

Prof. George J. Lyon, of Colorado College, furnished his services as hydrographer gratis for a number of weeks during the year.

The Tallahatchie drainage commission bore the expense of gage observers in the Yazoo River drainage basin, also for a part of the discharge measurements.

The State geologist of Arkansas, A. H. Purdue, maintained several stations in the White River drainage basin, the results being published by the United States Geological Survey.

Thanks are also due to the United States Weather Bureau, the A. L. Register Co., R. F. Proctor, F. H. Whiting, A. A. Weiland, and all other persons and companies who have rendered assistance.

DIVISION OF WORK.

The field data in the Arkansas River drainage basin were collected under the direction of W. B. Freeman, district engineer, by J. B. Stewart, G. H. Russell, and George F. Lyon.

The field data in the Canadian River drainage basin were collected under the general direction of W. B. Freeman, district engineer, by J. B. Stewart, but under the more immediate supervision of Vernon T. Sullivan, territorial engineer, by C. D. Miller and W. H. Sutton.

The field data for the Yazoo River drainage basin were collected under the direction of M. R. Hall, district engineer, by W. A. Lamb and E. H. Swett.

The field data in the White River drainage basin were collected under the direction of A. H. Horton, district engineer, by W. N. Gladson.

The ratings were made by W. B. Freeman, M. R. Hall, and R. H. Bolster. The computations were made and the completed data prepared for publication under the direction of R. H. Bolster, assistant engineer, by G. C. Stevens, R. C. Rice, J. G. Mathers, M. I. Walters, M. E. McChristie, and L. T. King. The manuscript was edited by Mrs. B. D. Wood.

GAGING STATIONS MAINTAINED IN THE LOWER MISSISSIPPI RIVER BASIN.

The following is a list of gaging stations maintained in the lower Mississippi River drainage basin by the United States Geological Survey and cooperative parties. The stations are arranged by river basins, in downstream order, as explained on page 11, tributaries being indicated by indention. Data for these stations have been published in the reports listed on page 9.

MERAMEC RIVER BASIN.

Meramec River near Meramec, Mo., 1903–1906.
Meramec River near Eureka, Mo., 1903–1906.
Meramec River (Station No. 1) at Fenton, Mo., 1903.
Meramec River (Station No. 2) below Fenton, Mo., 1903.
  Meramec Spring near Meramec, Mo., 1903–1906.
  Courtois Creek at Scotia, Mo., 1905–6.

WHITE RIVER BASIN.

White River at Beaver, Ark., 1909.
White River near Branson, Mo., 1909.
White River near Lead Hill, Ark., 1909.
White River near Cotter, Ark., 1909.
White River at Walls Ferry, Ark., 1909.
  Buffalo River near Gilbert, Ark., 1909.
  North Fork River near Henderson, Ark., 1909.
  Greer Spring at Greer, Mo., 1904.
  Little Red River near Pangburn, Ark., 1909.

ARKANSAS RIVER BASIN.

Arkansas River near Granite, Colo., 1895, 1897–1899, 1901.
Arkansas River near Salida, Colo., 1895–1903.
Arkansas River at Canon City, Colo., 1888–1909.
Arkansas River near Rock Canyon, Colo., 1889.
Arkansas River above Pueblo, Colo., 1885–1887.
Arkansas River at Pueblo, Colo., 1894–1909.
Arkansas River near Nepesta, Colo., 1897–1903.
Arkansas River near Manzanola, Colo., 1898.
Arkansas River near Rocky Ford, Colo., 1897–1903.
Arkansas River at La Junta, Colo., 1889, 1893–1895, 1903, 1908.
Arkansas River near Las Animas, Colo., 1898.
Arkansas River near Prowers, Colo., 1900, 1901, 1903.
Arkansas River near Amity canal head-gates, Colo., 1898–99.
Arkansas River near Granada, 1898–1901, 1904.
Arkansas River near Barton (Byron), Colo., 1893–94, 1901–2.
Arkansas River at Holly, Colo., 1907–1909.
Arkansas River near Syracuse, Kans., 1903–1906.
Arkansas River near Coolidge, Kans., 1903.
Arkansas River near Dodge, Kans., 1902–1906.
Arkansas River near Hutchinson, Kans., 1895–1905.
Arkansas River near Arkansas City, Kans., 1902–1906.
  Arkansas River, East Fork, near Leadville, Colo., 1890, 1903.
  Arkansas River, Tennessee Fork, near Leadville, Colo., 1890, 1903.
  Arkansas River, Lake Fork, near Arkansas Junction; Colo., 1903.
  Arkansas River, Lake Fork, near Leadville, Colo., 1890.
  Lake Creek near Twin Lakes, Colo., 1899–1900.
  Clear Creek near Granite, Colo., 1890.
  Cottonwood Creek:
    Cottonwood Creek, Middle Fork, near Buena Vista, Colo., 1890.
    Cottonwood Creek, South Fork, near Buena Vista, Colo., 1890.
  Grape Creek near Canon City, Colo., 1907–1909.
  Huerfano River near Undercliffe, Colo., 1908.
    Cucharas River at Walsenburg, Colo., 1907–8.
  Purgatory River at Trinidad, Colo., 1896–1899, 1905–1909.
  Purgatory River near Canon Entrance (Alfalfa), Colo., 1905–1907.
  Purgatory River near J. J. ranch, Colo., 1898.
  Purgatory River near Las Animas, Colo., 1889.
  Walnut River near Arkansas City, Kans., 1902–3.
  Arkansas River, Salt Fork, near Alva, Okla., 1904–5.
  Arkansas River, Salt Fork, near Tonkawa, Okla., 1903–5.
    Medicine River near Kiowa, Kans., 1895–96.

Cimarron River near Arkalon, Kans., 1895–96, 1903–1905.
Cimarron River near Kenton, Okla., 1904–5.
Cimarron River near Garrett, Okla., 1905–1907.
Cimarron River near Waynoka, Okla., 1903–1905.
Verdigris River near Independence, Kans., 1904.
Verdigris River near Liberty, Kans., 1895–1903.
Verdigris River near Catoosa, Okla., 1903–1905.
Fall River near Fall River, Kans., 1904–5.
Neosho River near Neosho Rapids, Kans., 1904.
Neosho River near Iola, Kans., 1895–1903.
Neosho River near Humboldt, Kans., 1904.
Neosho River (or Grand River) near Fort Gibson, Okla., 1899, 1903–1905.
Canadian River near Logan, N. Mex., 1905, 1909.
Canadian River at Calvin, Okla., 1904–1908.
Cimarron River at Ute Park, N. Mex., 1907–1909.
Cimarron River at Springer, N. Mex., 1907–1909.
Rayado River near Rayado, N. Mex., 1909.
Rayado River near Springer, N. Mex., 1907–1909.
Mora River at La Cueva, N. Mex., 1903–1908.
Mora River near Weber, N. Mex., 1903–4.
Mora River near Watrous, N. Mex., 1894–1896.
Sapello River at Sapello, N. Mex., 1903–4.
Sapello River at Los Alamos, N. Mex., 1903–1908.
Sapello Mill tailrace at Sapello, N. Mex., 1903–4.
Manuelitos River near Sapello, N. Mex., 1903–4.
Ute Creek near Logan, N. Mex., 1904–1906, 1909.
Beaver Creek at Beaver, Okla., 1904–5.
Canadian River, North Fork, near Woodward, Okla., 1903–1906.
Canadian River, North Fork, near El Reno, Okla., 1902–1908.
Canadian River, North Fork, near Oklahoma, Okla., 1899.
Canadian River, North Fork, near Eufaula, Okla., 1899.
Arkansas River canals:
Oxford Farmers Canal near Nepesta, Colo., 1903.
Colorado-Kansas Canal near Prowers, Colo., 1903.
Keese ditch near Prowers, Colo., 1903.

YAZOO RIVER BASIN.

Tallahatchie River at Batesville, Miss., 1906–1909.
Tallahatchie River at Philipp, Miss., 1908–9.
Yazoo River at Greenwood, Miss., 1908–9.
Yazoo River at Yazoo City, Miss., 1900–1905.
Coldwater River at Savage, Miss., 1908–9.
Yalobusha River at Grenada, Miss., 1906, 1908–9.
Sunflower River at Ruleville, Miss., 1908–9.
Sunflower River at Baird, Miss., 1908–9.

HOMOCHITTO RIVER BASIN.

Homochitto River at Rosetta, Miss., 1906.

RED RIVER BASIN.

Red River at Arthur City, Tex., 1905–6.
Red River, Salt Fork, at Mangum, Okla., 1905–6.
Turkey Creek at Olustee, Okla., 1905–1908.
Red River, North Fork, near Granite, Okla., 1903–1908.

Red River, North Fork, near Snyder, Okla., 1905.
Red River, North Fork, near Headrick, Okla., 1905–1908.
Red River, Elm Fork, near Mangum, Okla., 1905–1908.
Elk Creek near Hobart, Okla., 1904–1908.
Otter Creek near Mountain Park, Okla., 1903–1908.
Horse Creek near Mountain Park, Okla., 1905–6.
Otter Creek, Dry Fork, near Mountain Park, Okla., 1905–6.
Washita River near Anadarko, Okla., 1902–1908.
Ouachita River near Malvern, Ark., 1903–1905.
Ouachita River near Arkadelphia, Ark., 1905–6.

WHITE RIVER DRAINAGE BASIN.

DESCRIPTION.

White River rises in the Boston Mountains near the western border of Arkansas, nearly 50 miles south of the Arkansas-Missouri line, flows northward into Missouri, then bends southeastward and re-enters Arkansas, continuing its general southeasterly course to the southeast corner of Arkansas County, where its channel divides, one part entering Arkansas River and the other Mississippi River. The natural discharge of White River is into the Mississippi. The length of the river from its source to its mouth is about 300 miles by general course, but the stream is very crooked and, including the bends, it is probably not less than 400 miles long.

The important tributaries from the north are North Fork of White River, Black River, and Cache River; those from the south are Kings River, Buffalo Fork of White River, and Red River.

The basin comprises 27,700 square miles, of which 10,000 square miles lie in Missouri and the remainder in northern and eastern Arkansas. Topographically, it consists of two parts—a highland area, 22,200 square miles in extent, lying west of the St. Louis, Iron Mountain & Southern Railway, and an area of lowlands, including 5,500 square miles, lying east of this railroad.

The topography of the highland portion of the basin is rough. The rocks are sandstone, limestone, and shale, lying horizontal. Through these the main stream and all its tributaries have cut ravines that range in depth from a few score feet to more than 1,200 feet. Elevations in the Boston Mountains exceed 2,000 feet above sea level. The elevation of the bed of White River ranges from 1,250 feet at the north base of the mountains to less than 250 feet at Batesville. Throughout the distance between these two points there are no falls and but a few rapids.

The lowland area of the basin is level, and stands only a few feet above the water of the river at average stage. It is cut by numerous sloughs which have been formed by the clogging of the streams and the partial filling of horseshoe lakes. Probably all of it is susceptible to drainage.

The entire area was originally forest covered, but a large proportion of the river bottoms and the level parts of the uplands is now under cultivation. The steep rock-covered slopes, which constitute a considerable part of the area, are still forest covered.

The records kept at the agricultural experiment station at Fayetteville from 1871 to 1907, inclusive, show that the annual rainfall at that place ranges from a minimum of 34.58 inches in 1871 to a maximum of 67.48 inches in 1905. The average for the 37 years was 45.609 inches. The rainfall at Fayetteville is probably fairly representative for that part of the basin that lies within the highland division.

The average snowfall is about 9 inches. Snow lies on the ground but a few days at most, and there is seldom ice enough on the ground to interfere with travel.

Irrigation has not been attempted in this basin, but it is practicable in a small way along the stream bottoms, where the water may be taken from the streams, and on a still smaller scale on the benches of the hill slopes, where water from springs may be stored.

As the valleys are narrow and the banks in most places high, there are many points along the streams where water could be stored without flooding much land. Such storage sites may be found along White River and all its highland tributaries. Numerous large springs of fine water occur throughout the highland area.

Buffalo Fork of White River and that portion of White River above the mouth of Buffalo Fork can be utilized for logging or boating only during the rainy season. A series of Government dams above Batesville will, when completed, render White River navigable the year round as far up as the mouth of Buffalo Fork. In the lowland part of its course White River is navigable for small boats at all seasons.

A survey to determine the available water power along White River and its tributaries is now being conducted. The smaller of the numerous power sites can probably be made to furnish a few hundred horsepower and the larger ones several thousand horsepower.

WHITE RIVER AT BEAVER, ARK.

This station, which is located at the Missouri and North Arkansas Railroad bridge at Beaver, Ark., was established July 17, 1909, to obtain data for use in studying water power, water supply, flood control, storage, and navigation problems.

No important tributaries enter near the station.

The datum of the chain gage, which is fastened to the upstream handrail of the bridge, has not been changed. Measurements at high water are made from this bridge, at low water by wading.

The station is maintained under the direction of the state geologist of Arkansas.

Discharge measurements of White River at Beaver, Ark., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 3	W. N. Gladson	75	148	3.5	91
November 20	do	110	497	4.55	399
December 17	do	105	469	4.5	431

NOTE.—Measurements made by wading 1,000 feet above the bridge.

Daily gage height, in feet, of White River at Beaver, Ark., for 1909.

[Reno N. Lowe, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		3.58	3.2	3.05	3.25	3.7	16		3.3	3.15	3.15	3.85	4.6
2		3.5	3.2	3.05	3.25	3.7	17	4.4	3.3	3.1	3.15	4.1	4.52
3		3.5	3.2	3.05	3.25	3.7	18	4.2	3.3	3.1	3.15	4.25	4.45
4		3.5	3.2	3.05	3.25	3.7	19	4.05	3.3	3.1	3.2	4.7	4.35
5		3.5	3.2	3.05	3.55	6.38	20	4.0	3.3	3.1	3.25	4.5	4.3
6		3.48	3.25	3.05	4.4	8.85	21	3.9	3.25	3.12	3.3	4.35	4.3
7		3.42	3.25	3.05	3.85	7.35	22	3.9	3.22	3.15	3.45	4.15	4.22
8		3.4	3.25	3.05	4.25	6.12	23	3.8	3.2	3.12	3.45	4.12	4.22
9		3.4	3.2	3.25	4.2	5.5	24	3.8	3.2	3.12	3.4	4.0	4.1
10		3.4	3.18	3.25	4.0	5.2	25	3.7	3.2	3.1	3.35	3.9	4.0
11		3.4	3.18	3.2	3.8	4.98	26	3.7	3.2	3.1	3.3	3.85	4.05
12		3.4	3.18	3.15	3.7	4.82	27	3.7	3.2	3.1	3.25	3.8	4.05
13		3.35	3.18	3.15	3.65	4.7	28	3.7	3.2	3.1	3.25	3.72	4.0
14		3.35	3.2	3.25	3.65	4.7	29	3.6	3.25	3.1	3.25	3.7	4.0
15		3.3	3.18	3.15	3.6	4.65	30	3.6	3.25	3.1	3.25	3.7	4.25
							31	3.6	3.22		3.3		3.9

WHITE RIVER NEAR BRANSON, MO.

This station, which is located at the St. Louis, Iron Mountain & Southern Railway bridge near Branson, Mo., was established July 19, 1909, to obtain data for use in studying water power, water supply, flood control, storage, and navigation problems.

Turkey Creek enters the river on the right bank about 600 feet below the section.

The datum of the gage, which is fastened to the downstream guard rail of the bridge, has remained unchanged. At high water measurements are made from this bridge; at low water they are made by wading.

This station is maintained under the direction of the state geologist of Arkansas.

Discharge measurements of White River near Branson, Mo., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage. height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
November 22	W. N. Gladson	270	946	3.3	1,280
December 18	do	268	972	3.4	1,110

Daily gage height, in feet, of White River near Branson, Mo., for 1909.

[William Kruger, observer.]

Day.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	3.10	2.55	2.30	2.50	2.85	16	......	2.70	2.45	2.50	3.65	3.55
2	......	3.00	2.50	2.30	2.50	2.85	17	......	2.65	2.45	2.50	3.72	3.50
3	......	3.00	2.50	2.30	2.50	2.80	18	......	2.60	2.45	2.50	3.80	3.40
4	......	3.00	2.48	2.30	2.50	2.92	19	4.00	2.60	2.40	2.45	3.70	3.32
5	......	2.95	2.40	2.30	2.45	3.95	20	3.88	2.55	2.40	2.50	3.65	3.22
6	......	2.95	2.40	2.30	3.05	6.62	21	3.75	2.60	2.40	2.50	3.60	3.15
7	......	2.95	2.40	2.30	3.75	7.05	22	3.65	2.60	2.35	2.50	3.40	3.18
8	......	2.98	2.60	2.30	3.60	6.48	23	3.60	2.60	2.35	2.50	3.30	3.30
9	......	3.15	2.55	2.40	3.30	4.95	24	3.48	2.55	2.38	2.50	3.25	3.20
10	......	3.02	2.55	2.42	3.50	4.45	25	3.40	2.60	2.40	2.50	3.10	3.18
11	......	2.95	2.55	2.50	3.40	4.20	26	3.35	2.50	2.40	2.50	3.00	3.05
12	......	2.90	2.52	2.50	3.28	4.00	27	3.30	2.50	2.40	2.50	3.00	3.00
13	......	2.82	2.45	2.50	3.10	3.82	28	3.25	2.50	2.30	2.50	3.00	3.00
14	......	2.75	2.50	2.50	3.10	3.70	29	3.25	2.50	2.30	2.50	2.92	3.00
15	......	2.75	2.45	2.50	3.10	3.60	30	3.20	2.48	2.30	2.50	2.80	2.90
							31	3.20	2.45	......	2.50	......	3.00

WHITE RIVER NEAR LEAD HILL, ARK.

This station, which is located at Bradley's ferry, 5 miles northeast of Lead Hill, Ark., was established October 1, 1909, to obtain data for use in studying water power, navigation, flood control, and storage problems.

Fishtrap Shoals are about 400 feet below the station.

The gage consists of two vertical sections on the right bank of the river about 100 feet below the ferry. Its datum has not been changed. Measurements are made from the ferryboat.

The station is maintained under the direction of the state geologist of Arkansas.

Discharge measurements of White River near Lead Hill, Ark., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 19	W. N. Gladson	300	794	1.1	468
November 22	....do	300	936	2.4	1,400
December 20	....do	292	905	2.4	1,350

Daily gage height, in feet, of White River near Lead Hill, Ark., for 1909.

[Jerry Upshaw, observer.]

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	1.1	1.3	1.8	11	1.2	2.4	3.55	21	1.3	2.6	2.3
2	1.1	1.3	1.7	12	1.25	2.3	3.45	22	1.3	2.5	2.0
3	1.1	1.3	1.8	13	1.25	2.1	3.2	23	1.3	2.4	2.0
4	1.1	1.3	1.8	14	1.3	2.0	3.1	24	1.3	2.2	2.1
5	1.1	1.3	4.15	15	1.3	2.0	3.0	25	1.3	2.1	2.0
6	1.1	3.0	5.8	16	1.2	2.0	2.8	26	1.3	2.0	1.8
7	1.1	1.85	5.6	17	1.21	2.5	2.7	27	1.3	1.9	1.7
8	1.1	2.6	6.0	18	1.21	2.7	2.6	28	1.3	1.8	1.7
9	1.48	2.3	4.9	19	1.2	2.8	2.5	29	1.3	1.8	1.6
10	1.2	2.2	4.1	20	1.2	2.55	2.4	30	1.2	1.7	1.6
								31	1.3	......	2.0

WHITE RIVER NEAR COTTER, ARK.

This station, which is located at the St. Louis, Iron Mountain & Southern Railway bridge near Cotter, Ark., was established July 21, 1909, to obtain data for use in studying water power, water supply, flood control, storage, and navigation problems.

The station is about three-fourths of a mile below the mouth of Falling Ash Creek.

The datum of the gage, which is fastened to the upstream guardrail of the bridge, has remained unchanged. Measurements are made from the bridge, from a ferry about 500 feet above, or by wading.

This station is maintained under the direction of the State geologist of Arkansas.

Discharge measurements of White River near Cotter, Ark., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 31 [a]	W. N. Gladson	160	308	1.3	455
November 24 [b]	do	420	1,090	2.9	1,740
December 22 [b]	do	400	1,030	2.85	1,660

[a] Measurement by wading. [b] Measurement from the ferry.

Daily gage height, in feet, of White River near Cotter, Ark., for 1909.

[S. Butterfield, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.65	1.4	1.0	1.5	2.2
2		2.6	1.4	1.0	1.45	2.2
3		2.45	1.4	1.0	1.4	2.15
4		2.4	1.3	1.0	1.3	2.1
5		2.3	1.4	1.0	1.3	3.35
6		2.3	1.4	1.0	1.95	6.1
7		3.15	1.4	1.0	3.35	6.9
8		2.45	1.4	1.0	2.45	6.8
9		2.35	1.3	1.35	3.05	6.6
10		2.2	1.3	1.65	2.95	5.55
11		2.1	1.3	1.45	2.7	5.0
12		2.3	1.3	1.2	2.9	4.7
13		2.25	1.3	1.2	2.65	4.35
14		2.1	2.45	1.2	2.55	4.2
15		2.0	1.4	1.2	2.45	3.95
16		2.0	1.3	1.25	2.4	3.75
17		1.9	1.2	1.3	2.55	3.5
18		1.8	1.2	1.3	3.0	3.35
19		1.8	1.2	1.2	3.25	3.3
20		1.75	1.2	1.2	3.35	3.15
21	3.9	1.65	1.3	1.3	3.2	3.0
22	3.7	1.6	1.3	1.3	3.1	3.0
23	3.5	1.5	1.25	1.3	3.05	2.9
24	3.4	1.5	1.2	1.3	2.9	2.8
25	3.2	1.4	1.2	1.2	2.75	2.65
26	3.1	1.4	1.2	1.2	2.55	2.5
27	3.1	1.4	1.2	1.25	2.45	2.5
28	3.0	1.3	1.1	1.3	2.3	2.5
29	2.85	1.3	1.1	1.3	2.3	2.35
30	2.75	1.3	1.0	1.3	2.2	2.3
31	2.7	1.3		1.4		2.2

WHITE RIVER AT WALLS FERRY, ARK.

This station, which is located at the Government dam at Walls Ferry, Ark., will furnish data necessary in studying water power, navigation, and flood control problems. The discharge of the stream will be computed from the records of the gage heights above the lock, considering the dam as a weir. Discharge measurements will be made in order to determine the proper coefficients to be used. The first measurement was made in November, 1909.

This station is maintained under the direction of the State geologist of Arkansas.

The following discharge measurement was made by W. N. Gladson:

November 28, 1909: Width, 310 feet; area, 1,830 square feet; gage height, 6.8 feet; discharge, 2,790 second-feet.

BUFFALO RIVER NEAR GILBERT, ARK.

This station, which is located at the Missouri & North Arkansas Railroad bridge near Gilbert, Ark., was established July 16, 1909, to obtain data for use in studying water power and storage problems.

Bear Creek is tributary to Buffalo River from the right bank about one-fourth mile above the station.

The datum of the chain gage, which is fastened to the upstream guardrail of the bridge, from which high-water measurements are also made, has not been changed. Low-water measurements are made by wading. Measurements of high water may be complicated by the flow from Bear Creek.

This station is maintained under the direction of the State geologist of Arkansas.

Discharge measurements of Buffalo River near Gilbert, Ark., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
November 29	W. N. Gladson	65	98	3.0	131
December 23	do	68	128	3.2	155

NOTE.—Measurements made by wading.

Daily gage height, in feet, of Buffalo River near Gilbert, Ark., for 1909.

[Mrs. R. J. Williams, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.6	2.2	2.2	2.5	3.0	16	3.0	2.5	2.3	2.3	2.9	4.2
2		2.6	2.2	2.2	2.4	3.0	17	3.0	2.5	2.2	2.3	3.9	4.0
3		2.5	2.2	2.2	2.4	3.8	18	2.9	2.4	2.2	2.3	4.1	3.6
4		2.5	2.2	2.2	2.4	3.6	19	2.8	2.4	2.2	2.3	3.9	3.6
5		2.5	2.3	2.2	2.4	3.6	20	2.8	2.4	2.2	2.3	3.6	3.4
6		2.5	2.3	2.2	2.5	4.3	21	2.7	2.4	2.3	2.3	3.4	3.4
7		2.6	2.3	2.2	2.5	4.8	22	2.7	2.3	2.3	2.3	3.3	3.3
8		2.7	2.3	2.2	2.5	4.3	23	2.7	2.3	2.3	2.3	3.2	3.2
9		2.7	2.3	2.6	2.6	4.0	24	2.7	2.3	2.3	2.3	3.1	3.2
10		2.6	2.3	2.4	2.5	3.7	25	2.7	2.3	2.3	2.3	3.1	3.2
11		2.6	2.3	2.3	2.5	3.6	26	2.7	2.3	2.3	2.3	3.0	3.1
12		2.6	2.3	2.3	2.6	4.6	27	2.6	2.2	2.3	2.3	3.0	3.1
13		2.5	2.3	2.3	2.6	5.1	28	2.6	2.2	2.3	2.3	2.9	3.0
14		2.5	2.2	2.3	2.7	4.8	29	2.6	2.2	2.3	2.3	2.9	3.0
15		2.5	2.3	2.3	2.7	4.5	30	2.6	2.2	2.3	2.3	2.9	2.9
							31	2.6	2.2		2.3		2.9

NORTH FORK RIVER NEAR HENDERSON, ARK.

This station, which is located at Smith's ferry, near Henderson, Ark., was established July 23, 1909, to obtain data for use in studying water power, storage, and navigation problems.

Bayou Creek enters on the left bank about 1¼ miles above the station.

The gage consists of three vertical sections on the left bank near the ferry. Its datum has not been changed. Measurements are made from the ferryboat or by wading at low water.

This station is maintained under the direction of the State geologist of Arkansas.

Discharge measurements of North Fork River near Henderson, Ark., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 4[a]	W. N. Gladson	210	709	1.4	851
November 26	do	230	718	1.6	719
December 21	do	240	777	1.75	911

[a] Measurement by wading one-half mile below the ferry.

Daily gage height, in feet, of North Fork River near Henderson, Ark., for 1909.

[F. S. Field, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.1	1.7	1.5	1.6	1.8	16		1.7	1.75	1.4	1.7	1.9
2		2.0	1.6	1.5	1.65	1.85	17		1.6	1.65	1.5	1.75	1.8
3		2.9	1.55	1.5	1.8	1.9	18		1.6	1.5	1.5	1.7	1.7
4		2.9	1.5	1.4	1.75	1.8.	19		1.6	1.5	1.45	1.65	1.7
5		2.8	1.65	1.45	1.65	1.8	20		1.5	1.5	1.4	1.7	1.7
6		2.8	1.6	1.5	1.6	1.85	21		1.4	1.65	1.5	1.6	1.75
7		2.7	1.5	1.6	1.7	1.9	22		1.4	1.75	1.5	1.65	1.8
8		2.65	1.6	1.6	1.8	2.0	23	2.2	1.4	1.6	1.5	1.7	1.8
9		2.55	1.6	1.6	1.9	2.5	24	2.15	1.35	1.5	1.5	1.65	1.7
10		2.5	1.55	1.6	1.85	2.65	25	2.1	1.3	1.5	1.5	1.6	1.6
11		2.4	1.5	1.5	1.75	1.9	26	2.1	1.3	1.5	1.5	1.6	1.6
12		2.35	1.5	1.5	1.65	1.9	27	2.05	1.3	1.5	1.45	1.6	1.55
13		1.95	1.5	1.5	1.6	1.8	28	2.0	1.3	1.5	1.4	1.7	1.5
14		1.7	1.7	1.45	1.5	1.85	29	2.0	2.0	1.6	1.4	1.7	1.6
15		1.7	1.85	1.4	1.55	1.85	30	2.55	2.0	1.55	1.4	1.8	1.6
							31	2.1	1.9		1.5		1.6

LITTLE RED RIVER AT PANGBURN, ARK.

This station, which is located at Skillern's ferry, near Pangburn, Ark., was established July 15, 1909, to obtain data for use in studying water power, water supply, storage, and navigation problems.

Big Red Creek joins Little Red River about one-half mile below the station.

This stream is used to considerable extent for running logs. Log jams above and below the station affect the gage for short periods. Ice rarely, if ever, forms on this stream.

The gage consists of three vertical sections on the right bank near the ferry. Its datum has not been changed. Measurements are made from a ferryboat or by wading at low water.

This station is maintained under the direction of the State geologist of Arkansas.

Discharge measurements of Little Red River near Pangburn, Ark., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
November 28	W. N. Gladson	170	552	3.1	329
December 25	do	200	674	3.7	637

Daily gage height, in feet, of Little Red River near Pangburn, Ark., for 1909.

[A. J. Stolz, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.0	1.5	1.4	1.6	3.0	16	3.2	1.6	1.4	1.5	2.9	7.0
2		1.9	1.4	1.5	1.6	2.9	17	3.0	1.7	1.4	1.5	2.9	6.4
3		1.9	1.4	1.5	1.6	2.9	18	3.2	1.8	1.3	1.5	8.4	5.8
4		1.8	1.5	1.5	1.6	5.4	19	3.1	1.7	1.3	1.5	6.4	5.2
5		1.8	1.5	1.5	1.5	4.8	20	3.1	1.7	1.3	1.5	5.0	4.9
6		1.8	1.5	1.6	1.5	4.5	21	3.1	1.7	1.6	1.6	4.3	4.7
7		1.8	1.8	1.6	2.2	5.1	22	2.1	1.7	1.8	1.5	3.9	4.3
8		1.7	1.6	1.5	2.5	5.0	23	2.3	1.6	2.2	1.6	3.7	3.9
9		1.7	1.5	1.5	2.4	4.8	24	2.2	1.6	1.8	1.6	3.5	3.8
10		1.7	1.5	1.5	2.3	4.4	25	2.2	1.6	1.6	1.6	3.6	3.7
11		1.7	1.5	1.4	2.4	4.5	26	2.1	1.6	1.6	1.6	3.6	3.7
12		1.7	1.4	1.4	3.0	7.5	27	2.1	1.6	1.5	1.6	3.5	3.6
13		1.7	1.4	1.4	2.9	13.4	28	2.7	1.6	1.5	1.6	3.4	3.5
14	2.65	1.6	1.4	1.5	2.9	10.6	29	2.2	1.6	1.4	1.5	3.2	3.4
15	2.9	1.6	1.4	1.5	3.0	8.2	30	2.0	1.5	1.4	1.5	3.0	3.3
							31	2.0	1.5		1.5		3.2

ARKANSAS RIVER DRAINAGE BASIN.

DESCRIPTION.

The western rim of the Arkansas basin is formed by three of the highest mountain ranges of Colorado—the Saguache, Sangre de Cristo, and Culebra, each having summits more than 14,000 feet in altitude. The melting of the almost perpetual snow that mantles the high peaks near the north end of this rim furnishes water for three small creeks, the East, Lake, and Tennessee forks, which unite near Leadville to form the Arkansas.

From the junction of the forks the river flows a little east of south for about 75 miles, then turns to the east and cuts through a canyon whose perpendicular walls attain elevations of more than 2,000 feet above the water's edge, emerging finally into the plains region near Canon City. From Canon City to the Colorado-Kansas State line its general course is eastward for about 200 miles. Entering Kansas the river runs for 140 miles by general course a little south of east; it then makes a bold curve to the north, forming what is known as the Great Bend, below which it flows southeastward across Oklahoma to its junction with the Mississippi in northeastern Arkansas. The entire length of the stream from source to mouth is about 1,500 miles and its drainage basin includes 177,500 square miles.

In its upper course the Arkansas is fed by numerous small streams, generally short, which lie wholly in or have their sources in the mountains. Those that head in the mountains and flow out onto the prairies are used more or less for irrigation. The most important of these tributaries are Greenhorn, Huerfano, Apishapa, and Purgatory rivers. The plains tributaries include Black Squirrel, Horse, Two Butte and Big Sandy Creeks, Salt Fork, Cimarron, Verdigris, Grand, and Canadian rivers, and scores of smaller streams. The largest of these tributaries is Canadian River.

Above Pueblo, Colo., the drainage basin is generally mountainous, but toward the south the elevation decreases and the country is well marked by stream channels that trend in a general northeasterly direction. The streams on the north flow generally southward when they emerge from the mountains.

At the base of the mountains are the foothills, irregular and seared by canyons, and marked by disconnected mesas and buttes of different but moderate altitudes; beyond are great level plains, extending far to the east and constituting a portion of what was formerly known as the Great American Desert. East of the foothills and north of the river the topography is that typical of the Great Plains region, but to the south the surface of the plains is generally more accented. That part of the drainage basin that extends from the mountains to the Colorado-Kansas line embraces an area of about 25,000 square miles. Beyond this is the flat semiarid section of western Kansas, and then the more humid country in eastern Kansas, Oklahoma, and Arkansas.

The rocks exposed in the mountainous area present great variety, ranging from the metamorphic granites of Pikes Peak and the Royal Gorge of the Arkansas to the glacial drift in the upper valley of the Arkansas from Salida to Leadville and in the upper Grape Creek Range. Next to the granites the eruptive rocks are most common, and sedimentary rocks are found over wide areas.

In the plains region the principal rock exposures seen along the heavily eroded stream channels are shales, sandstone, and limestone in alternating layers. The soil cover, which is necessarily rather meager in the mountainous section, varies in the plains region from the upland sands and gravels of the mesas to the sandy loams and adobe clays of the river valleys. The adobe soils are very friable and dry and melt away rapidly under the action of water. Many of the dry intermittent channels, usually termed arroyos, are narrow and have high vertical walls, and are cut deeper by each succeeding flood. The vegetation is scanty, consisting of native grasses, sagebrush, chico, and cactus pads. The ranges have been very closely pastured, making conditions conducive to an excessive flood run-off.

Above Canon City the fall of the river is about 40 feet to the mile. The elevation at Canon City is 5,300 feet; at the Colorado-Kansas state line, 220 miles below, the elevation is 3,350 feet, making the average fall about 9 feet per mile. At the mouth the river has an elevation slightly exceeding 100 feet above sea level.

The drainage basin of Arkansas River contains about 1,000 square miles of merchantable timber land and considerably more than that amount of woodland; the rest, except for the considerable area under cultivation, may be classed as barren and sagebrush land.

The principal source of the water which the river bears to the plains is the precipitation along the crest of the high ranges. This is mainly in the form of snow, and amounts to 20 or 30 inches each year. From the foothills to Arkansas City the precipitation ranges from 12 to 35 inches, being 25 to 35 inches in the last 100 miles below Hutchinson. The natural storage in the basin is limited to a few mountain lakes of glacial origin.

The streams of this drainage area are subject to floods of two kinds—the annual spring floods caused by the melting of the snows in the headwater regions and floods caused by the violent storms, locally known as cloudbursts, in the foothills and plains regions. Occasionally, too, the river runs dry, and many of the tributaries are intermittent in character.

As altitudes within this basin range from 14,000 feet almost down to sea level, the climatic conditions vary greatly. In the mountainous sections the winters are severe, the snowfall is heavy, and the rivers have a thick ice cover for several months. As the altitude decreases the winters become milder.

At the present time about half a million acres of land are under irrigation on Arkansas River and its tributaries in Colorado, but beyond the Colorado line only a very few thousand acres are irrigated. The Garden City project of the United States Reclamation Service will eventually provide for the irrigation of probably 15,000 acres in the Arkansas Valley in western Kansas, principally by pumping the underflow.

Numerous reservoirs now in operation along the Arkansas, together with direct diversions for irrigation, provide for the use of the greater part of the flow of Arkansas River in Colorado. The largest reservoirs are in the system of the Great Plains Reservoir Company, on the north side of the river in the eastern part of the State. The reservoirs of this system are supplied by feeder canals, and have a combined capacity of almost 200,000 acre-feet. Other reservoirs now contemplated or under construction, on the tributaries of the Arkansas, will provide for the irrigation of a large additional area. These reservoirs are necessitated by the intermittent character of the streams upon which they are situated. The basin contains many excellent reservoir sites. The flood on the Arkansas in October, 1908, illustrates the possibility for additional storage in some of them. (For report on this flood, see Water-Supply Paper 247, p. 35.)

On account of the use of water for irrigation in the open country, power development is necessarily confined to the upper reaches of the Arkansas and its tributaries. It seems probable that, with proper storage, about 100,000 horsepower can be developed. Somewhat over 5,000 horsepower is now being used.

The years of greatest average flow on the upper Arkansas since the beginning of measurements seem to have been 1891 and 1899. The flow in 1905 was also very high and that in 1906 and 1907 was nearly as great. The year of lowest flow is 1902, while 1908 is second.

ARKANSAS RIVER AT SALIDA, COLO.

A station was maintained on Arkansas River at Salida under the direction of the United States Geological Survey from 1895 to 1903.[1] The station was reestablished November 3, 1909, by the state engineer of Colorado, who placed a Bristol automatic gage with an auxiliary slope gage about a block below the concrete bridge on the road from town to the Denver & Rio Grande Railroad depot. The records furnish data concerning the amount of water available for irrigation.

The new and old stations bear the same relation to tributaries and diversions, but are at different sections.

The gage has no determined relation to the gage used in 1903. Discharge measurements are made from the concrete bridge.

On account of springs in the vicinity of the station, the channel is open throughout the winter months, making a very favorable location for the gage.

Discharge measurements of Arkansas River at Salida, Colo., in 1909.

Date.	Hydrographer.	Area of section.	Gage height.	Discharge.
		Sq. ft.	*Feet.*	*Sec.-ft.*
November 3	Grieve and Chatfield	174	1.60	547
December 15	C. L. Chatfield	102	.70	243

[1] For description, see Water-Supply Paper U. S. Geol. Survey No. 99, p. 301.

Daily gage height, in feet, of Arkansas River at Salida, Colo., for 1909.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1		1.05	11	1.15	0.85	21	1.15	0.7
2		1.1	12	1.15	.85	22	1.1	.8
3		1.1	13	1.1	.9	23	1.1	.85
4		.95	14	1.0	.85	24	1.1	.85
5		.8	15	1.05	.8	25	1.05	.8
6		.9	16	1.1	.75	26	1.1	.8
7		.9	17	1.1	.8	27	1.1	.85
8		.9	18	1.1	.7	28	1.05	.8
9		.9	19	1.1	.65	29	1.1	.8
10		.95	20	1.15	.65	30	1.1	.8
						31		.8

Daily discharge, in second-feet, of Arkansas River at Salida, Colo., for 1909.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1		325	11	358	262	21	358	225
2		340	12	358	262	22	340	250
3		340	13	340	275	23	340	262
4		292	14	310	262	24	340	262
5		250	15	325	250	25	325	250
6		275	16	340	238	26	340	250
7		275	17	340	250	27	340	262
8		275	18	340	225	28	325	250
9		275	19	340	212	29	340	250
10		292	20	358	212	30	340	250
						31		250

NOTE.—These discharges are based on the rating curve used by the State engineer of Colorado. It is fairly well defined.

Monthly discharge of Arkansas River at Salida, Colo., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
November 11-30	358	310	337	13,400
December	340	212	263	16,200

ARKANSAS RIVER AT CANON CITY, COLO.

This station, which was established April 17, 1889, is located at the mouth of the canyon, just below the suspension footbridge at Hot Springs Hotel, about 1½ miles above the Denver & Rio Grande Railroad depot at Canon City, Colo.

The records at this point show the greater part of the run-off of the river and are valuable both for power and irrigation projects.

Grape Creek enters about one-eighth of a mile above the station and Oil Creek comes in about 5 miles below. The drainage area comprises about 3,000 square miles. North and South Canyon ditches divert water above the station, and their flow is not included in the run-off. No accurate records have been kept of the discharge in these canals but the combined flow is from 50 to 100 second-feet during the irrigation season. Some water is also diverted for the irrigation of a few thousand acres on the upper Arkansas and its tributaries.

The flow of the river is affected by ice for three or four months during the winter season.

On October 4, 1895, a new rod gage was established on the left bank, opposite the original gage and at the same datum. This gage read 0.4 foot lower than the old gage at low stages, but at high water both gages read the same. This new gage was used until August 26, 1902, when another gage was established on the right bank at the datum of the original gage, though it is situated a short distance farther downstream. The present chain gage is a few feet upstream from the cable. In September, 1909, the state engineer established a Bristol self-recording gage near the location of the chain gage, but with a datum 2 feet higher. Both gages have been read since that time. Measurements are made from a cable.

As the stream bed is rough it is difficult to obtain very accurate measurements at high stages. Moreover, the channel is subject to considerable shifting, which makes the estimates of daily discharge rather uncertain, especially after violent flood.

Discharge measurements of Arkansas River at Canon City, Colo., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 6[a]	W. B. Freeman	88	152	3.40	388
June 10	Freeman, Lyon, and Grieve	106	423	6.15	2,870
June 28	W. B. Freeman	106	443	6.40	3,000
July 21	Lyon and Russell	100	289	5.00	1,530
August 9	Thos. Grieve	....	232	4.30	882
August 21	G. H. Russell	98	223	4.65	1,080
September 1	C. L. Chatfield	100	212	4.75	1,310
September 16	do	....	284	5.10	1,310
September 18	G. H. Russell	100	235	4.95	1,220
October 11	Thos. Grieve	96	196	4.30	735
October 14	G. H. Russell	96	192	4.20	689
November 4	Chatfield and Grieve	117	188	4.13	631
November 23	G. H. Russell	97	180	4.10	559
December 15[b]	C. L. Chatfield	....	143	3.95	427
December 21[b]	G. H. Russell	45	81	3.65	276

[a] Wading measurement. [b] Ice along edges.

Daily gage height, in feet, of Arkansas River at Canon City, Colo., for 1909.

[S. R. McKissick, observer.]

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	3.15	4.65	6.25	4.7	4.8	4.3	4.0	4.1
2	....	3.0	4.6	6.4	4.7	4.8	4.2	4.1	4.1
3	....	3.05	4.7	6.4	4.5	4.65	4.2	4.1	4.1
4	....	3.1	5.2	6.7	4.2	4.7	4.2	4.0	4.0
5	....	3.2	5.7	7.0	4.25	5.45	4.25	3.9	3.9
6	....	3.35	5.75	6.5	4.15	6.4	4.3	3.9	3.9
7	....	3.45	5.95	5.9	4.15	6.0	4.35	3.85	4.0
8	....	3.55	6.1	5.9	4.4	6.05	4.35	3.8	4.0
9	....	3.65	5.95	5.75	4.25	6.0	4.35	3.8	4.05
10	....	3.75	6.05	5.6	4.2	5.8	4.3	3.9	4.1

Daily gage height, in feet, of Arkansas River at Canon City, Colo., for 1909—Continued.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
11	....	4.05	6.25	5.5	4.25	5.35	4.3	3.9	4.1
12	....	4.05	6.35	5.25	4.1	5.25	4.3	3.9	4.0
13	....	4.0	6.55	5.05	4.4	5.45	4.2	3.9	4.05
14	....	4.0	6.3	4.85	4.2	5.3	4.15	3.9	4.1
15	....	4.0	5.95	4.85	4.5	5.2	4.1	4.0	4.0
16	....	3.9	5.9	4.95	4.25	5.1	4.1	4.0	4.0
17	....	4.0	6.05	4.8	5.35	5.0	4.1	3.95	4.0
18	....	4.0	6.65	4.75	7.95	4.9	4.1	4.0	3.7
19	....	4.1	7.05	4.7	6.2	4.8	4.1	4.05	3.6
20	3.45	4.25	7.25	4.65	4.55	4.75	4.0	4.0	3.6
21	3.3	4.35	6.65	4.85	4.95	4.5	4.0	4.15	3.6
22	3.2	4.35	6.25	5.3	4.6	4.5	4.1	4.1	3.75
23	3.15	4.5	6.15	5.05	4.3	4.5	4.2	4.1	4.05
24	3.1	4.5	6.85	5.2	4.3	4.5	4.2	4.1	4.1
25	3.1	4.5	6.7	5.4	4.6	4.45	4.2	4.1	4.0
26	3.1	4.4	6.45	5.15	4.4	4.4	4.1	4.05	4.0
27	3.15	4.5	6.45	5.2	4.4	4.4	4.1	4.05	4.1
28	3.2	4.7	6.35	5.1	4.3	4.3	4.1	4.05	4.1
29	3.25	4.85	6.35	5.1	4.45	4.3	4.05	4.05	4.1
30	3.2	4.8	6.4	4.95	4.5	4.3	4.0	4.1	4.05
31	....	4.65	....	4.75	4.75	....	4.0	....	4.15

NOTE.—Probable ice conditions December 4 to 31.

Daily discharge, in second-feet, of Arkansas River at Canon City, Colo., for 1909.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	292	1,180	3,000	1,220	1,360	695	520	583
2	....	236	1,130	3,190	1,220	1,350	620	583	583
3	....	254	1,220	3,190	1,040	1,170	625	583	583
4	....	273	1,740	3,590	811	1,190	630	520	552
5	....	311	2,320	3,990	848	2,040	670	464	400
6	....	370	2,380	3,320	777	3,260	710	464	400
7	....	410	2,620	2,560	777	2,700	755	438	455
8	....	452	2,800	2,560	962	2,740	760	412	455
9	....	497	2,620	2,380	848	2,630	765	412	484
10	....	544	2,740	2,200	811	2,320	725	464	612
11	....	712	3,000	2,080	848	1,730	729	464	612
12	....	712	3,120	1,790	743	1,580	729	464	455
13	....	680	3,390	1,570	962	1,790	652	464	484
14	....	680	3,060	1,370	811	1,580	618	464	612
15	....	680	2,620	1,370	1,040	1,440	583	520	455
16	....	622	2,560	1,470	810	1,310	583	520	455
17	....	680	2,740	1,320	1,960	1,240	553	492	455
18	....	680	3,520	1,270	5,400	1,170	583	520	300
19	....	743	4,060	1,220	3,030	1,070	583	552	255
20	410	848	4,320	1,180	1,000	1,030	520	520	255
21	350	923	3,520	1,370	1,390	810	520	618	255
22	311	923	3,000	1,850	1,040	810	583	583	240
23	292	1,040	2,870	1,570	790	820	652	583	280
24	273	1,040	3,790	1,740	800	820	652	583	280
25	273	1,040	3,590	1,960	1,080	790	652	583	280
26	273	962	3,260	1,680	900	760	583	552	280
27	292	1,040	3,260	1,740	910	760	583	552	280
28	311	1,220	3,120	1,630	840	690	583	552	280
29	330	1,370	3,120	1,630	980	690	552	552	280
30	311	1,320	3,190	1,470	1,040	690	520	583	280
31	....	1,180	....	1,270	1,300	....	520	....	280

NOTE.—These discharges are based on rating curves applicable as follows: April 20 to August 15, well defined below 3,000 second-feet; August 15 to October 10, indirect method for shifting channels; October 11 to December 4, fairly well defined; December 5 to December 21, based on measurements under slight ice conditions; December 22 to 31, estimated on account of ice conditions.

Monthly discharge of Arkansas River at Canon City, Colo., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
April (20-30)	410	273	311	6,790	B.
May	1,370	236	733	45,100	A.
June	4,320	1,130	2,860	170,000	B.
July	3,990	1,180	2,020	124,000	A.
August	5,400	743	1,190	73,200	B.
September	3,260	690	1,410	83,900	B.
October	765	520	623	38,300	A.
November	618	412	519	30,900	A.
December	612	240	402	24,700	C.
The period				597,000	

ARKANSAS RIVER AT PUEBLO, COLO.

This station was established September 30, 1894, at the Santa Fe Avenue Bridge, Pueblo, Colo. On July 10, 1898, another gage was established on the east side of Main Street Bridge, which was used until March 3, 1900. Then a staff gage fastened to the retaining wall, a short distance below the Union Avenue Bridge, was used to July 14, 1902. From July 14, 1902, until July 7, 1905, readings were taken at a rod gage, having a different datum, located just above this bridge. The present chain gage on the Main Street Bridge has been in use since July 7, 1905. Measurements are made from this bridge.

As this station is near the head of the principal irrigated portion of the Arkansas Valley and above the head gates of the larger canals, the data are especially valuable to water superintendents and the State water commissioners in making distribution of water to the canals below.

No important tributaries enter within several miles above the station. Fountain Creek enters just below, and the Huerfano, the most important tributary in that vicinity, comes in about 20 miles below.

At various points above this station water is diverted for the irrigation of about 70,000 acres of land. The diversion for the Pueblo water supply also takes out above. Additional filings for irrigation above this station on the Arkansas are impossible, except for storage on some of the minor tributaries.

Slush and flowing ice are usually found at this station during the winter months and sometimes the river is frozen over or affected by ice jams below, but the results are rarely influenced by ice conditions for more than two months during the year. As noted above, numerous changes have been made in the datum of the gage.

Very good measurements can be obtained at this point, although the channel sometimes shifts considerably during floods.

Discharge measurements of Arkansas River at Pueblo, Colo., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 5	W. B. Freeman	67	66	1.74	106
May 23	G. J. Lyon	150	282	3.20	1,050
June 5	do	150	432	3.95	2,310
June 10	W. B. Freeman	152	439	4.35	2,470
June 24	do	152	477	4.64	2,610
July 16	Thos. Grieve		312	3.38	1,280
July 22	G. H. Russell	150	306	3.56	1,370
July 23	Thos. Grieve		331	3.52	1,370
July 30	do		346	3.65	1,580
August 7	do		196	2.63	548
August 25	G. H. Russell	146	266	3.18	980
September 16	C. L. Chatfield	151	366	3.72	1,710
September 17	do	150	347	3.60	1,590
October 7	Thos. Grieve	151	262	3.00	949
October 15	do	150	221	2.76	696
October 18	G. H. Russell	148	213	2.70	685
November 5	C. L. Chatfield	79	168	2.49	494
November 24	G. H. Russell	145	187	2.65	595
December 16	C. L. Chatfield		181	2.52	567
December 21 [a]	G. H. Russell	111	128	2.55	268

[a] Ice conditions.

Daily gage height, in feet, of Arkansas River at Pueblo, Colo., for 1909.

[D. J. Cox, observer.]

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.2	3.3	4.65	3.3	3.35	2.95	2.6	2.6
2		2.05	3.25	4.75	3.3	3.4	2.9	2.6	2.6
3		2.0	3.25	4.65	3.3	3.3	2.9	2.6	2.6
4		1.9	3.5	4.7	2.95	4.2	2.9	2.7	2.7
5		1.85	4.1	4.9	2.95	4.3	2.9	2.55	2.5
6		1.9	4.65	5.45	2.8	4.8	2.9	2.5	2.5
7		2.0	4.55	4.4	2.75	4.65	3.0	2.6	2.5
8		2.2	4.65	4.2	2.75	5.1	3.1	2.6	2.55
9		2.3	4.55	4.05	3.1	5.0	3.1	2.5	2.6
10		2.35	4.3	4.0	2.9	4.8	3.0	2.5	2.7
11		2.65	4.6	3.85	2.9	4.1	3.0	2.5	2.7
12		2.75	4.7	3.65	2.9	4.0	3.0	2.55	2.6
13		2.8	4.7	3.5	2.9	4.1	3.0	2.6	2.7
14		2.8	5.05	3.5	3.2	4.05	2.9	2.6	2.6
15		2.8	4.35	3.3	3.4	3.85	2.85	2.6	2.6
16		2.7	4.25	3.4	2.95	3.65	2.8	2.6	2.6
17		2.6	4.25	3.55	3.25	3.65	2.7	2.6	2.6
18		2.6	4.65	3.35	6.05	3.55	2.7	2.6	1.95
19		2.7	5.45	3.25	4.65	3.65	2.7	2.6	2.0
20	2.3	2.85	5.55	3.2	4.05	3.45	2.7	2.6	2.35
21	2.3	3.15	5.45	3.1	3.4	3.35	2.65	2.65	2.6
22	2.3	3.2	4.6	3.7	4.55	3.3	2.6	2.7	2.75
23	2.4	3.2	4.45	3.6	2.9	3.3	2.7	2.65	3.2
24	2.35	3.3	4.8	4.7	2.8	3.3	2.7	2.6	3.4
25	2.3	3.2	5.3	4.0	3.0	3.3	2.7	2.5	3.5
26	2.0	3.1	4.85	3.8	2.95	3.1	2.6	2.5	3.05
27	2.0	3.1	4.65	3.65	3.0	3.1	2.6	2.5	3.15
28	2.05	3.2	4.7	3.7	3.0	3.05	2.6	2.55	3.3
29	2.1	3.4	4.75	3.75	3.0	3.0	2.6	2.6	3.15
30	2.15	3.45	4.7	3.6	3.15	2.95	2.6	2.6	3.2
31		3.35		3.2	3.15		2.6		3.3

NOTE.—Probable ice conditions December 21 to 31.

Daily discharge, in second-feet, of Arkansas River at Pueblo, Colo., for 1909.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		300	1,180	2,850	1,180	1,230	835	550	550
2		228	1,120	2,990	1,180	1,280	790	550	550
3		205	1,120	2,850	1,180	1,180	790	550	550
4		165	1,390	2,920	835	2,240	790	625	625
5		145	2,120	3,200	835	2,380	790	515	480
6		165	2,850	4,000	705	3,060	790	480	480
7		205	2,710	2,500	665	2,850	880	550	480
8		300	2,850	2,240	665	3,500	975	550	515
9		355	2,710	2,050	975	3,350	975	480	550
10		385	2,380	1,990	790	3,060	880	480	625
11		588	2,780	1,800	790	2,120	880	480	625
12		665	2,920	1,560	790	1,990	880	515	550
13		705	2,920	1,390	790	2,120	880	550	625
14		705	3,420	1,390	1,080	2,050	790	550	550
15		705	2,440	1,180	1,280	1,800	748	550	550
16		625	2,310	1,280	835	1,560	705	550	550
17		550	2,310	1,450	1,120	1,560	625	550	550
18		550	2,850	1,230	4,920	1,450	625	550	185
19		625	4,000	1,120	2,850	1,560	625	550	205
20	355	748	4,160	1,080	2,050	1,340	625	550	385
21	355	1,020	4,000	975	1,280	1,230	588	588	268
22	355	1,080	2,780	1,620	2,710	1,180	550	625	320
23	415	1,080	2,570	1,500	790	1,180	625	588	320
24	385	1,180	3,060	2,920	705	1,180	625	550	320
25	355	1,080	3,780	1,990	880	1,180	625	480	320
26	205	975	3,130	1,740	835	975	550	480	320
27	205	975	2,850	1,560	880	975	550	480	320
28	228	1,080	2,920	1,620	880	928	550	515	320
29	250	1,280	2,990	1,680	880	880	550	550	320
30	275	1,340	2,920	1,500	1,020	835	550	550	320
31		1,130		1,080	1,020		550		320

NOTE.—The above discharges are based on a rating curve which is fairly well defined between 415 and 1,990 second-feet. Ice conditions December 21 to 31; flow estimated.

Monthly discharge of Arkansas River at Pueblo, Colo., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
April 20-30	415	205	308	6,720	B.
May	1,340	145	682	41,900	B.
June	4,160	1,120	2,720	162,000	B.
July	4,000	975	1,910	117,000	B.
August	4,920	665	1,210	74,400	B.
September	3,500	835	1,740	104,000	B.
October	975	550	716	44,000	B.
November	625	480	538	32,000	B.
December	625	185	440	27,100	C.
The period				609,000	

ARKANSAS RIVER AT LAS ANIMAS, COLO.

On May 13, 1898, a station was established at a wagon bridge about half a mile north of Las Animas. A rod gage was fastened to one of the bridge piers. No continuous records were obtained, as the gage has only been read occasionally and but few discharge measurements made. On August 1, 1909, the station was reestablished by the State engineer of Colorado. It is believed the same gage was used and that the datum remained unchanged. The bed of the stream is very shifting, and owing to the skew of the bridge measurements must be made by wading at various sections. The station is of no value for high-water measurements.

Available data are insufficient to warrant estimates of daily discharge.

Discharge measurements of Arkansas River at Las Animas, Colo., in 1909.

Date.	Hydrographer.	Area of section.	Gage height.	Discharge.
		Sq. ft.	*Feet.*	*Sec.-ft.*
August 1	Thos. Grieve	67	1.80	117
August 3	do	31	1.50	53
November 10	C. L. Chatfield	69	1.65	119

NOTE.—Measurements made by wading below the bridge.

Daily gage height, in feet, of Arkansas River at Las Animas, Colo., for 1909.

[S. W. Dobbins, observer.]

Day.	Aug.	Sept.	Oct.	Day.	Aug.	Sept.	Oct.	Day.	Aug.	Sept.	Oct.
1		1.8	1.6	11	0.9	4.5		21	4.4	2.0	
2		1.9	1.6	12	.7	4.2		22	3.6	2.0	
3		2.0	1.7	13	.8	3.2		23	2.5	1.9	
4	0.5	2.8	1.6	14	1.0	4.0		24	1.5	1.9	
5	.5	2.5	1.4	15	1.5	4.2		25	1.5	1.7	
6	.6	6.0	1.4	16	1.4	3.1		26	1.5	1.7	
7	.6	4.5	1.8	17	1.5	2.2		27	1.6	1.8	
8	.7	4.6	1.7	18	3.3	2.0		28	1.9	1.8	
9	.8	6.3	1.9	19	3.0	2.0		29	1.7	1.7	
10	.8	5.8		20	6.0	2.1		30	1.5	1.7	
								31	1.5		

ARKANSAS RIVER AT HOLLY, COLO.

This station, which was established October 15, 1907, is located at the pile highway bridge one-half mile southeast of Holly, Colo., about 4 miles above the Colorado-Kansas line.

As no important diversions are made between the two points the data obtained at this station have special value as showing the amount of surface water passing from Colorado to Kansas.

The station is just above the mouth of Wild Horse Creek and about 1 mile below the mouth of Two Butte Creek. The drainage area is about 25,000 square miles.

As nearly half a million acres of land are under irrigation above this point most of the ordinary flow of the stream is diverted during the irrigation season, while during the winter months it is used to fill up the numerous storage reservoirs in the basin. Except during periods of heavy flood, the flow at Holly consists chiefly of return waters. The stream flow is little affected by ice.

The gage heights here published have all been referred to the same datum, though a rod gage at a different datum was used during part of 1908. During high stages measurements are made from highway bridge and during low stages by wading at miscellaneous sections.

Fairly good measurements can be taken at this point, but in order to obtain accurate records of daily discharge it is necessary to take them frequently on account of the extremely shifting character of the channel.

Discharge measurements of Arkansas River at Holly, Colo., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet.*	*Sec.-ft.*
April 17 [a]	G. J. Lyon	37	9.7	0.13	5.4
May 8 [a]	do	23	8.6	.20	12.5
May 30 [a]	do	22	6.4	.15	5.4
July 10	do	284	243	1.47	409
August 13 [a]	do	7.5	8.6	.30	7.1
August 26	G. H. Russell	211	225	1.90	500
September 6	C. L. Chatfield	251	266	1.90	706
November 10 [a]	do	106	54	1.25	90
December 31 [b]	G. H. Russell	206	207	2.20	431

[a] Made by wading. [b] Ice conditions. Made by wading.

Daily gage height, in feet, of Arkansas River at Holly, Colo., for 1909.

[S. W. Jones, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.45	0.5	0.3	0.5	0.25	0.2	0.9	1.1	0.9	1.5	1.2	1.6
2	.45	.5	.3	.4	.2	.1	.9	1.1	.8	1.45	1.25	1.55
3	.45	.45	.4	.4	.2	.1	.8	1.05	.8	1.5	1.3	1.65
4	.45	.4	.4	.4	.2	.1	.8	.9	.8	1.4	1.25	1.6
5	.4	.3	.4	.4	.2	.1	.7	.8	.7	1.45	1.25	1.6
6	.4	.3	.4	.4	.2	.15	.6	.8	1.0	1.35	1.15	1.55
7	.4	.3	.4	.4	.2	.15	1.9	.7	3.45	1.55	1.1	1.5
8	.4	.3	.4	.3	.2	.15	2.5	.6	4.8	1.65	1.2	1.6
9	.4	.3	.4	.3	.2	1.1	1.65	.5	4.1	1.5	1.25	1.65
10	.4	.4	.4	.3	.2	1.1	1.45	.4	3.9	1.55	1.25	1.8
11	.4	.45	.4	.3	.2	.9	1.3	.3	3.7	1.5	1.3	1.9
12	.55	.45	.4	.3	.2	1.0	1.05	.35	3.75	1.45	1.3	1.75
13	.6	.4	.5	.25	.2	1.1	.9	.3	2.8	1.45	1.5	1.85
14	.6	.4	.6	.2	.2	1.15	1.3	.15	3.95	1.45	1.5	1.85
15	.6	.6	.6	.2	.1	3.05	.85	.4	4.4	1.3	1.6	1.8
16	.6	.9	.6	.15	.15	2.8	.8	1.05	3.5	1.3	1.35	2.05
17	.6	.9	.6	.15	.15	2.2	.8	1.0	2.9	1.3	1.55	2.15
18	.6	.9	.6	.15	.15	2.25	.8	.9	2.55	1.25	1.5	2.15
19	.6	.9	.6	.15	.15	1.75	.65	2.15	2.25	1.15	1.45	2.1
20	.55	.9	.5	.2	.2	1.4	.6	3.9	2.15	1.25	1.4	2.0
21	.55	.9	.5	.2	.2	1.2	.6	5.25	2.0	1.2	1.55	1.9
22	.55	.8	.4	.25	.15	1.4	.6	2.7	1.95	1.25	1.75	2.0
23	.6	.65	.4	.25	.15	1.75	3.25	1.35	1.75	1.25	1.8	2.2
24	.6	.5	.55	.25	.2	1.7	2.75	2.2	1.3	1.2	1.6	2.15
25	.5	.5	.6	.25	.25	1.7	2.1	2.1	1.6	1.1	1.55	2.05
26	.5	.5	.55	.25	.2	1.45	1.5	1.9	1.35	1.15	1.55	2.05
27	.5	.4	.5	.25	.2	1.1	2.2	2.05	1.7	1.2	1.4	2.15
28	.5	.4	.5	.3	.15	1.0	1.6	1.65	1.75	1.15	1.45	1.85
29	.5	......	.5	.35	.15	1.0	1.85	1.4	1.65	1.15	1.6	2.15
30	.5	......	.5	.3	.15	1.0	1.35	1.15	1.55	1.15	1.6	2.15
31	.5	......	.5	......	.15	......	1.15	.9	......	1.2	......	2.2

GRAPE CREEK AND DE WESSE-DYE DITCH NEAR CANON CITY, COLO.

This station was established July 24, 1907, primarily to determine the amount of flood waters available for storage. Two gages have been used, which have been called the upper and the lower gages. The lower gage was established because of its accessibility. It is located about 150 yards above the junction of the creek with Arkansas River, some distance below the head of the De Wesse-Dye ditch, which has a capacity of about 25 second-feet. The upper gage is located about 1½ miles above the mouth of the stream, and 200 yards above the headgates of the De Wesse-Dye ditch. At high water discharge measurements are made at the upper gage from a car and cable equipment and the discharge of the De Wesse-Dye ditch is subtracted to show the flow past the lower gage.

No important tributaries enter below the upper gage. Pine Creek enters a few miles above.

Considerable irrigation is practiced above this station in the vicinity of Silver Cliff, and a storage reservoir is also used to regulate the supply of water for the De Wesse-Dye ditch.

No change has been made in the datum of either gage since the station was established. During 1909 the lower gage was not used but gage readings were made by means of a Friez automatic gage at the same datum and near the location of the upper rod gage.

High velocities, the character of the stream bed, and the shifting nature of the channel during flood make it difficult to obtain accurate measurements. Moreover, the stream is subject to very rapid rises and subsides just as suddenly, so that an automatic register is necessary to record the changes in the gage heights.

The flow is usually very small during the winter months except when a flood occurs, so that ice conditions have very little influence on the flow. The drainage area at the mouth is 545 square miles, the elevation ranging from 14,000 feet above sea level at headwaters to 5,500 feet at the mouth.

Discharge measurements of Grape Creek near Canon City, Colo., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 6 [a]	W. B. Freeman	24	11	0.60	23
June 28	....do	....	....	....	[c] 42.5
July 21 [a]	G. H. Russell	18.6	11	1.0	31
August 21 [a]	....do	15.5	7.2	.90	21.7
September 18	....do	23	29	3.0	232
October 14 [a]	....do	14	9.8	1.2	30.9
November 4 [a]	Chatfield and Grieve	16.5	12.4	1.08	38.9
November 24	G. H. Russell	24	25.5	2.15	121
December 22 [b]	....do	10	12	1.20	19

[a] Made by wading.
[b] Ice effect. Wading measurement.
[c] Discharge obtained by separate measurements of Grape Creek and De Wesse-Dye ditch.

Daily gage height, in feet, of Grape Creek, near Canon City, Colo., for 1909.

[R. L. Proctor, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1								
2								
3								
4				0.92			1.08	
5				.92				
6	0.60			.92				
7				.91				
8				1.10				
9								
10				.80				
11								
12								
13								
14						1.20		
15								
16								
17								
18					3.00			
19								
20								
21			1.00	.90				
22			1.00					1.20
23			1.02					
24			.98				2.15	
25			.98					
26			.96					
27			.95					
28			.94					
29			.95					
30								
31								

PURGATORY RIVER DRAINAGE BASIN.

DESCRIPTION.

Purgatory[1] River, the principal tributary of Arkansas River in Colorado, rises in the Culebra Mountains and flows northeastward across the plains for a distance of 165 miles. In the spring the channel carries a moderate volume of water, but as summer approaches this is greatly diminished by irrigation and natural conditions until the channel is practically dry. The volume of water contributed to the Arkansas is so small that it has no appreciable effect on the discharge of that river except at times of excessive rainfall, when it may discharge a large volume for a short time.

The drainage basin of Purgatory River is long and narrow. The total area is 3,400 square miles. The 742 square miles lying above Trinidad are mountainous and the surface is much broken by stream channels, which are normally dry. The lower basin is foothill country, merging into rough plains farther east. Drainage lines are well defined throughout part of the area. For 60 miles of its length, com-

[1] This stream is often termed Las Animas, especially along its lower course, and sometimes it is called Picket Wire. It is sometimes spelled Purgatoire.

mencing 25 miles below Trinidad, Purgatory River flows in a deep canyon. Many small tributary canyons enter at various angles to the main channel.

In the mountainous portion the Weather Bureau records at Clearview for fifteen years give a mean annual rainfall of 23 inches; at Trinidad, ten years' record, 17 inches. The plains drainage has approximately a mean annual precipitation of 12 inches.

No storage is practiced on this stream, though investigations are being made by a corporation with the purpose of constructing a large storage reservoir for use in irrigation. No power has been developed, and because of the abundance of coal in the vicinity of Trinidad it is doubtful if power development would be feasible, even under very favorable circumstances.

The basin contains about 100 square miles of merchantable timber land and a small amount of woodland, all of which is included in the Las Animas National Forest.

Some 20,000 acres of land are now being irrigated along Purgatory River.

PURGATORY RIVER AT TRINIDAD, COLO.

This station has been maintained at the Animas Street Bridge, Trinidad, Colo., from May 1, 1896, to July 31, 1899; from August 25, 1905, to December 31, 1905; from November 7, 1906, to March 10, 1907; and from October 14, 1907, to date.

The records furnish information as to flood discharge and are valuable also for irrigation projects.

The South Fork joins the upper Purgatory about 14 miles above Trinidad. Chaquaqua River, the first important tributary below, enters about 60 miles below Trinidad. Considerable water is being diverted for irrigation above the station and some below. No power has yet been developed from this stream.

The flow at this point is affected to some extent by ice conditions, though the winter discharge is usually small.

The datum of the present chain gage, which has been used since August 25, 1905, is 1.70 feet below the datum of the old rod gage formerly used. The chain gage is located on the upstream side of the Animas Street Bridge.

Low-water measurements are usually made by wading. Measurements at higher stages are made from the bridge, where conditions are not favorable. The stream bed is shifting in character.

Discharge measurements of Purgatory River at Trinidad, Colo., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 1 [a]	G. J. Lyon	33	27.4	4.40	47
May 22 [a]	.....do	55	50.4	4.70	151
June 28 [a]	.....do	49.5	48.3	4.80	167
July 23 [b]	Lyon and Russell	55	59	3.60	181
August 24	G. H. Russell	68	88	4.55	402
September 8	C. L. Chatfield	48	80	4.45	373
September 16 [a]	G. H. Russell	67	55	3.80	153
October 20 [a]	.....do	30	30	3.40	50.5
October 29 [a]	W. B. Freeman	27.8	25.8	3.35	37.3
November 25 [a]	G. H. Russell	20.4	28	3.35	34
December 9 [c]	.....do	25	33	3.65	28.7

[a] Made by wading.
[b] Measurement not accurate, owing to poor conditions.
[c] Made by wading. Ice conditions.

Daily gage height, in feet, of Purgatory River at Trinidad, Colo., for 1909.

[H. D. Albertson, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		4.7	4.65	3.8	3.8	3.55	3.3	3.4
2		4.65	4.6	3.7	3.8	3.55	3.3	3.4
3		4.7	6.4	3.7	3.85	3.5	3.3	3.4
4		4.7	4.75	4.7	4.0	3.5	3.3	3.45
5		4.8	6.3	3.85	5.4	3.5	3.3	3.45
6		4.8	5.15	3.8	8.0	3.5	3.3	3.4
7		4.85	5.2	4.9	5.25	3.5	3.3	3.5
8		4.9	5.7	3.75	4.4	3.5	3.3	3.85
9	4.5	4.9	6.0	3.35	6.3	3.5	3.3	3.8
10	4.5	4.95	4.75	4.4	4.1	3.5	3.3	3.55
11	4.65	5.0	4.0	4.5	4.35	3.5	3.3	3.65
12	4.65	5.0	4.0	4.8	4.4	3.45	3.3	3.65
13	4.6	5.0	4.45	5.2	4.3	3.45	3.4	3.65
14	4.6	5.0	4.1	5.0	4.1	3.4	3.4	3.65
15	4.65	4.9	5.45	5.1	3.95	3.4	3.4	3.6
16	4.6	4.8	4.8	4.85	3.85	3.4	3.4	3.6
17	4.5	4.8	4.6	7.4	3.8	3.4	3.4	3.6
18	4.5	4.8	4.6	5.0	3.8	3.4	3.4	3.6
19	4.5	4.85	4.7	8.0	3.7	3.4	3.4	3.6
20	4.65	4.9	4.5	4.5	3.8	3.4	3.4	3.6
21	4.75	4.85	5.9	4.0	3.8	3.4	3.4	3.6
22	4.7	4.8	5.25	4.0	3.75	3.4	3.4	3.6
23	4.7	4.7	5.0	3.9	3.7	3.4	3.35	3.6
24	4.65	4.7	6.4	4.8	3.65	3.4	3.35	3.65
25	4.7	5.4	5.0	4.1	3.6	3.35	3.35	3.7
26	4.7	4.8	4.8	4.75	3.6	3.35	3.3	3.85
27	4.6	4.75	4.6	4.0	3.6	3.35	3.3	4.0
28	4.6	4.8	4.5	3.9	3.6	3.35	3.3	4.1
29	4.7	5.7	4.3	3.9	3.6	3.3	3.35	4.0
30	4.7	4.8	4.1	3.8	3.55	3.3	3.35	4.0
31	4.7		4.0	3.85		3.3		4.2

PURGATORY RIVER NEAR HIGBEE, COLO.

For a few months during 1909 daily gage heights were taken on Purgatory River by F. H. Whiting, an engineer for the Bent-Prowers irrigation district, about 1 mile below the district reservoir site.

The rod gage is in sec. 27, T. 25 S., R. 53 W.. 8 or 9 miles below Higbee.

Daily gage height, in feet, of Purgatory River near Higbee, Colo., for 1909.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	......	0.45	1.8	1.6	11	1.85	3.0	1.1	4.95	21	1.4	1 1	4.25	1.6
2	......	.35	1.8	1.7	12	2.3	2.95	1.1	4.3	22	.9	6.9	3.4	1.0
3	......	.3	1.8	1.35	13	4.15	4.2	1.35	6.45	23	.9	3.1	2.15	1.75
4	......	.55	2.6	2.85	14	2.5	2.2	4.0	5.95	24	.95	2.3	1.65	1.2
5	0.2	2.2	2.6	3.65	15	4.3	2.35	3.95	4.3	25	1.4	2.2	2.3	1.6
6	.2	1.65	1.8	4.15	16	2.3	3.5	3.7	3.8	26	1.35	3.5	3.0	1.75
7	.2	2.3	1.6	5.5	17	1.95	2.3	3.4	2.45	27	1.15	3.1	1.65	1.25
8	.2	1.45	1.45	6.05	18	2.45	2.2	8.95	1.75	28	1.55	2.2	1.8	1.45
9	.1	1.35	1.05	5.3	19	2.0	2.1	6.4	1.25	29	.55	1.95	2.85	1.45
10	.1	1.35	1.15	4.45	20	1.55	1.65	7.65	1.35	30	.2	3.0	3.2	1.25
										31	......	2.4	3.0	......

PURGATORY RIVER NEAR LAS ANIMAS, COLO.

This station was originally established May 22, 1889, and discontinued September 3, 1889. A number of miscellaneous discharge measurements were made in 1903.

On August 4, 1909, a chain gage was installed by the state engineer's office at the Atchison, Topeka & Santa Fe Railway bridge which crosses the river a short distance above its mouth. As but few gage heights and low-water measurements were obtained the data are inadequate to make estimates of the daily discharge.

Discharge measurements of Purgatory River near Las Animas, Colo., in 1909.

Date.	Hydrographer.	Area of section.	Gage height.	Discharge.
		Sq. ft.	*Feet.*	*Sec.-ft.*
July 31	Thos. Grieve	70	5.90	131
August 3	....do	51	5.89	107
November 10	C. L. Chatfield	23.2	5.80	25.5

NOTE.—Measurements made by wading.

Daily gage height, in feet, of Purgatory River near Las Animas, Colo., for 1909.

Day.	Aug.	Sept.	Oct.	Day.	Aug.	Sept.	Oct.	Day.	Aug.	Sept.	Oct.
1	......	6.4	8.7	11	5.9	9.7	......	21	7.8	9.7	......
2	......	6.4	8.3	12	5.7	9.6	......	22	6.8	9.6	......
3	......	6.5	8.4	13	5.5	9.4	......	23	6.3	9 4	......
4	6.0	6.7	8.2	14	6.0	9.9	......	24	6.0	9 4	......
5	5.8	7.0	7.9	15	7.0	9.9	......	25	6.4	9.2	......
6	6.1	8.0	7.5	16	6.8	10.1	......	26	6.4	9.1	......
7	5.9	9.9	7.1	17	6.5	10.3	......	27	6.5	8.9	......
8	5.9	11.9	6.9	18	7.5	10.3	......	28	6.5	8.4	......
9	5.8	9.9	6.7	19	8.65	9.9	......	29	7.1	8.4	......
10	5.9	10.3	......	20	10.2	9.7	......	30	6.5	8.8	......
								31	6.5	......	......

CANADIAN RIVER DRAINAGE BASIN.

DESCRIPTION.

Canadian River (frequently called Red River in New Mexico) rises in the Cimarron Mountains in Colfax County, N. Mex., flows southward across Mora and San Miguel counties, then turns and flows eastward across northern Texas and through Oklahoma, uniting with Arkansas River about 80 miles above Fort Smith, Ark. The total length of the river from Raton Pass, N. Mex., to the mouth is about 750 miles. Altitudes within the basin range from about 9,000 feet at the head to 460 feet at the mouth. Some of the highest peaks in the Cimarron Range are more than 12,000 feet in elevation.

Cimarron, Mora, and Sapello rivers and Ute Creek, all in New Mexico, are the principal perennial tributaries, but many of the intermittent tributaries, such as the Sweetwater, carry large quantities of flood water. The total drainage of the river in New Mexico is about 13,000 square miles. The North Fork of the Cimarron (frequently called Beaver Creek at its head) is the most important of the lower tributaries. Its drainage area lies just south of the Cimarron (Dry). Along the headwaters of the Canadian in New Mexico is a considerable area of timber land and woodland, and the drainage area in eastern Oklahoma is also wooded. The remainder of the area in New Mexico, Texas, and Oklahoma consists of dry plains.

The annual precipitation varies from 20 inches or more in the mountainous sections to 12 inches or less on the plains of New Mexico and Texas; in Oklahoma the range is from 20 inches in the western part to 35 inches near the mouth of the stream. Except along the lower course the run-off is very uncertain and the river bed is frequently dry for long periods; at other times it carries very disastrous floods. The winters along this stream are mild and the stream flow is rarely affected by ice conditions, except at the higher altitudes.

Many tracts of land are irrigated along the upper Canadian and tributaries, although the aggregate area is only a few thousand acres; the number and acreage of these tracts are, however, rapidly being increased. Good storage sites are afforded by a number of natural lakes and basins, and reservoirs will eventually be constructed on the Cimarron, Vermejo, Ute Creek, Sapello, Mora, and other tributaries, which will provide for the irrigation of hundreds of thousands of acres.

Owing to the intermittent character of the stream, opportunities for water-power development are not very good except on the upper reaches of the mountain streams, but these opportunities will be somewhat increased by storage reservoirs. It may eventually be possible to develop commercially over 25,000 horsepower in New Mexico. At present no important water-power plants are in operation.

CANADIAN RIVER AT LOGAN, N. MEX.

This station, which was reestablished December 22, 1908, for the purpose of determining the amount of water available for storage and irrigation, is located at the Chicago, Rock Island & Pacific Railway bridge, 1 mile south of the depot at Logan, N. Mex. It is near the location of the bridge and gage used by the United States Reclamation Service from June 29, 1904, to February 26, 1905, which were washed out by flood, but the present gage has no determined relation to that gage.

The station is about 5 miles below the mouth of Ute Creek and 3 miles above the mouth of Arroyo Largo. The drainage area is about 12,000 square miles.

The stream flow is not affected by ice and very little by artificial control above. The extremely shifting nature of the stream bed makes it necessary to obtain a large number of discharge measurements in order to obtain the best results. It is usually difficult to make discharge measurements at higher stages on account of the sudden rise and equally rapid subsidence of the river during floods. High-water measurements must be made by floats, because of a large amount of drift in the river. Low-water measurements are made by wading, and those at ordinary stages from a cable 450 feet upstream from the railroad bridge, which is 140 feet high.

Numerous rod gages, secured to old piling under the bridge, were used during 1909, but all gage readings have been referred to the datum of the two railroad gages, which are at the same datum and are painted on the third concrete pier from each bank.

The records have been maintained in cooperation with the territorial engineer of New Mexico.

Discharge measurements of Canadian River at Logan, N. Mex., in 1908-9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		Feet.	Sq. ft.	Feet.	Sec.-ft.
November 3 [a]					32.5
December 22 [a]	J. B. Stewart			3.79	43
1909.					
January 26	J. B. Stewart	26.5	15.7	3.57	10.2
April 12	do				(b)
May 31	do	35	22	3.72	21
June 29	do	142	126	4.22	249
July 21	W. H. Sutton	43	42	3.52	24.4
August 22	do	270	408	5.62	1,850
September 6 [c]	J. B. Stewart	410	4,660	16.0	69,900
Do. [c]	do	415	5,380	18.0	87,700
Do. [c]	do	428	6,640	21.0	111,000
Do. [c]	do	438	7,930	24.0	141,000
October 22	W. B. Freeman	91	101	3.48	150
December 4	G. H. Russell	58	67	3.20	69

[a] Published in Water-Supply Paper 247 as miscellaneous.
[b] Stream dry.
[c] Flood measurement by floats.

Daily gage height, in feet, of Canadian River at Logan, N. Mex., for 1908-9.

[R. L. Smith, observer.]

Day.	Dec.	Day.	Dec.
1908.		1908.	
25	3.85	29	3.75
26	3.85	30	3.75
27	3.75	31	3.65
28	3.75		

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	3.65	3.6	......	2.95	......	3.7	3.4	4.3	3.6	......	......	......
2	3.65	3.6	......	3.0	......	3.7	3.3	4.3	3.4	......	......	......
3	3.65	3.6	......	3.05	......	3.7	3.3	4.3	......	......	......	......
4	3.65	3.6	......	3.0	......	3.7	3.2	4.3	......	......	......	3.2
5	3.65	3.55	......	2.95	......	3.7	3.5	4.2	6.2	......	......	3.7
6	3.65	3.55	......	2.9	......	3.7	3.4	4.8	14.0	......	......	3.65
7	3.65	3.5	......	2.85	......	3.7	3.4	4.4	10.1	......	......	3.65
8	3.65	3.45	......	......	......	3.6	3.3	4.3	6.1	......	......	3.65
9	3.65	3.35	......	......	......	3.4	3.5	4.4	5.1	......	......	3.8
10	3.65	3.25	......	......	......	3.2	5.1	4.4	5.3	......	......	3.85
11	3.65	3.15	......	......	......	3.1	4.6	4.3	4.45	......	......	3.85
12	3.65	3.05	......	......	......	6.4	4.0	4.3	5.25	......	......	3.85
13	3.65	2.95	......	......	......	6.2	3.8	4.4	5.7	......	......	3.85
14	3.65	2.9	......	......	......	6.5	3.6	5.4	4.5	......	......	3.9
15	3.75	2.85	......	......	......	6.5	4.6	5.4	4.95	......	......	3.95
16	3.75	2.8	......	......	......	6.4	4.1	4.3	......	......	......	4.0
17	3.75	2.8	......	......	......	6.2	4.0	3.95	......	......	......	4.3
18	3.75	2.8	......	......	......	6.0	3.9	4.3	......	......	......	4.3
19	3.75	2.75	......	......	......	5.9	3.7	5.0	......	......	......	4.25
20	3.65	2.75	......	......	......	5.8	3.6	6.95	......	......	......	4.25
21	3.65	2.75	......	......	......	5.6	3.5	6.65	......	......	......	4.25
22	3.65	2.7	......	......	......	5.4	3.5	5.6	......	......	......	4.25
23	3.65	2.7	......	......	3.6	5.3	3.4	5.25	......	......	......	4.25
24	3.6	......	......	......	3.6	5.3	4.7	3.85	......	......	......	4.25
25	3.6	......	......	......	4.6	5.6	4.7	3.65	......	......	......	4.25
26	3.6	......	......	......	4.4	5.5	4.6	3.6	......	......	......	4.25
27	3.6	......	......	......	4.2	5.1	4.6	3.6	......	......	......	4.25
28	3.6	......	......	......	4.0	4.6	4.5	3.6	......	......	......	4.25
29	3.6	......	......	......	4.0	4.15	4.4	3.7	......	......	......	4.25
30	3.6	......	......	......	3.8	3.7	4.4	4.4	......	......	......	4.25
31	3.6	......	......	......	3.8	......	4.3	4.25	......	......	......	4.25

NOTE.—River dry February 20 to April 1, 1909; April 8 to May 23, 1909; September 3 to 4, 1909. Gage heights September 16 to December 3, 1909, too unreliable to publish.

Daily discharge, in second-feet, of Canadian River at Logan, N. Mex., for 1908-9.

Day.	Dec.	Day.	Dec.
1908.		1908.	
25	58	29	35
26	58	30	35
27	35	31	20
28	35		

Daily discharge, in second-feet, of Canadian River at Logan, N. Mex., 1908–9—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	20	14	......	0.4	......	26	13	290	38	......	......	......
2	20	14	......	.6	......	26	7	290	13	......	......	......
3	20	14	......	.8	......	26	7	290	0	......	......	......
4	20	14	......	.6	......	26	2	290	0	......	......	69
5	20	11.9	......	.4	......	26	23	240	3,800	......	......	155
6	20	11.9	......	.3	......	26	13	650	53,200	......	......	145
7	20	7.8	......	.2	......	26	13	350	26,200	......	......	145
8	20	6.2	......	......	......	14	7	290	3,350	......	......	145
9	20	3.7	......	......	......	4.5	23	350	1,840	......	......	178
10	20	2.4	......	......	......	1.8	980	350	2,300	......	......	190
11	20	1.4	......	......	......	1.0	480	290	810	......	......	190
12	20	0.8	......	......	......	4,700	155	290	2,170	......	......	190
13	20	.4	......	......	......	3,800	85	350	3,800	......	......	190
14	20	.3	......	......	......	5,150	38	1,420	870	......	......	202
15	35	.2	......	......	......	5,150	480	1,420	1,550	......	......	216
16	35	.1	......	......	......	4,700	195	290	......	......	......	230
17	35	.1	......	......	......	3,800	155	138	......	......	......	330
18	35	.1	......	......	......	2,950	120	290	......	......	......	330
19	35	.1	......	......	......	2,600	58	860	......	......	......	315
20	20	......	......	......	......	2,300	38	7,300	......	......	......	315
21	20	......	......	......	......	1,800	23	5,820	......	......	......	315
22	20	......	......	......	......	1,420	23	1,800	......	......	......	315
23	20	......	......	......	14	1,260	13	1,180	......	......	......	315
24	14	......	......	......	14	1,260	560	102	......	......	......	315
25	14	......	......	......	480	1,800	560	48	......	......	......	315
26	14	......	......	......	335	1,600	480	38	......	......	......	315
27	14	......	......	......	210	980	480	38	......	......	......	315
28	14	......	......	......	110	480	410	38	......	......	......	315
29	14	......	......	......	110	218	350	58	......	......	......	315
30	14	......	......	......	44	58	350	350	......	......	......	315
31	14	......	......	......	44	......	290	265	......	......	......	315

NOTE.—These discharges are based on rating curves applicable as follows: December 25, 1908, to June 11, 1909, fairly well defined between 8 and 110 second-feet; June 12 to September 8, 1909, well defined; September 9 to 15, 1909, indirect method for shifting channels; September 16 to December 3, 1909, no estimates on account of uncertain gage heights; December 4 to 31, 1909, well defined. River dry February 20 to April 1, April 8 to May 23, and September 3 to 4, 1909.

Monthly discharge of Canadian River at Logan, N. Mex., for 1908–9.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
1908.					
December 25–31	58	20	39.4	547	B.
1909.					
January	35	14	20.9	1,290	B.
February	14	0	3.63	202	C.
March	0	0	0	0	
April	8	0	.11	7	C.
May	480	0	43.9	2,700	C.
June	5,150	1.0	1,540	91,600	B.
July	980	2	207	12,700	B.
August	7,300	38	831	51,100	B.
September 1–15	53,200	0	6,660	198,000	C.
December 4–31	330	69	250	13,900	B.
The period	......	......	......	371,000	

CIMARRON RIVER AT UTE PARK, N. MEX.

This station, which was established July 14, 1907, to determine the amount of water available for storage and irrigation, is located at the highway bridge 300 feet north of the railway station at Ute Park, N. Mex., the terminus of the St. Louis, Rocky Mountain & Pacific Railway. It has been maintained in cooperation with the Territorial engineer of New Mexico.

The station is one-half mile below the mouth of Ute Creek and is below most of the mountain tributaries except the Rayado, which enters several miles below. The drainage area above the station is over 200 square miles.

Very little water is diverted above this point, but most of the normal flow of the stream is used for irrigation in the valley below. The Eagles Nest reservoir site, which has a capacity of over 100,000 acre-feet, is situated in the canyon a few miles upstream from this station and is capable of storing the entire run-off.

Ice is found on this stream during the winter months, but usually has very little effect on the open-channel flow.

The rod-gage datum has remained constant since the station was established. In September, 1909, a Frieze automatic gage was installed at the same location and datum. High-water measurements are made at the bridge and low-water measurements by wading. The stream bed is fairly permanent, but it is rather rough, making high-water measurements somewhat inaccurate. Results, however, should be very good.

Discharge measurements of Cimarron River at Ute Park, N. Mex., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 26[a]	R. L. Cooper	36	39	1.10	117
1909.					
January 24	J. B. Stewart	19.5	13	0.43	14.2
April 10	do	24.5	27	.65	35
Do	do	25.5	19.4	.65	40
May 27	do	27	23.6	.70	58
Do	do	28	24.6	.70	54
June 28	do	18.5	10.8	.40	11.8
July 24	W. H. Sutton	20	14.4	.50	21.3
August 28	C. D. Miller	24	28	.65	45
October 13	do	22	19.1	.45	24.4
October 24	W. B. Freeman	21	15.6	.40	17.1
November 27	G. H. Russell	8	4	.32	8.7

[a] This measurement is republished here as it was in error as published in the 1907–8 report. On the basis of this change the 1907–8 estimates have been revised.

NOTE.—Measurements made by wading at various sections.

Daily gage height, in feet, of Cimarron River at Ute Park, N. Mex., for 1909.

[Mrs. R. P. Woodard, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.4	0.35	0.45	0.6	0.85	0.9	0.4	0.2	0.6	0.35	0.3	0.4
2	.4	.35	.45	.6	.85	.9	.4	.3	.6	.35	.3	.4
3	.4	.45	.5	.6	.9	.8	.4	.4	.6	.4	.3	.4
4	.4	.45	.5	.6	1.05	.8	.4	.3	.5	.4	.3	.35
5	.3	.5	.5	.6	1.1	.6	.4	.3	1.0	.4	.3	.3
6	.3	.5	.55	.6	1.1	.6	.3	.3	.8	.4	.3	.3
7	.3	.5	.8	.6	1.1	.6	.3	.3	.7	.45	.3	.3
8	.3	.5	.7	.6	1.15	.6	.3	.3	.7	.45	.3	.3
9	.3	.5	.6	.5	1.1	.6	.3	.3	.7	.45	.3	.35
10	.3	.5	.5	.6	1.1	.6	.3	.35	.6	.45	.3	.35
11	.3	.5	.45	.7	1.1	.6	.3	.4	.6	.45	.3	.35
12	.3	.5	.4	.55	1.0	.6	.3	.4	.6	.45	.3	.4
13	.3	.45	.4	.6	1.0	.6	.3	.4	.6	.45	.3	.4
14	.4	.45	.45	.7	1.0	.6	.3	.4	.6	.4	.3	.4
15	.4	.45	.45	.75	1.0	.6	.3	.6	.55	.45	.3	.45
16	.5	.4	.45	.8	1.0	.6	.3	.6	.5	.45	.3	.5
17	.5	.4	.55	.9	1.0	.6	.3	.7	.5	.45	.3	.5
18	.5	.4	.7	1.0	1.0	.6	.2	.7	.5	.45	.3	.5
19	.5	.4	.85	1.0	1.0	.6	.2	.6	.45	.45	.3	......
20	.5	.45	.6	1.0	1.0	.4	.2	.6	.45	.4	.3	......
21	.4	.45	.6	.95	1.2	.3	.2	.6	.45	.4	.3	......
22	.4	.4	.6	.9	1.0	.3	.2	.9	.4	.4	.3	......
23	.4	.4	.55	1.0	1.0	.3	.3	.7	.4	.4	.3	......
24	.45	.4	.55	.9	1.0	.3	.5	.7	.4	.35	.3	......
25	.45	.45	.55	.9	1.0	.3	.3	.7	.4	.35	.3	......
26	.45	.45	.6	.9	1.0	.3	.2	.7	.4	.35	.3	......
27	.45	.45	.6	.9	.85	.4	.2	.7	.4	.3	.3	......
28	.4	.45	.6	1.0	.7	.4	.2	.7	.4	.3	.3	......
29	.3	......	.7	1.1	.6	.4	.2	.7	.4	.3	.2	......
30	.3	......	.7	.9	1.0	.4	.2	.7	.4	.3	3	......
31	.3	......	.7	......	.9	......	.2	.7	......	.3	......	......

Daily discharge, in second-feet, of Cimarron River at Ute Park, N. Mex., for 1907–1909.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.							1907.						
1	......	32	59	14	14	14	16	22	22	14	14	22	9
2	......	32	44	14	14	14	17	22	14	14	14	14	9
3	......	44	44	14	14	9	18	22	22	14	14	14	9
4	......	44	32	14	14	9	19	22	14	14	14	14	9
5	......	32	22	14	14	9	20	22	32	14	14	14	9
6	......	22	22	14	14	14	21	22	22	14	14	22	9
7	......	22	22	32	14	14	22	32	22	14	14	18	14
8	......	22	22	32	14	14	23	32	22	14	14	14	14
9	......	22	22	22	14	14	24	22	22	14	14	14	14
10	......	22	22	22	14	14	25	22	22	14	14	9	14
11	......	22	22	14	14	14	26	22	22	14	14	22	14
12	......	32	22	14	14	14	27	22	22	14	14	14	14
13	......	32	22	14	32	14	28	44	32	14	14	14	14
14	22	44	22	14	32	9	29	32	32	14	14	14	14
15	22	32	22	14	22	9	30	22	44	14	14	9	14
							31	32	44	......	14	......	14

Daily discharge, in second-feet, of Cimarron River at Ute Park, N. Mex., for 1907–1909—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1	14	22	14	22	96	77	14	22	9	9	22	7
2	14	22	14	22	96	44	14	22	9	9	22	10
3	14	22	14	22	117	44	14	22	9	6	14	10
4	22	22	14	22	117	44	14	14	14	6	14	10
5	14	22	14	22	117	44	14	14	14	6	14	10
6	14	22	14	22	117	44	14	14	9	6	14	15
7	14	14	14	22	96	44	14	22	9	6	13	15
8	14	14	14	22	77	44	22	22	9	6	13	15
9	14	14	14	22	77	44	22	22	9	6	13	8
10	14	14	14	32	77	44	14	22	9	6	13	8
11	14	14	14	14	96	44	14	14	6	6	13	8
12	14	14	14	59	96	44	14	14	6	6	13	8
13	14	14	14	86	96	44	14	14	6	6	13	4
14	14	14	14	96	96	32	14	22	6	6	13	4
15	14	14	32	184	77	32	14	22	9	6	13	7
16	14	22	32	196	77	32	22	14	9	6	8	7
17	14	22	32	184	96	22	22	14	9	6	5	12
18	14	14	32	184	96	22	22	14	9	6	5	12
19	14	14	32	161	96	22	22	14	9	6	5	12
20	14	14	32	161	96	14	22	22	9	6	5	8
21	14	14	32	161	96	14	22	22	9	6	7	8
22	14	14	32	139	77	9	14	22	6	6	7	8
23	14	14	32	161	77	9	14	14	6	6	7	8
24	14	9	32	161	77	9	14	14	9	6	7	8
25	14	9	32	161	96	9	9	22	9	6	7	8
26	14	9	32	117	77	14	14	22	9	6	7	8
27	14	9	32	117	77	14	14	22	9	9	7	13
28	14	9	32	117	77	14	14	22	9	9	7	13
29	14	9	32	96	96	14	14	22	9	14	7	13
30	22	......	32	96	96	14	22	14	9	14	7	9
31	22	......	22	......	77	......	22	14	......	14	......	9
1909.												
1	9.5	10	16	31	86	104	12	6	35	13	10	16
2	9.5	10	16	31	86	104	12	8	35	13	10	16
3	9.5	16	20	31	99	77	12	13	35	16	10	16
4	9.5	16	21	31	139	77	12	8	21	16	10	13
5	7.2	20	21	31	153	35	12	8	130	16	10	10
6	7.2	20	25	31	153	35	8	8	78	16	10	10
7	7.2	20	55	31	154	35	8	8	56	22	10	10
8	7.2	20	42	31	167	35	8	8	56	22	10	10
0	7.6	20	30	21	154	35	8	8	57	22	10	13
10	7.6	20	20	31	154	35	8	10	38	22	10	13
11	7.6	20	16	46	155	35	8	13	38	22	10	13
12	7.6	20	13	23	127	35	8	13	38	22	10	16
13	8	16	13	30	127	35	8	13	39	22	10	16
14	11	16	16	47	127	34	8	13	39	16	10	16
15	11	16	17	58	128	34	8	36	30	22	10	16
16	19	13	17	70	128	34	8	36	25	22	10	16
17	19	13	25	94	128	34	8	55	25	22	10	16
18	19	13	43	121	128	34	6	55	25	22	10	16
19	19	13	64	122	128	34	6	36	20	22	10	16
20	19	16	31	122	129	12	6	36	20	16	10	16
21	12	16	31	109	182	7	6	36	20	16	10	16
22	12	13	31	96	129	7	6	102	15	16	10	16
23	12	13	26	123	129	7	8	55	15	16	10	16
24	16	13	26	96	130	7	22	55	15	13	10	16
25	16	16	26	96	130	7	8	55	15	13	10	16
26	16	16	31	97	131	7	6	55	15	13	10	16
27	16	16	31	97	91	12	6	55	16	10	10	16
28	12	16	31	124	55	12	6	55	16	10	10	16
29	8	......	43	151	36	12	6	53	16	10	6.5	16
30	8	......	43	98	130	12	6	53	16	10	10	16
31	8	......	43	......	104	......	6	53	......	10	......	16

NOTE.—These discharges were obtained as follows: July 14, 1907, to November 2, 1908, based on a rating curve which is fairly well defined; November 3, 1908, to September 30, 1909, indirect method for shifting channels; October 1 to December 14, 1909, based on a rating curve which is not well defined; December 15 to 31, 1909, estimated.

Monthly discharge of Cimarron River at Ute Park, N. Mex., for 1907–1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
1907.				
July 14-31	44	22	25.4	907
August	44	14	27.9	1,720
September	59	14	21.0	1,250
October	32	14	15.7	965
November	32	9	15.9	946
December	14	9	12.2	750
1908.				
January	22	14	14.8	910
February	22	9	15.2	874
March	32	14	23.5	1,450
April	196	22	96.0	5,710
May	117	77	91.4	5,620
June	77	9	30.0	1,790
July	22	9	16.4	1,010
August	22	14	18.4	1,130
September	14	6	8.73	519
October	14	6	7.16	440
November	22	5	10.5	620
December	15	4	9.52	580
The year	196	4	28.5	20,700
1909.				
January	19	7.2	11.6	713
February	20	10	16.0	889
March	64	13	28.5	1,750
April	151	31	70.7	4,210
May	182	36	126	7,750
June	104	7	32.8	1,950
July	12	6	8.39	516
August	102	6	32.8	2,020
September	130	16	33.3	1,980
October	22	10	16.9	1,040
November	10	6.5	9.88	588
December	16	10	14.8	910
The year	182	6	33.5	24,300

NOTE.—Values for 1907-8 supersede those published in Water Supply Paper 247. Revision was necessary because of an error discovered in computation of discharge measurement of April 26, 1908. Owing to the shifting nature of the stream bed at this station the above values of mean monthly discharge are at best only approximate.

CIMARRON RIVER AT SPRINGER, N. MEX.

This station, which was established July 13, 1907, primarily to determine the amount of unused water in the valley above, is located at Springer, N. Mex., at the highway bridge which crosses the river about one-half mile above the Atchison, Topeka & Santa Fe Railway bridge, about 6 miles below the mouth of the Rayado and 6 miles above its junction with the upper Canadian. The channel is practically without flow during the irrigation season. The drainage area is nearly 1,000 square miles.

The station has been maintained in cooperation with the territorial engineer of New Mexico.

The datum of the rod gage has not been changed. High-water measurements are made from the bridge. The flow is little affected by ice.

On account of the shifting character of the stream and the comparatively small number of discharge measurements the results at this station have not been entirely satisfactory. The station was discontinued December 31, 1909.

Discharge measurements of Cimarron River at Springer, N. Mex., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 22	J. B. Stewart	17.5	4.7	0.15	2.6
April 7	do	12	3.3	.10	1.3
May 24	do	51.5	23.8	.68	29
June 26	do	8.4	3	.18	1.7
July 27	W. H. Sutton	6	1.5	−.18	.96
September 14	J. B. Stewart	38	22.5	.74	26
October 14	C. D. Miller	17	6.2	.35	5.8
October 26	W. B. Freeman	14	4.1	.23	3.7
November 28	G. H. Russell	13	8.2	.30	5.3

NOTE.—Measurements are made by wading at various sections.

Daily gage height, in feet, of Cimarron River at Springer, N. Mex., for 1909.

[W. L. Sever, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.6	0.1	0.1	0.1	0.7	0.4	0.15	−0.15	−0.1	0.35	0.2	0.8
2	.5	.4	.1	.1	.65	.3	.15	− .15	− .1	.35	.2	.8
3	.5	.2	.1	.1	.6	.3	.15	− .2	− .1	.35	.2	.8
4	.4	.2	.1	.0	.5	.25	.35	+ .5	− .1	.35	.2	.8
5	.3	.1	.1	.0	.5	.25	.1	− .1	+3.1	.35	.2	.8
6	.5	.0	.0	.1	.65	.25	.2	− .1	1.55	.35	.2	.8
7	.4	.2	.0	.1	.7	.25	.05	− .1	1.5	.35	.2	.8
8	.4	.1	.1	.1	.75	.3	.25	− .1	.9	.35	.2	.8
9	.3	.2	.0	.1	.95	.25	.25	− .1	.9	.3	.2	.8
10	.3	.3	.0	.1	.9	.25	.25	− .1	.6	.3	.2	.8
11	.3	.2	.2	.05	.8	.3	.2	− .1	1.8	.25	.2	.8
12	.3	.0	.4	.05	.6	.8	.2	− .1	.7	.25	.3	.8
13	.3	.0	.4	.0	.5	.4	.2	− .1	.7	.3	.3	.8
14	.3	.2	.4	.05	.5	.35	.2	− .1	.75	.35	.3	.8
15	.2	.2	.3	.1	.5	.35	.2	− .1	.55	.35	.35	.8
16	.2	.1	.3	.1	.4	.35	.2	− .1	.55	.3	.35	.8
17	.2	.1	.1	.1	.4	.25	+ .2	− .1	.5	.25	.3	.8
18	.2	.1	.1	.2	.4	.25	− .1	− .1	.5	.25	.35	.8
19	.2	.2	.1	.25	.4	.25	− .1	+ .2	.45	.3	.3	.8
20	.2	.1	.2	.4	.4	.3	− .1	.25	.4	.25	.3	.8
21	.2	.0	.1	.6	.6	.3	− .1	.0	.4	.25	.3	.8
22	.1	.1	.1	.8	.8	.3	− .1	.1	.4	.25	.3	.8
23	.1	.2	.1	.8	.8	.25	− .1	.1	.4	.2	.3	.8
24	.1	.2	.1	.75	.7	.2	− .1	+ .1	.4	.2	.3	.8
25	.1	.1	.0	.7	.7	.2	− .1	− .1	.3	.2	.3	.8
26	.1	.1	.0	.75	.75	.2	− .1	− .1	.35	.25	.3	.8
27	.1	.1	.0	.7	.8	.2	− .15	− .1	.35	.25	.3	.8
28	.1	.1	.0	.5	.75	.2	− .15	− .1	.35	.25	.3	.8
29	.1	......	.0	.6	.7	.15	− .15	− .1	.35	.25	.8	.8
30	.1	......	.0	.8	.6	.15	− .15	− .1	.35	.25	.8	.8
31	.1	......	.1	......	.5	......	− .15	− .1	......	.2	......	1.3

NOTE.—Ice conditions November 29 to December 31.

Daily discharge, in second-feet, of Cimarron River at Springer, N. Mex., for 1907–1909.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.						1907.					
1	......	66	3.4	3.0	2.7	16	8	5.3	3.2	4.6	2.5
2	......	51	3.4	3.0	2.7	17	5.3	3.4	3.2	4.6	2.5
3	......	66	3.4	3.0	2.7	18	5.3	3.4	3.2	2.8	2.5
4	......	51	3.4	3.0	2.6	19	5.3	3.4	3.2	6.6	2.5
5	......	51	3.4	3.0	2.6	20	5.3	3.4	3.2	4.4	2.5
6	......	31	3.4	3.0	2.6	21	28	3.4	3.2	2.8	2.5
7	......	19	3.4	3.0	2.6	22	19	3.4	3.2	2.8	2.5
8	......	19	3.4	3.0	2.6	23	19	3.4	3.1	2.8	2.5
9	......	12	3.4	3.0	2.6	24	8	3.4	3.1	2.8	2.5
10	......	12	3.4	2.9	2.6	25	8	5.3	4.9	2.8	2.5
11	......	12	3.4	2.9	2.6	26	8	5.3	3.1	2.7	2.5
12	19	12	3.3	4.6	2.5	27	51	5.3	3.1	2.7	2.5
13	12	8	3.3	4.6	2.5	28	166	5.3	3.1	2.7	2.5
14	12	5.3	3.2	4.6	2.5	29	93	3.4	3.1	2.7	2.5
15	8	5.3	3.2	4.6	2.5	30	51	3.4	3.1	2.7	2.5
						31	107	......	3.1	......	2.5

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1	3	43	23	19	135	12	1.4	1.4	1.7	1.1	17	5.3
2	3	11	22	12	135	12	1.4	1.4	1.7	1.1	17	5.0
3	3	43	22	8	200	5.2	1.4	1.4	2.9	1.1	17	7.2
4	3	26	22	8	200	3.3	1.4	1.4	1.8	1.1	17	6.9
5	3	25	22	5.2	200	3.3	.9	1.4	1.8	1.1	16	6.6
6	3	10	35	5.2	200	3.3	.9	1.4	1.8	1.2	15	6.3
7	3	16	35	5.2	135	1.4	.9	2.2	1.9	1.2	14	6.1
8	3	25	35	5.2	135	1.4	1.4	2.2	1.9	1.2	9.4	5.9
9	3	16	58	5.2	84	1.4	1.4	1.4	1.2	1.2	8.9	5.6
10	3	10	22	5.2	84	1.4	1.4	1.4	1.2	1.2	8.7	5.4
11	5	16	21	5.2	84	1.4	1.4	2.2	1.2	1.2	8.2	5.1
12	5	16	21	8	84	2.2	1.4	2.2	1.2	1.3	12	4.9
13	5	16	21	19	84	2.2	1.4	1.4	1.2	1.3	12	7.2
14	5	39	21	51	84	2.2	1.4	232	1.2	1.3	11	4.5
15	5	39	21	135	84	2.2	4.2	13	1.2	1.4	11	2.9
16	5	39	21	135	84	2.2	2.2	5.4	1.3	1.4	10	2.8
17	5	39	21	232	84	2.2	1.4	1.4	1.3	1.4	6.4	1.6
18	5	39	33	265	84	2.2	1.4	1.4	1.3	1.5	5.9	2.6
19	5	39	33	200	51	1.4	1.4	1.4	1.5	1.5	5.6	6.1
20	5	39	32	200	31	1.4	1.4	5.8	1.5	1.5	5.3	6.0
21	10	64	44	232	31	1.4	1.4	14	1.5	1.5	5.1	6.2
22	10	37	32	200	31	1.4	1.4	11	1.0	6.0	4.9	6.2
23	10	23	32	232	135	1.4	1.4	9.1	1.0	9.6	3.0	4.1
24	10	23	20	232	135	1.4	1.4	9.1	1.0	9.6	2.9	4.3
25	17	23	20	265	84	1.4	3.3	6.0	1.0	9.6	2.8	4.5
26	17	23	19	200	84	6.6	1.4	6.2	1.0	9.9	2.7	26
27	17	23	19	200	84	3.3	1.4	4.0	1.1	9.9	2.6	11
28	16	14	19	135	51	2.2	1.4	2.6	1.1	9.9	14	7.3
29	16	23	19	135	31	1.4	1.4	2.7	1.1	16	5.6	4.8
30	16	......	31	135	19	1.4	25	2.7	1.1	16	5.4	5.0
31	16	......	19	......	19	......	5.2	1.6	......	16	......	7.6
1909.												
1	12	2.2	2.2	2.2	31	8.0	2.8	0.8	0.9	5.6	3.3	5.0
2	7.8	8.0	2.2	2.2	25	5.2	2.8	.8	.9	5.6	3.3	5.0
3	8.2	3.3	2.2	2.2	19	5.2	2.8	.6	.9	5.6	3.3	5.0
4	5.6	3.3	2.2	1.4	12	4.2	6.6	12	.9	5.8	3.3	5.0
5	3.7	2.2	2.2	1.4	12	4.2	2.2	.9	800	5.8	3.3	5.0
6	9.0	1.4	1.4	2.2	25	4.2	3.3	.9	490	5.8	3.3	5.0
7	5.8	3.3	1.4	2.2	31	4.2	1.8	.9	455	5.8	3.3	5.0
8	5.8	2.2	2.2	2.2	41	5.2	4.2	.9	77	6.0	3.3	5.0
9	3.9	3.3	1.4	2.2	110	4.2	4.2	.9	74	4.9	3.3	5.0
10	3.9	5.2	1.4	2.2	84	4.2	4.2	.9	16	4.9	3.3	5.0
11	3.9	3.3	3.3	1.8	51	5.2	3.3	.9	500	4.0	3.3	5.0
12	4.1	1.4	8.0	1.8	19	51	3.3	.9	24	4.1	5.2	5.0
13	4.1	1.4	8.0	1.4	12	8.0	3.3	.9	22	5.1	5.2	5.0
14	4.1	3.3	8.0	1.8	12	6.6	3.3	.9	27	6.4	5.2	5.0
15	2.8	3.3	5.2	2.2	12	6.6	3.3	.9	11	6.6	6.6	5.0

Daily discharge, in second-feet, of Cimarron River at Springer, N. Mex., for 1907–1909—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
16	2.8	2.2	5.2	2.2	8.0	6.6	3.3	.9	11	5.2	6.6	5.0
17	2.9	2.2	2.2	2.2	8.0	4.2	3.3	.9	8.9	4.2	5.2	5.0
18	2.9	2.2	2.2	3.3	8.0	4.2	.9	.9	9.4	4.2	6.6	5.0
19	3.0	3.3	2.2	4.2	8.0	4.2	.9	3.3	7.6	5.2	5.2	5.0
20	3.0	2.2	3.3	8.0	8.0	5.2	.9	4.2	6.1	4.2	5.2	5.0
21	3.1	1.4	2.2	19	19	5.2	.9	1.4	6.1	4.2	5.2	5.0
22	2.0	2.2	2.2	51	51	5.2	.9	2.2	6.4	4.2	5.2	5.0
23	2.2	3.3	2.2	51	51	4 2	.9	2.2	6.4	3.3	5.2	5.0
24	2.2	3.3	2.2	41	31	3.3	.9	2.2	6.4	3.3	5.2	5.0
25	2.2	2.2	1.4	31	31	3.3	.9	.9	4.1	3.3	5.2	5.0
26	2.2	2.2	1.4	41	41	3.3	.9	.9	5.4	4.2	5.2	5.0
27	2.2	2.2	1.4	31	51	3.3	.8	.9	5.4	4.2	5.2	5.0
28	2.2	2.2	1.4	12	41	3.3	.8	.9	5.4	4.2	5.2	5.0
29	2.2	......	1.4	19	31	2.8	.8	.9	5.4	4.2	5.0	5.0
30	2.2	......	1.4	51	19	2.8	.8	.9	5.6	4.2	5.0	5.0
31	2.2	......	2.2	......	12	......	.8	.9	......	3.3	......	5.0

NOTE.—These discharges were obtained as follows: March 29 to August 14, 1908; January 23 to September 4, 1909, and October 1 to November 28 from a rating curve which is well defined below 30 second-feet; August 12 to December 16, 1907; January 25 to March 28, 1908; August 15 to January 22, 1909, and September 6 to 30, 1909, indirect method for shifting channels; December 17, 1907, to January 24, 1908; September 5, 1909, and November 22 to December 31, 1909, estimated.

Monthly discharge of Cimarron River at Springer, N. Mex., for 1907–1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
1907.					
August 12–31	166	5.3	31.9	1,270	C.
September	66	3.4	16.0	952	C.
October	4.9	3.1	3.31	204	C.
November	6.6	2.7	3.39	202	C.
December	2.7	2.5	2.55	157	D.
1908.					
January	17	....	7.6	467	D.
February	64	10	27.6	1,590	C.
March	58	19	26.3	1,620	C.
April	265	5.2	110	6,550	B.
May	200	19	95.7	5,880	B.
June	12	1.4	2.87	171	C.
July	25	.9	2.41	148	C.
August	232	1.4	11.3	695	C.
September	2.9	1.0	1.39	83	C.
October	16	1.1	4.49	276	C.
November	17	2.6	9.21	548	C.
December	26	1.6	6.16	379	C.
The year	265	.9	25.4	18,400	
1909.					
January	12	2.0	4.01	247	C.
February	8.0	1.4	2.79	155	B.
March	8.0	1.4	2.77	170	B.
April	51	1.4	13.2	786	B.
May	110	8.0	29.5	1,810	B.
June	51	2.8	6.24	371	B.
July	6.6	.8	2.26	139	B.
August	12	.6	1.57	97	C.
September	[a] 800	.9	86.6	5,150	B.
October	6.6	3.3	4.76	293	B.
November	6.6	3.3	4.63	276	B.
December	....	....	5.0	307	C.
The period	....	....	13.6	9,800	

[a] Estimated.

RAYADO RIVER AT ABREU'S RANCH, NEAR CIMARRON, N. MEX.

This station, which was established during the first part of 1908 as a temporary station by the New Mexico Hydrographic Survey to determine the amount of water available for irrigation, is located three-fourths of a mile upstream from Abreu's ranch, which is 20 miles west of Springer and 12 miles southwest of Cimarron, the two nearest railroad points. Daily gage readings were taken during 1909 by the Territorial Survey. In October, 1909, when the United States Geological Survey abandoned the station on the Rayado at Miami ranch, near Springer, it took over the station at Abreu's ranch.

The station is now maintained in cooperation with the territorial engineer of New Mexico.

The river receives no tributaries for several miles above or below the station, and the station is above all irrigation diversions.

The datum and location of the gage has remained constant during the maintenance of the station. On November 27, 1909, a chain gage was installed at the same location and datum as the rod gage.

Measurements of discharge are made by wading in the vicinity of the gage or from a foot log about 100 yards upstream. Fair results should be obtained. Thin ice is sometimes found at the station during the winter months.

Discharge measurements of Rayado River at Abreu's ranch, near Cimarron, N. Mex., in 1908-9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 10 [a]	R. L. Cooper	22.5	11.7	1.25	6.1
October 31 [a]	do	21	7.3	1.15	3
1909.					
January 23	J. B. Stewart	11.2	7.3	1.20	4.2
April 9	do	15.5	9.1	1.33	9.6
May 25	do	15.5	16.7	1.55	20.5
June 27	do	12	6.6	1.25	4.8
July 26	W. H. Sutton	14	14.7	1.20	3.8
August 3	do	12	7.0	1.22	4.1
August 7	do	12	7.9	1.24	4.4
August 9	do	13	6.2	1.19	3.7
August 11	do	12.5	7.2	1.26	4.8
August 12	do	12.5	8.4	1.37	9.4
August 13	do	12	6.1	1.20	3.8
August 15	do	13	9.9	1.45	13.6
August 16	do	12.3	7.2	1.30	5.5
August 18	do	14.3	18.3	1.95	73
August 19	do	13.0	8.8	1.35	9.4
August 20	C. D. Miller	12.5	8.0	1.36	10.1
August 21	do	13.0	9.7	1.41	13.9
Do	do	13.0	9.6	1.41	13.7
August 24	do	13.0	10.9	1.50	18.7
August 26	do	13.0	11.1	1.50	18.7
September 26	J. B. Stewart			1.50	[b] 20.0
October 14	C. D. Miller	13.0	7.5	1.20	5.1
October 25	W. B. Freeman	12.5	6.2	1.25	4.3
November 26	G. H. Russell	12.5	7.6	1.30	5.8

[a] Published in Water Supply Paper 247 as miscellaneous.

[b] Estimated.

Daily gage height, in feet, of Rayado River at Abreu's ranch, near Cimarron, N. Mex., for 1909.

[W. W. Dougan, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				1.3	1.6		1.3	1.2	1.35	1.2	1.30	1.29
2						1.45			1.5	1.2	1.26	1.30
3	1.25		1.3		1.5		1.3	1.28	1.4	1.2	1.28	1.30
4		1.20	1.3	1.4		1.45		1.36	1.5	1.22	1.30	1.32
5	1.25				1.6		1.35	1.69	1.9	1.25	1.29	1.33
6				1.3		1.4		1.30	1.8	1.25	1.30	1.33
7	1.15		1.25		1.6		1.52	1.22	1.7	1.3	1.30	1.30
8				1.3		1.4		1.2	1.65	1.28	1.27	1.32
9		1.2			1.7		1.3	1.2	1.6	1.28	1.29	1.34
10			1.25	1.35		1.4	1.25	1.2	1.9	1.28	1.30	1.35
11					1.6			1.26	1.7	1.26	1.30	1.38
12	1.2					1.4	1.2	1.21	1.5	1.26	1.28	1.40
13					1.6			1.20	1.45	1.30	1.27	1.31
14	1.2	1.2	1.25	1.35		1.4	1.2	1.22	1.4	1.30	1.28	1.36
15					1.6	1.4		1.45	1.35	1.28	1.30	
16							1.25	1.29	1.35	1.30	1.27	
17				1.70	1.55	1.3		1.25	1.3	1.32	1.30	1.70
18		1.3					1.2	1.64	1.28	1.34	1.30	1.70
19				1.80	1.6	1.3		1.35	1.28	1.32	1.29	1.72
20	1.2						1.2		1.3	1.3	1.30	1.73
21		1.3	1.3	1.50	1.55	1.3			1.28	1.3	1.30	1.75
22							1.2	1.40	1.25	1.3	1.30	1.78
23	1.2				1.5	1.3			1.25	1.3	1.28	1.79
24	1.2	1.3	1.3	1.5		1.25	1.25	1.52	1.2	1.28	1.29	1.80
25	1.2				1.52			1.50	1.2	1.28	1.29	1.82
26				1.5		1.25	1.25	1.5	1.18	1.30	1.30	1.35
27					1.5	1.25		1.45	1.18	1.32	1.30	1.35
28		1.3	1.3	1.55			1.2	1.4	1.16	1.30	1.30	1.40
29				1.55	1.45	1.25		1.4	1.20	1.30	1.28	1.41
30							1.2	1.4	1.22	1.28	1.27	1.38
31	1.35				1.5		1.3	1.4		1.32		1.40

NOTE.—Ice conditions January 1 to about February 28, December 4 and December 17 to 25. December 4 reading to top of ice 2 inches thick. December 17 to 25 readings to top of ice 3 to 4 inches thick.

Daily discharge, in second-feet, of Rayado River at Abreu's ranch, near Cimarron, N. Mex., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.2	3.8	6.7	6.7	28	18	6.7	3.8	9.4	3.8	6.7	6.4
2	5.2	3.8	6.7	8.5	24	16	6.7	5.0	19	3.8	5.5	6.7
3	5.2	3.8	6.7	10.2	19	16	6.7	6.1	12	3.8	6.1	6.7
4	5.2	3.8	6.7	12	24	16	8.0	9.9	19	4.4	6.7	6.0
5	5.2	3.8	6.2	9.4	28	14	9.4	38	66	5.2	6.4	8.3
6	4.2	3.8	5.7	6.7	28	12	15	6.7	52	5.2	6.7	8.3
7	3.2	3.8	5.2	6.7	28	12	21	4.4	39	6.7	6.7	6.7
8	3.3	3.8	5.2	6.7	34	12	14	3.8	34	6.1	5.8	7.8
9	3.4	3.8	5.2	8.0	39	12	6.7	3.8	28	6.1	6.4	8.8
10	3.5	3.8	5.2	9.4	34	12	5.2	3.8	66	6.1	6.7	9.4
11	3.7	3.8	5.2	9.4	28	12	4.5	5.5	39	5.5	6.7	10.9
12	3.8	3.8	5.2	9.4	28	12	3.8	4.1	19	5.5	6.1	12
13	3.8	3.8	5.2	9.4	28	12	3.8	3.8	16	6.7	5.8	7.2
14	3.8	3.8	5.2	9.4	28	12	3.8	4.4	12	6.7	6.1	9.9
15	3.8	4.0	5.4	19	28	12	4.5	16	9.4	6.1	6.7	8.0
16	3.8	4.8	5.6	29	26	9.4	5.2	6.4	9.4	6.7	5.8	6
17	3.8	5.7	5.8	39	24	6.7	4.5	5.2	6.7	7.8	6.7	6
18	3.8	6.7	6.1	46	26	6.7	3.8	32	6.1	8.8	6.7	6
19	3.8	6.7	6.3	52	28	6.7	3.8	9.4	6.1	7.8	6.4	7
20	3.8	6.7	6.5	36	26	6.7	3.8	10.3	6.7	6.7	6.7	7
21	3.8	6.7	6.7	19	24	6.7	3.8	11.1	6.1	6.7	6.7	7
22	3.8	6.7	6.7	19	22	6.7	3.8	12	5.2	6.7	6.7	8
23	3.8	6.7	6.7	19	19	6.7	4.5	16	5.2	6.7	6.1	8
24	3.8	6.7	6.7	19	20	5.2	5.2	21	3.8	6.1	6.4	8
25	3.8	6.7	6.7	19	21	5.2	5.2	19	3.8	6.1	6.4	8

Daily discharge, in second-feet, of Rayado River at Abreu's ranch, near Cimarron, N. Mex., for 1909—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
26	3.8	6.7	6.7	19	20	5.2	5.2	19	3.6	6.7	6.7	9.4
27	3.8	6.7	6.7	22	19	5.2	4.5	16	3.6	7.8	6.7	9.4
28	3.8	6.7	6.7	24	18	5.2	3.8	12	3.3	6.7	6.7	12
29	3.8	....	6.7	24	16	5.2	3.8	12	3.8	6.7	6.1	12.7
30	3.8	....	6.7	26	18	6.0	3.8	12	4.4	6.1	5.8	10.9
31	3.8	....	6.7	....	19	....	6.7	12	....	7.8	....	12

NOTE.—These discharges are based on a rating curve which is fairly well defined below 80 second-feet. Periods for which gage heights are missing were obtained by interpolation.

Monthly discharge of Rayado River at Abreu's ranch, near Cimarron, N. Mex., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
January	5.2	3.2	3.98	245	C.
February	6.7	3.8	5.05	280	C.
March	6.7	5.2	6.12	376	B.
April	52	6.7	18.4	1,090	A.
May	39	16	24.9	1,530	A.
June	18	5.2	9.78	582	A.
July	21	3.8	6.17	379	A.
August	38	3.8	11.1	682	A.
September	66	3.3	17.3	1,030	A.
October	8.8	3.8	6.25	384	A.
November	6.7	5.5	6.39	380	A.
December	12.7	6	8.40	516	C.
The year	66	3.2	10.3	7,470	

RAYADO RIVER NEAR SPRINGER, N. MEX.

This station, which was established July 9, 1907, to obtain data concerning the amount of water available for storage and irrigation, is located at the proposed site of the Farmers Development Company's reservoir dam, and about one-half mile north of their office, which is at Miami ranch, 12 miles west of Springer, the nearest railroad point. The records have been obtained in cooperation with the territorial engineer of New Mexico.

The station is about 6 miles above the junction of the Rayado with Cimarron River, and below the important tributaries. The drainage area is about 100 square miles. Considerable water is diverted for irrigation above this point.

The rod-gage datum has remained permanent since the station was established. Discharge measurements are made by wading. The flow is practically unaffected by ice. The stream bed is fairly permanent, and good results will be obtained when the discharge has been well defined by measurements.

The station was abandoned in October, 1909.

Discharge measurements of Rayado River near Springer, N. Mex., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 23	J. B. Stewart	3.4	0.46	0.05	0.29
Do	.....do	7.2	1.3	.05	.2
April 8	.....do	14.5	4.0	.29	5.9
May 25	.....do	12.5	2.9	.22	2.7
July 26	W. H. Sutton	....	....	.06	*a* .2
September 13	J. B. Stewart	....	....	.40	*a* .15
October 14	C. D. Miller	....	....	.20	*a* .5
October 25	W. B. Freeman	8	1.9	.15	1.3

a Estimated.

Daily gage height, in feet, of Rayado River near Springer, N. Mex., for 1909.

[J. W. Ausherman, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.
1	....	....	....	0.25	0.20	0.22	0.08	....
2	....	0.1	0.1	.3	.39	.2	.08	0.10
3	0.1	....	....	.3	.4	.2	.08	.09
4	.1	.1	....	.4	.4	.2	.08	....
5	.1	....	.1	.38	.4	.2	.08	.08
6	.1	....	....	.4	.4	.2	.20	....
7	.1	.1	.1	.3	.39	.2	.09	.08
8	.1	....	....	.3	.40	.2	.08	....
9	....	.1	.1	.28	.42	....	.08	.06
10	.1	....	.1	.3	.40	.11	.08	.06
11	.1	.1	....	.3	.32	.1	....	.06
12	....	....	.1	.31	.32	.1	.08	....
13	.1	.1	.1	.44	.31	.12	.10	.08
14	.1	....	....	.32	.29	....	.08	.08
15	.1	....	.1	.36	.30	.1	.05	.08
16	.1	....	.1	.4	.32	.1	.05	.08
17	....	....	.15	.51	.3	.1	.05	....
18	.1	.1	.15	.6	.3	.09	.08	....
19	.1	....	.2	.61	.14	.09	.08	....
20	.1	.1	.15	.5	....	.09	.08	....
21	.1	....	.15	.48	.3	.1	.08	....
22	.1	.1	.2	.4	.3	....	.10	....
23	....	.1	.2	.25	.24	.09	.08	....
24	.1	....	....	.2	....	....	.08	....
25	.1	.1	.15	.29	.3	.09	.08	....
26	....	....	.15	.33	.22	.09	.08	....
27	.1	.1	.15	.30	.2	.09	.06	....
28	....	....	.15	.31	.2	.08	....	....
29	.1	....	....	.33	.2	.08	.06	.12
30	....	....	.15	.29	.2	....	....	....
31	.1	....	....	....	.2	....	.06	....

Daily discharge, in second-feet, of Rayado River near Springer, N. Mex., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	0.4	0.4	0.4	3.8	1.8	2.6	0.4	0.4
2	.4	.4	.4	5.8	10	1.8	.4	.4
3	.4	.4	.4	5.8	11	1.8	.4	.4
4	.4	.4	.4	11	11	1.8	.4	.4
5	.4	.4	.4	10	11	1.8	.4	.4
6	.4	.4	.4	11	11	1.8	1.8	.4
7	.4	.4	.4	5.8	10	1.8	.4	.4
8	.4	.4	.4	5.8	11	1.8	.4	.4
9	.4	.4	.4	5.0	12	1.2	.4	.3
10	.4	.4	.4	5.8	11	.5	.4	.3
11	.4	.4	.4	5.8	6.8	.4	.4	.3
12	.4	.4	.4	6.3	6.8	.4	.4	.4
13	.4	.4	.4	13	6.3	.6	.4	.4
14	.4	.4	.4	6.8	5.4	.5	.4	.4
15	.4	.4	.4	8.9	5.8	.4	.3	.4
16	.4	.4	.4	11	6.8	.4	.3	.4
17	.4	.4	.8	18	5.8	.4	.3	.4
18	.4	.4	.8	25	5.8	.4	.4	.4
19	.4	.4	1.8	26	.7	.4	.4	.5
20	.4	.4	.8	17	3.2	.4	.4	.5
21	.4	.4	.8	16	5.8	.4	.4	.5
22	.4	.4	1.8	11	5.8	.4	.4	.5
23	.4	.4	1.8	3.8	3.4	.4	.4	.5
24	.4	.4	1.3	1.8	4.6	.4	.4	.5
25	.4	.4	.8	5.4	5.8	.4	.4	.5
26	.4	.4	.8	7.4	2.6	.4	.4	.6
27	.4	.4	.8	5.8	1.8	.4	.3	.6
28	.4	.4	.8	6.3	1.8	.4	.3	.6
29	.4	....	.8	7.4	1.8	.4	.3	.6
30	.4	....	.8	5.4	1.8	.4	.3	.6
31	.4	....	2.3	....	1.8	....	.3	.6

NOTE.—The above discharges are based on a well-defined rating curve. The periods for which gage heights are missing are interpolated.

Monthly discharge of Rayado River near Springer, N. Mex., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
January	0.4	0.4	0.4	25	C.
February	.4	.4	.4	22	C.
March	2.3	.4	.75	46	B.
April	26	1.8	9.26	551	A.
May	12	.7	6.14	378	A.
June	2.6	.4	.84	50	B.
July	1.8	.3	.42	26	B.
August	.6	.3	.45	28	C.
The period	....	....	....	1,130	

MORA RIVER AND LA CUEVA CANAL AT LA CUEVA, N. MEX.

This station, which was established August 25, 1903, primarily to determine the amount of water available for storage, is located at the wagon bridge at La Cueva, N. Mex., in the Mora land grant, 26 miles north of Las Vegas, N. Mex. Since July, 1907, the records have been obtained in cooperation with the territorial engineer of New Mexico.

The station is a few miles above the mouth of the Cebolla and a short distance downstream from the intake of La Cueva Canal, and just below the canal waste way. This canal carries water for irrigation, and during the nonirrigating season it is used as a feeder for a reservoir below.

The canal rod gage is located at a footbridge below the wasteway, just north of the gaging station on the river. The datum of the canal gage has remained constant and gage readings have been taken continuously since the station was established whenever there was any water in the canal. Apparent discrepancies in the gagings of the canal are accounted for by the fact that the bed of the canal occasionally contains a considerable deposit of silt, which is cleaned out at intervals.

A little water is diverted above the station for irrigation in addition to that taken out by La Cueva canal, and considerable land is irrigated below the station. By developing the available storage at reservoir sites in that locality it will be possible to utilize the entire flow of the stream for irrigation.

The original gage was washed out in the flood of September 29, 1904, and was replaced by another at practically the same section on April 29, 1905. The datum of this staff gage, which is still in use, is 1.32 feet above that of the original gage.

Fair measurements can be made by wading at low stages; high-water measurements must be corrected for the skew of the bridge. The channel is subject to some shifting, but fair results should be obtained by making frequent measurements at the higher stages.

Discharge measurements of Mora River at La Cueva, N. Mex., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 21	J. B. Stewart	17.7	11.8	0.64	11.8
April 6	do	15.5	9.4	.60	8.6
Do	do	16.5	11.9	.60	8.5
May 23	do	21	23.7	1.12	48
June 25	do	18	14.5	.69	17
July 29	W. H. Sutton	10	4.0	.42	2.7
August 28	do	26	42	2.20	111
October 27	W. B. Freeman	17	15.6	1.11	15
November 30	G. H. Russell	19	15.8	1.08	15.6

Daily gage height, in feet, of Mora River at La Cueva, N. Mex., for 1909.

[Hugh Loudon, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		0.65	0.6	0.5	0.7	1.0	1.05	0.4	1.6	1.15	1.15	1.0
2		.65	.6	.5	.85	.9	.95	.4	1.45	1.15	1.15	1.05
3		.55	.6	.65	.8	.9	.8	1.7	1.45	1.15	1.1	......
4		.5	.6	.5	.95	.9	1.25	1.2	1.4	1.15	1.05	1.1
5		.7	.45	.5	.9	1.0	1.4	1.05	3.45	1.2	1.05	1.15

Daily gage height, in feet, of Mora River at La Cueva, N. Mex., for 1909—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
6	0.65	0.65	0.4	0.5	1.05	1.3	1.5	1.0	3.7	1.2	1.0	1.15
7	.6	.6	.5	.6	1.10	1.1	1.4	.9	3.0	1.2	1.05	1.15
8	.5	.6	.5	.5	1.15	1.1	1.2	1.95	2.55	1.2	1.05	1.05
9	.5	.6	.5	.5	1.1	1.0	1.15	1.0	2.3	1.3	1.1	1.1
10	.35	.6	.6	.65	1.0	1.0	1.0	1.3	2.2	1.3	1.05	1.05
11	.3	.65	1.8	.55	.95	1.1	.95	1.3	2.1	1.3	1.05	1.1
12	.65	.6	.7	.55	1.0	1.2	.75	1.2	2.0	1.25	......	1.15
13	.7	.6	.7	.6	.8	1.15	.6	2.3	1.9	1.25	1.05	1.1
14	.6	.65	.7	.45	.75	1.10	.6	1.35	1.8	1.2	1.05	1.05
15	.6	.8	.65	.4	.8	1.05	.6	2.3	1.7	1.1	1.1	1.1
16	.6	.6	.7	.45	.9	.9	.55	1.3	1.65	1.2	1.1	1.1
17	.6	.6	.7	.5	.75	.9	.5	1.2	1.6	1.2	1.0	1.05
18	.6	.65	.65	.6	.7	.9	.5	1.15	1.6	1.3	.8	......
19	.6	.65	.65	.9	.75	1.4	.5	2.55	1.55	1.25	1.1	......
20	.6	.6	.65	.8	1.2	1.6	.5	1.8	1.5	1.25	1.05	......
21	.6	.6	......	.7	1.05	1.2	.45	1.75	1.45	1.2	1.1	......
22	.65	.7	.70	.75	1.1	1.15	.5	1.45	1.3	......	1.0	......
23	.6	.8	.65	.75	1.1	.9	.6	2.8	1.3	......	1.05	......
24	.6	.65	.6	.8	1.05	.7	.5	2.4	1.3	1.2	1.05	......
25	.6	.6	.6	.7	1.05	.7	.7	3.15	1.3	1.2	1.05	......
26	.5	.6	.7	.7	1.05	.7	.8	2.8	1.25	1.2	1.0	......
27	.6	.6	.7	.65	1.05	.7	.75	2.55	1.25	1.1	1.0	......
28	.6	.6	.7	.7	1.0	.55	.45	2.2	1.2	1.15	......	......
29	.8	......	.7	.9	1.05	.5	.5	2.1	1.2	1.15	1.1	......
30	.8	......	.7	.8	1.1	1.1	.5	1.95	1.2	1.05	1.1	......
31	.75	......	.5	......	1.05	......	.4	1.7	1.15	1.1	......	......

NOTE.—Possible ice effect at times during January, February, and March, which did not materially affect the flow. Ice jam March 11. River frozen December 18 to 31.

Daily discharge, in second-feet, of Mora River at La Cueva, N. Mex., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10	12	10	5.5	15	38	42	1.5	49	18	18	10
2	10	12	10	5.5	26	29	34	.9	35	18	18	12
3	10	7.8	10	12	22	29	22	106	35	18	15	14
4	10	5.5	10	5.5	34	29	62	52	32	18	12	15
5	10	15	3.8	5.5	29	38	79	36	268	22	12	18
6	12	12	2.0	5.5	42	68	91	31	320	22	10	18
7	10	10	5.5	10	47	47	79	22	211	22	12	18
8	5.5	10	5.5	5.5	52	47	57	125	155	22	12	12
9	5.5	10	5.5	5.5	47	38	52	26	125	29	15	15
10	1.0	10	10	12	38	38	38	51	115	29	12	12
11	0	12	12	7.8	34	47	34	49	120	29	12	15
12	12	10	15	7.8	38	57	18	38	92	26	12	18
13	15	10	15	10	22	52	10	156	82	26	12	15
14	10	12	15	3.8	18	47	10	49	71	22	12	12
15	10	22	12	2.0	22	42	10	151	61	15	15	15
16	10	10	15	3.8	29	29	7.8	41	58	22	15	15
17	10	10	15	5.5	18	29	5.5	31	53	22	10	12
18	10	12	12	10	15	29	5.5	18	53	29	2.5	8
19	10	12	12	29	18	79	5.5	172	48	26	15	8
20	10	10	12	22	57	103	5.5	83	43	26	12	8
21	10	10	14	15	42	57	3.8	76	39	22	15	8
22	12	15	15	18	47	52	5.5	44	27	22	10	8
23	10	22	12	18	47	29	10	194	27	22	12	8
24	10	12	10	22	42	15	5.5	143	27	22	12	8
25	10	10	10	15	42	15	15	234	27	22	12	8
26	5.5	10	15	15	42	15	22	188	25	22	10	8
27	10	10	15	12	42	15	18	155	25	15	10	8
28	10	10	15	15	38	7.8	3.8	111	22	18	12	8
29	22	......	15	29	42	5.5	5.5	100	22	18	15	8
30	22	......	15	22	47	47	5.5	84	18	12	15	8
31	18	......	5.5	......	42	......	2.0	58	......	15	......	8

NOTE.—These discharges are based on curves applicable as follows: January 1 to 5, estimated; January 6 to July 31, well defined below 57 second-feet; August 1 to September 27, indirect method for shifting channels; September 28 to December 17, not well defined; December 18 to 31, estimated on account of ice conditions; March 11 and all other days for which there are no gage heights, interpolated.

Monthly discharge of Mora River at La Cueva, N. Mex., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
January	22	0	10.3	633	C.
February	22	5.5	11.5	639	A.
March	15	2.0	11.3	695	A.
April	29	2.0	11.8	702	A.
May	57	15	35.4	2,180	A.
June	103	5.5	39.1	2,330	B.
July	91	2.0	24.7	1,520	B.
August	234	.9	84.7	5,210	C.
September	320	18	76.2	4,530	C.
October	29	12	21.6	1,330	B.
November	18	2.5	12.6	750	B.
December	18	....	11.5	707	C.
The year	320	0	29.2	21,200	

Discharge measurements of La Cueva canal at La Cueva, N. Mex., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 6	J. B. Stewart	8.3	9.1	0.55	6.5
May 23	....do	8.7	9.7	.85	11.0
July 29	W. H. Sutton	11.5	6.5	.50	6.6
August 28	....do	8.5	9.6	1.10	10.5
October 27	W. B. Freeman	7.6	7.2	.82	6.6

Daily gage height, in feet, of La Cueva canal at La Cueva, N. Mex., for 1909.

[Hugh Loudon, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.3	0.05	0.05	0.5	0.9	0.9	0.8	0.7	1.2	1.2	0.3	0.7
2	.3	(a)	.05	.5	.75	.8	.95	.45	1.2	1.2	.3	.8
3	.3	.2	.05	.3	.75	.8	.9	1.05	1.2	1.2	.6	......
4	.4	.15	.45	.5	.4	.9	.85	.9	1.2	1.2	.65	.2
5	.4	.1	.55	.5	.9	.85	.95	.9	(a)	1.2	.65	(a)
6	(a)	(a)	.2	.55	.55	.3	(a)	.85	(a)	1.25	.65	.5
7	(a)	(a)	.25	.5	.6	.8	.9	.9	(a)	1.2	.65	.55
8	.4	(a)	.2	.5	.7	.9	.9	1.3	1.0	1.5	.65	.5
9	.3	(a)	(a)	.5	.7	1.05	.85	1.1	1.0	.3	.7	(a)
10	.7	(a)	(a)	.2	1.0	1.05	1.0	1.2	.9	.3	.7	.3
11	.7	(a)	(a)	.5	.85	1.1	.95	(a)	.4	.3	.8	.25
12	.1	(a)	(a)	.5	.9	1.05	.9	(a)	.5	.3	.8	.25
13	(a)	(a)	(a)	.55	.7	1.05	1.2	(a)	.4	.3	.8	(a)
14	.05	(a)	(a)	.75	.8	1.0	.7	(a)	.3	.3	.7	(a)
15	.05	.1	(a)	.6	.85	1.1	.7	(a)	.45	1.1	.7	(a)
16	.05	.1	(a)	.5	.95	1.1	.65	(a)	.35	.25	.2	(a)
17	.05	(a)	(a)	.65	.6	1.1	.6	(a)	.3	.25	.6	(a)
18	.05	.05	.15	.95	.9	1.0	.5	(a)	.25	.3	1.05	(a)
19	.05	.05	.2	1.0	1.15	.9	.5	(a)	.15	.3	.25	(a)
20	.05	.05	.1	.95	.8	1.0	.5	.65	.1	.2	.7	(a)
21	.05	(a)	.1	1.35	.75	.75	.35	.7	(a)	.2	.2	(a)
22	.05	(a)	.15	1.1	.85	.8	.6	1.0	1.2	.2	.9	(a)
23	.05	(a)	.3	1.15	.85	.9	.7	.5	1.25	.2	.7	(a)
24	.05	(a)	.3	.9	.8	.8	.75	(a)	1.3	.2	.55	(a)
25	.05	.1	.3	1.15	.9	.9	.8	(a)	1.3	.2	.55	(a)
26	.05	.05	(a)	1.1	.9	1.2	1.0	.9	1.3	.2	.9	(a)
27	.05	.1	(a)	1.1	.9	1.0	1.0	.9	1.3	.9	.85	(a)
28	.05	.05	(a)	1.15	.8	.9	.6	1.1	1.3	.5	......	(a)
29	.05	......	(a)	1.3	.95	.85	.5	1.15	1.25	.5	.1	(a)
30	(a)	......	(a)	1.25	.9	.8	.5	1.15	1.25	1.0	.2	(a)
31	(a)	......	.5	......	.9	......	.5	1.05	......	.3	......	(a)

a Water turned out of canal.

Daily discharge, in second-feet, of La Cueva canal at La Cueva, N. Mex., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.3	1.2	1.2	5.8	12	12	10	8.7	12.5	12.5	1.1	4.8
2	3.3	0	1.2	5.8	9.3	10	13	4.9	12.5	12.5	1.1	6.1
3	3.3	2.4	1.2	3.3	9.3	10	12	14	12.5	12.5	3.6	3.3
4	4.5	2.0	1.2	5.8	4.5	12	11	11	12.5	12.5	4.2	.5
5	4.5	1.6	5.2	5.8	12	11	13	10.7	0	12.5	4.2	0
6	0	0	6.5	6.5	6.5	3.3	0	9.5	0	13.4	4.2	2.6
7	0	0	2.4	5.8	7.2	10	12.2	10	0	12.5	4.2	3.1
8	4.5	0	2.8	5.8	8.6	12	12.2	16.7	9.1	17.9	4.2	2.6
9	3.3	0	2.4	5.8	8.6	15	11.4	12.8	9.1	1.1	4.8	0
10	8.6	0	0	2.4	14	15	14.0	14.2	7.5	1.1	4.8	1.1
11	8.6	0	0	5.8	11	16	13.1	0	1.8	1.1	6.1	.7
12	1.6	0	0	5.8	12	15	12.2	0	2.6	1.1	6.1	.7
13	0	0	0	6.5	8.6	15	23	0	1.8	1.1	6.1	0
14	1.2	0	0	9.3	10	14	9.2	0	1.1	1.1	4.8	0
15	1.2	1.6	0	7.2	11	16	9.2	0	2.2	10.8	4.8	0
16	1.2	1.6	0	5.8	13	16	8.4	0	1.4	.7	.5	0
17	1.2	0	0	7.9	7.2	16	7.6	0	1.1	.7	3.6	0
18	1.2	1.2	2.0	13	12	14	6.4	0	.8	1.1	9.9	0
19	1.2	1.2	2.4	14	17	12	6.4	0	.3	1.1	.7	0
20	1.2	1.2	1.6	13	10	14	6.4	5.4	.1	.5	4.8	0
21	1.2	0	1.6	21	9.3	9.3	4.5	5.8	0	.5	.5	0
22	1.2	0	2.0	16	11	10	7.9	10	12.5	.5	7.5	0
23	1.2	0	3.3	17	11	12	9.6	2.9	13.4	.5	4.8	0
24	1.2	0	3.3	12	10	10	10.4	0	14.3	.5	3.1	0
25	1.2	1.6	3.3	17	12	12	11.3	0	14.3	.5	3.1	0
26	1.2	1.2	0	16	12	18	14.8	7.8	14.3	.5	7.5	0
27	1.2	1.6	0	16	12	14	14.9	7.6	14.3	7.5	6.8	0
28	1.2	1.2	0	17	10	12	8.1	10.5	14.3	2.6	3.4	0
29	1.2	....	0	20	13	11	6.6	11.7	13.4	2.6	.1	0
30	0	....	0	19	12	10	6.4	11.7	13.4	9.1	.5	0
31	0	....	5.8	....	12	....	6.1	9.9	....	1.1	....	0

NOTE.—Discharges January 1 to July 6 are based on a rating curve which is poorly defined. The indirect method for shifting channels is used for the remainder of the year.

Monthly discharge of La Cueva canal at La Cueva, N. Mex., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
January	8.6	0	2.09	129	C.
February	2.4	0	.70	39	C.
March	6.5	0	1.59	98	C.
April	21	2.4	10.4	619	B.
May	17	4.5	10.6	652	B.
June	18	3.3	12.6	750	B.
July	23	0	10.0	615	C.
August	16.7	0	6.32	389	C.
September	14.3	0	7.30	434	C.
October	17.9	.5	4.96	305	C.
November	9.9	.1	4.04	240	C.
December	6.1	0	.82	50	C.
The year	23	0	5.95	4,320	

SAPELLO RIVER AT LOS ALAMOS, N. MEX.

This station, which was established August 22, 1903, to determine the amount of water available for diversion into the San Guijuella reservoir for the Las Vegas project, is located about 100 yards upstream from the post-office and general store at Los Alamos, N. Mex., 13 miles north of Las Vegas, the nearest railroad point.

The proposed reservoir lies about 6 miles northwest of Las Vegas, has a storage capacity of about 40,000 acre-feet, is to be filled from the Gallinas, Sapello, and other streams in that vicinity, and is to be used for the irrigation of 10,000 acres of land. The station is situated about 4 miles below the mouth of the Manuelitos and a few miles above the junction of the Sapello with Mora River. A considerable portion of the normal flow of the stream is diverted for irrigation above the station.

The original gage was destroyed by a flood on September 29, 1904, and was replaced in April, 1905, by the present chain gage 400 feet upstream, and at a different datum. Results for short periods during the winter season are sometimes affected by ice on this stream.

The channel is somewhat shifting in character, and on account of the inadequacy of discharge measurements, especially at the higher stages, results have not been entirely satisfactory. Discharge measurements are made from cable during high stages and by wading at miscellaneous sections during low stages. Cable is located about 200 feet above chain gage.

Discharge measurements of Sapello River at Los Alamos, N. Mex., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 21	J. B. Stewart	9	3.3	−0.25	1.1
April 6	do	8.5	2.9	− .25	1.6
May 23	do	9.2	2.7	− .20	1.4
June 25	do	4.3	.8	− .25	.7
July 29	W. H. Sutton	12	3.8	− .18	1.7
August 28	do	22	24.6	.30	12.5
October 27	W. B. Freeman	8	2.5	− .15	1.2
November 30	G. H. Russell	11	8.9	− .10	1.6

Daily gage height, in feet, of Sapello River at Los Alamos, N. Mex., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	−0.2	−0.3	−0.25	−0.3	−0.25	−0.2	−0.2	−0.2	0.0	−0.1	−0.1	−0.1
2	− .2	− .3	− .25	− .3	− .2	− .2	− .2	− .2	.0	− .1	− .1	− .1
3	− .2	− .3	− .25	− .3	− .2	− .2	− .2	− .2	.0	− .1	− .1	− .1
4	− .2	− .3	− .25	− .3	− .2	− .2	− .25	− .2	.0	− .1	− .1	− .1
5	− .2	− .3	− .25	− .3	− .2	− .2	− .25	− .2	.75	.0	− .1	− .1
6	− .2	− .3	− .25	− .25	− .2	− .2	− .25	− .2	1.6	.0	− .1	− .1
7	− .2	− .3	− .25	− .2	− .2	− .2	.1	− .2	1.4	− .1	− .1	− .1
8	− .2	− .3	− .25	− .2	− .2	.2	.05	− .2	1.15	− .1	− .1	− .1
9	− .2	− .3	− .2	− .2	− .2	− .2	− .1	− .2	.0	− .1	− .1	− .1
10	− .2	− .3	− .2	− .2	− .2	− .2	− .2	.6	.05	− .1	− .1	− .1
11	− .2	− .3	− .2	− .25	− .2	− .2	− .2	.05	.05	− .1	− .1	− .1
12	− .2	− .3	− .3	− .2	− .2	− .2	− .25	− .15	.05	− .1	− .1	− .1
13	− .2	− .3	− .3	− .2	− .2	− .2	1.0	.0	.05	− .1	− .1	− .1
14	− .2	− .3	− .3	− .2	− .2	− .2	.1	− .05	.05	− .1	− .1	− .1
15	− .1	− .25	− .3	− .2	− .2	− .2	− .2	.0	.05	− .1	− .1	− .1
16	− .1	− .3	− .3	− .2	− .2	− .2	1.25	.0	.0	− .1	− .1	− .1
17	− .1	− .3	− .3	− .2	− .2	− .2	− .1	− .15	.0	− .1	− .1	− .1
18	− .1	− .3	− .3	− .2	− .2	− .2	− .2	− .2	.0	− .1	− .1	− .1
19	− .1	− .3	− .3	− .2	− .25	− .2	− .2	.35	.0	− .1	− .1	− .1
20	− .1	− .35	− .3	− .2	− .2	− .2	− .25	.05	− .05	− .1	− .1	− .1

Daily gage height, in feet, of Sapello River at Los Alamos, N. Mex., for 1909—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
21	-0.25	-0.35	-0.3	-0.2	-0.2	-0.2	-0.2	0.05	-0.1	-0.1	-0.1	-0.15
22	- .25	- .3	- .3	- .2	- .2	- .2	.1	.0	- .1	- .1	- .1	- .2
23	- .25	- .25	- .3	- .25	- .2	- .25	- .2	.05	- .1	- .1	- .1	- .2
24	- .25	- .25	- .3	- .25	- .2	- .25	- .25	.05	- .1	- .15	- .1	- .2
25	- .25	- .25	- .3	- .25	- .2	- .25	- .1	.05	- .1	- .15	- .1	- .2
26	- .25	- .25	- .25	- .25	- .2	- .2	- .2	.05	- .1	- .15	- .1	- .1
27	- .3	- .25	- .3	- .25	- .2	- .2	- .2	.05	- .1	- .15	- .1	- .1
28	- .3	- .25	- .3	- .25	- .2	- .2	- .2	.05	- .1	- .1	- .1	- .1
29	- .3	....	- .3	- .25	- .2	- .2	- .2	.0	- .1	- .1	- .1	- .1
30	- .3	....	- .3	- .25	- .2	- .25	- .2	.0	- .1	- .1	- .1	- .1
31	- .3	....	- .3	....	- .2	....	- .2	.0	....	- .1	....	- .1

Daily discharge, in second-feet, of Sapello River at Los Alamos, N. Mex., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.4	0.7	1.3	1.1	1.2	1.3	1.1	1.5	4.3	2.1	1.7	1.6
2	1.4	.7	1.3	1.1	1.8	1.3	1.1	1.5	4.3	2.1	1.7	1.6
3	1.4	.7	1.3	1.1	1.8	1.3	1.1	1.5	4.2	2.1	1.7	1.6
4	1.5	.7	1.3	1.1	1.8	1.3	.7	1.5	4.2	2.1	1.7	1.6
5	1.5	.7	1.3	1.1	1.8	1.3	.8	1.5	39	3.4	1.7	1.6
6	1.5	.7	1.3	1.6	1.8	1.3	.8	1.5	159	3.4	1.7	1.6
7	1.5	.7	1.3	2.1	1.8	1.2	5.9	1.5	121	2.1	1.7	1.6
8	1.5	.7	1.3	2.1	1.7	1.2	4.8	1.5	77	2.0	1.7	1.6
9	1.5	.7	1.9	2.1	1.7	1.2	2.3	1.5	4.0	2.0	1.7	1.6
10	1.5	.7	1.9	2.1	1.7	1.2	1.2	29	5.0	2.0	1.7	1.6
11	1.5	.7	1.9	1.5	1.7	1.2	1.2	5.3	5.0	2.0	1.7	1.6
12	1.5	.7	.8	2.1	1.7	1.2	.8	2.0	5.0	2.0	1.7	1.6
13	1.6	.7	1.0	2.1	1.7	1.2	72	4.3	4.9	1.9	1.7	1.6
14	1.6	.7	1.0	2.1	1.7	1.2	6.1	3.4	4.9	1.9	1.7	1.6
15	2.8	1.2	1.0	2.1	1.7	1.1	1.3	4.3	4.9	1.9	1.7	1.6
16	2.8	.8	1.0	2.1	1.5	1.1	95	4.3	3.9	1.9	1.6	1.6
17	2.8	.8	1.0	2.1	1.5	1.1	2.4	2.0	3.9	1.9	1.6	1.6
18	2.8	.8	1.0	2.1	1.5	1.1	1.2	1.5	3.8	1.8	1.6	1.6
19	2.8	.8	1.0	2.1	1.0	1.1	1.2	15	3.8	1.8	1.6	1.6
20	2.8	.3	1.0	2.1	1.5	1.1	.8	5.3	2.9	1.8	1.6	1.6
21	1.1	.3	1.0	2.1	1.4	1.1	1.3	5.3	2.3	1.8	1.6	1.1
22	1.2	.8	1.0	2.1	1.4	1.1	1.0	4.3	2.3	1.8	1.6	.6
23	1.2	1.3	1.0	1.3	1.4	.7	1.3	5.3	2.2	1.7	1.6	.6
24	1.2	1.3	1.0	1.3	1.4	.7	.9	5.3	2.2	1.2	1.6	.6
25	1.2	1.3	1.0	1.3	1.4	.7	2.6	5.3	2.2	1.2	1.6	.6
26	.7	1.3	1.5	1.3	1.4	1.1	1.3	5.3	2.2	1.2	1.6	1.6
27	.7	1.3	1.1	1.3	1.4	1.1	1.4	5.3	2.2	1.2	1.6	1.6
28	.7	1.3	1.1	1.3	1.4	1.1	1.4	5.3	2.2	1.7	1.6	1.6
29	.7	....	1.1	1.3	1.3	1.1	1.4	4.3	2.2	1.7	1.6	1.6
30	.7	....	1.1	1.3	1.3	.7	1.5	4.3	2.1	1.7	1.6	1.6
31	.7	....	1.1	....	1.3	....	1.5	4.3	....	1.7	....	1.6

NOTE.—These discharges were obtained by the indirect method for shifting channels.

Monthly discharge of Sapello River at Los Alamos, N. Mex., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
January	2.8	0.7	1.56	96	C.
February	1.3	.3	.84	47	C.
March	1.9	.8	1.19	73	C.
April	2.1	1.1	1.68	100	C.
May	1.8	1.0	1.54	95	C.
June	1.3	.7	1.11	66	C.
July	95	.7	7.01	431	B.
August	29	1.5	4.65	286	B.
September	159	2.1	16.2	964	B.
October	3.4	1.2	1.91	117	C.
November	1.7	1.6	1.65	98	C.
December	1.6	.6	1.45	89	C.
The year	159	.3	3.40	2,460	

UTE CREEK NEAR LOGAN, N. MEX.

This station, which was reestablished April 13, 1909, to obtain records of the flow available for storage and irrigation, is located 7 miles northwest of Logan, N. Mex., 4 miles above the mouth of Ute Creek, and 100 yards northwest of the old Martinez house. The station is maintained in cooperation with the territorial engineer of New Mexico.

No important tributaries enter Ute Creek below the station or for several miles above. The stream is intermittent in character and most of the run-off water is derived from heavy rains on the basin. A little water is diverted for irrigation above the station, but storage is necessary in order to utilize any considerable proportion of the flow for that purpose. Several reservoir sites are located in that vicinity, the best known of which is probably the Ute Creek reservoir site, a few miles above the gaging station.

Measurements are made by wading near the gage. Estimates of flood discharge have been made by Kutter's formula. To obtain good results it will be necessary to install a cable in the vicinity of the gage. The stream bed is very shifting in character and the creek is subject to sudden rises, so that results obtained will at best be only moderately accurate.

The location and datum of the inclined rod gage has remained constant and is the same as that used by the United States Reclamation Service from August 12, 1904, to June 30, 1906.

Discharge measurements of Ute Creek near Logan, N. Mex., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 13	J. B. Stewart			0.50	0.2
July 22	W. H. Sutton				(a)
August 23	do	26	16.4	1.05	27
September 8	J. B. Stewart	96.5	83	2.10	310
October 21	W. B. Freeman	41	15.2	.90	10.4
December 4	G. H. Russell	26	10.2	.80	13.4

a Creek dry.

NOTE.—An estimate of the flood of September 6 was made by slope measurement. The maximum gage height was 12.2 feet and discharge 22,900 second-feet.

Daily gage height, in feet, of Ute Creek near Logan, N. Mex., for 1909.

[Eligio Martinez, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1							0.3	0.6
2							.3	.65
3						1.8	.3	.7
4						1.9	.3	.8
5						2.1	.2	.7
6					7.5	2.1	.2	.7
7					3.7	2.1	.2	.7
8					2.4	1.9	.2	.7
9				2.9	1.8	1.8	.2	.7
10				1.7	1.3	1.0	.2	.7
11				1.5	1.05	.85	.2	.7
12				1.5	1.1	.55	.2	.7
13				1.7	.95		.2	.7
14				.75	.7		.3	.7
15		2.3		.2	1.1		.3	.7
16		2.2		1.1	1.4		.3	.7
17		1.7		1.35	1.25	1.85	.3	.7
18		.55		3.15	1.0	1.6	.3	.7
19		.25		2.1	.95	1.0	.3	.6
20		.25		1.7	.55	.9	.3	.6
21	0.75	.25		1.65	.35	.9	.3	.5
22	.55	.25		1.15	.25	.6	.3	.5
23	.2	.4		1.1	.10	.5	.3	.5
24	1.3	.8		1.35		.5	.3	.5
25	.75	2.05		.8		.45	.3	.5
26	.35	3.2		.55		.4	.3	.5
27	.15	1.3		.35		.3	.3	.5
28		1.8		.2		.3	.3	.4
29		1.9		.1		.3	.35	.4
30		2.5		.1		.3	.5	.4
31						.3		.4

Daily discharge, in second-feet, of Ute Creek near Logan, N. Mex., for 1909.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0	0	0	0	0	0	0	4
2	0	0	0	0	0	0	0	6
3	0	0	0	0	0	196	0	8
4	0	0	0	0	0	232	0	13
5	0	0	0	0	0	310	0	8
6	0	0	0	0	9,500	310	0	8
7	0	0	0	0	1,700	310	0	8
8	0	0	0	0	490	232	0	8
9	0	0	0	890	196	196	0	8
10	0	0	0	164	67	21	0	8
11	0	0	0	110	27	10	0	8
12	0	0	0	110	33	1.1	0	8
13	0	0	0	164	17	0	0	8
14	0	0	0	6.2	4.5	0	0	8
15	0	420	0	0	33	0	0	8
16	0	360	0	33	88	0	0	8
17	0	164	0	78	58	210	0	8
18	0	1.1	0	1,120	21	132	0	8
19	0	0	0	310	17	19	0	5
20	0	0	0	164	1.1	11	0	5
21	6.2	0	0	150	0	10	0	2
22	1.1	0	0	41	0	1	0	2
23	0	0	0	33	0	0	0	2
24	67	8	0	78	0	0	0	2
25	6.2	290	0	8	0	0	0	2
26	0	1,160	0	1.1	0	0	0	2
27	0	67	0	0	0	0	0	2
28	0	196	0	0	0	0	0	1
29	0	232	0	0	0	0	0	1
30	0	560	0	0	0	0	2	1
31	0		0	0		0		1

NOTE.—Discharges May 1 to October 16 are based on a poorly defined rating curve. The indirect method for shifting channels used November 30 to December 31.

Monthly discharge of Ute Creek near Logan, N. Mex., for 1909.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
May	67	0	2.60	160	C.
June	1,160	0	115	6,840	C.
July	0	0	0	0	
August	1,120	0	112	6,890	C.
September	9,500	0	408	24,300	C.
October	310	0	71.0	4,370	C.
November	2	0	.07	4	D.
December	13	1	5.5	338	D.
The period				42,900	

YAZOO RIVER DRAINAGE BASIN.

DESCRIPTION.

Yazoo River is formed by the union of Tallahatchie and Yalobusha rivers just above Greenwood, Miss., whence it flows southward and southwestward to its junction with the Mississippi at Vicksburg.

Tallahatchie River and its large tributary, Coldwater River, rise in the northern part of Mississippi. Yokona River, also an important tributary of the Tallahatchie, comes in from the east just above the mouth of the Coldwater. Yalobusha River rises in the northern part of the State, farther east than the other tributaries. Sunflower River, which empties into the Yazoo about 20 miles above Vicksburg, drains a narrow basin along the upper western border of the State which is cut off from Mississippi River by the levees.

The drainage area may be divided into two distinct parts, the delta and the hill lands. The delta comprises a strip of land east of the Mississippi extending from the state line on the north to Vicksburg on the south, about 60 miles wide at the center and decreasing in width to about 5 miles at either end. The hill lands comprise the portion of the drainage area located to the east of the delta. The entire delta is traversed by many small streams and bayous and contains numerous so-called lakes, which are really old river channels. During high-water periods the natural channels carry water from one stream to another, and large areas are covered by overflow water.

Except for the land that has been cleared for cultivation—at present a relatively small amount—the drainage area is forested. The mean annual precipitation is about 50 inches. Yazoo River is navigable for its entire length, and most of the larger tributaries are navigable for small boats. The tributaries are used to some extent for logging.

The data collected in the drainage basin are of value for drainage and navigation problems. The Tallahatchie drainage commission is engaged in a drainage project in the upper portion of the basin.

TALLAHATCHIE RIVER AT BATESVILLE, MISS.

This station, which is located at the county highway bridge 1 mile west of Batesville and about 2 miles below the crossing of the Illinois Central Railroad, was established on June 15, 1906. The record has been continuous since that time except for a break from August 1 to September 19, 1906. The station is now maintained in connection with the Tallahatchie drainage commission.

The ground on the right bank is low for a mile or more, but the road has been raised above high water except at a number of bridged openings.

Discharge measurements can be conveniently made at all stages and the relation between gage heights and discharge should be fairly constant. A chain gage attached to the bridge is used, the datum of which has remained the same.

Discharge measurements of Tallahatchie River at Batesville, Miss., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 18	Engineers of the Tallahatchie drainage commission	198	2,010	11.90	5,220
February 21	do			16.91	[a] 11,200
May 28	do	150	1,200	7.68	2,520
June 1	do			15.47	[b] 8,850
August 29	E. H. Swett	130	538	2.58	391

[a] Including overflow of 2,030 second-feet. [b] Including overflow of 1,080 second-feet.

Daily gage height, in feet, of Tallahatchie River at Batesville, Miss., for 1909.

[John S. Goff, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.7	3.7	16.2	6.8	10.6	15.3	6.4	3.2	2.5	2.8	2.5	2.7
2	3.6	3.8	16.9	6.3	10.0	15.9	6.1	3.5	2.5	2.7	2.5	2.7
3	3.5	3.9	16.7	5.9	9.1	15.3	5.9	3.2	2.5	2.6	2.5	2.7
4	3.6	3.9	16.1	5.6	8.9	15.1	10.7	3.1	2.5	2.6	2.5	2.7
5	3.9	4.0	15.8	5.2	8.6	15.6	11.9	3.1	5.8	2.6	2.5	2.8
6	4.0	4.1	14.3	5.5	8.5	16.7	12.7	3.3	5.4	2.5	2.5	2.7
7	4.2	4.1	13.7	5.9	8.4	16.7	12.6	3.7	4.8	2.5	2.5	5.4
8	4.2	5.0	13.2	5.6	8.4	16.1	11.6	4.4	3.1	2.5	2.5	4.5
9	3.9	5.2	13.3	5.4	8.4	15.2	9.6	3.9	3.2	2.5	2.5	3.7
10	3.6	5.8	13.3	5.2	8.7	14.0	7.4	3.7	3.2	2.4	2.7	3.7
11	3.6	6.0	12.9	5.2	7.0	12.4	5.0	3.3	3.2	2.4	2.7	3.7
12	3.5	6.0	11.6	5.9	5.4	9.9	5.8	3.3	3.1	2.4	2.8	7.1
13	3.5	6.1	12.7	10.6	5.0	7.5	5.7	3.2	3.0	2.4	2.7	6.7
14	3.6	9.2	13.7	10.2	4.7	7.8	5.3	3.2	3.0	2.4	2.5	5.7
15	4.1	12.3	14.0	9.8	4.5	7.9	4.8	3.1	2.9	2.4	2.5	5.2
16	4.6	11.5	13.9	9.9	4.4	8.1	4.5	3.0	2.8	2.4	2.4	5.2
17	5.5	11.2	13.4	10.0	4.2	8.4	4.3	3.0	2.7	2.4	2.4	4.9
18	5.4	11.9	13.1	10.7	4.1	9.5	4.3	3.0	2.6	2.4	2.4	4.5
19	5.3	13.5	13.9	11.2	4.2	9.6	4.4	2.9	2.6	2.4	2.4	4.0
20	5.2	15.6	15.0	13.0	5.5	10.7	4.7	2.9	2.5	2.5	2.5	3.7
21	4.9	16.9	15.3	13.9	5.9	11.9	4.7	2.8	3.4	2.5	2.7	3.4
22	4.9	16.7	14.7	13.6	5.5	12.7	4.3	2.8	4.6	2.5	2.7	3.3
23	4.8	16.3	13.4	12.7	6.0	12.6	4.0	2.8	3.9	2.5	3.1	3.3
24	4.7	16.0	12.4	10.8	6.4	11.6	3.8	2.7	3.6	2.5	2.9	6.8
25	4.7	15.7	10.9	8.0	7.0	9.6	3.4	2.7	3.4	2.5	2.8	7.1
26	4.6	15.3	9.5	7.8	10.6	7.4	3.5	2.7	3.4	2.5	2.8	6.9
27	4.4	14.7	8.4	7.5	8.5	6.9	3.5	2.6	3.3	2.5	2.8	5.3
28	4.1	14.7	8.1	7.3	7.7	6.9	3.4	2.6	3.2	2.4	2.8	5.3
29	3.7	......	7.7	7.2	7.9	6.8	3.3	2.6	3.0	2.4	2.8	5.3
30	3.6	......	7.4	7.4	8.2	6.5	3.3	2.6	2.9	2.4	2.8	5.2
31	3.6	......	7.1	......	14.0	......	3.2	2.5	......	2.5	......	5.2

Daily discharge, in second-feet, of Tallahatchie River at Batesville, Miss., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	849	849	10,100	2,060	4,220	8,760	1,880	679	455	549	455	517
2	815	883	11,100	1,840	3,820	9,610	1,760	781	455	517	455	517
3	781	919	10,800	1,680	3,250	8,760	1,680	679	455	485	455	517
4	815	919	9,910	1,560	3,130	8,500	4,300	645	455	485	455	517
5	919	955	9,460	1,400	2,960	9,180	5,220	645	1,640	485	455	549
6	955	991	7,540	1,520	2,900	10,800	5,920	713	1,480	455	455	517
7	1,030	991	6,890	1,680	2,840	10,800	5,820	849	1,250	455	455	1,480
8	1,030	1,320	6,390	1,560	2,840	9,910	4,980	1,100	645	455	455	1,140
9	919	1,400	6,490	1,480	2,840	8,630	3,560	919	679	455	455	849
10	815	1,640	6,490	1,400	3,010	7,200	2,330	849	679	425	517	849
11	815	1,720	6,100	1,400	2,150	5,640	1,320	713	679	425	517	849
12	781	1,720	4,980	1,680	1,480	3,750	1,640	713	645	425	549	2,200
13	781	1,760	5,920	4,220	1,320	2,380	1,600	679	613	425	517	2,020
14	815	3,310	6,890	3,940	1,210	2,530	1,440	679	613	425	455	1,600
15	991	5,560	7,200	3,680	1,140	2,580	1,250	645	581	425	455	1,400
16	1,170	4,900	7,100	3,750	1,100	2,680	1,140	613	549	425	425	1,400
17	1,520	4,660	6,590	3,820	1,030	2,840	1,060	613	517	425	425	1,290
18	1,480	5,220	6,300	4,300	991	3,490	1,060	613	485	425	425	1,140
19	1,440	6,690	7,100	4,660	1,030	3,560	1,100	581	485	425	425	955
20	1,400	9,180	8,370	6,200	1,520	4,300	1,210	581	455	455	455	849
21	1,290	11,100	8,760	7,100	1,680	5,220	1,210	549	747	455	517	747
22	1,290	10,800	8,000	6,790	1,520	5,920	1,060	549	1,170	455	517	713
23	1,250	10,200	6,590	5,920	1,720	5,820	955	549	919	455	645	713
24	1,210	9,760	5,640	4,360	1,880	4,980	883	517	815	455	581	2,060
25	1,210	9,320	4,440	2,630	2,150	3,560	747	517	747	455	549	2,200
26	1,170	8,760	3,490	2,530	4,220	2,330	781	517	747	455	549	2,100
27	1,100	8,000	2,840	2,380	2,900	2,100	781	485	713	455	549	1,440
28	991	8,000	2,680	2,280	2,480	2,100	747	485	679	425	549	1,440
29	849	....	2,480	2,240	2,580	2,060	713	485	613	425	549	1,440
30	815	....	2,330	2,330	2,740	1,920	713	485	581	425	549	1,400
31	815	....	2,200	....	7,200	....	679	455	....	455	....	1,400

NOTE.—The above daily discharges are based on a rating curve well defined between discharges 500 and 12,000 second-feet.

Monthly discharge of Tallahatchie River at Batesville, Miss., for 1909.

Month.	Discharge, in second-feet.			Accuracy.
	Maximum.	Minimum.	Mean.	
January	1,520	781	1,040	A.
February	11,100	849	4,700	A.
March	11,100	2,200	6,490	A
April	7,100	1,400	3,080	A.
May	7,200	991	2,450	A.
June	10,800	1,920	5,400	A.
July	5,920	679	1,920	A.
August	1,100	455	641	A.
September	1,640	455	718	A.
October	549	425	450	B.
November	645	425	494	B.
December	2,200	517	1,190	A.
The year	11,100	425	2,380	

TALLAHATCHIE RIVER AT PHILIPP, MISS.

This station is located at the Yazoo Mississippi & Valley Railroad bridge at Philipp. It was established September 6, 1908, for the purpose of obtaining run-off data in connection with the work of the Tallahatchie drainage commission.

The stream above the station will at times overflow the surrounding country for a distance of several miles on either side. The overflow, however, with small exceptions, is intercepted by the railroad embankment and is made to flow in the main channel at the gaging station, and a few trestled openings in the railroad embankment. Variations in the relative stage of the river below the station will probably so affect the slope as to disturb the relation between gage heights and discharge. Judging by the plotting of the discharge measurements so far made, this disturbance does not appear to be great.

The datum of the gage, which is a vertical staff, is mean sea level; the gage readings therefore represent elevations above sea level. Measurements are made from the downstream side of the railway bridge.

Discharge measurements of Tallahatchie River at Philipp, Miss., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
1908.					
June 13	M. R. Hall	192	2,680	124.38	6,670
December 5	W. A. Lamb	142	1,080	115.35	1,880
1909.					
January 29	Engineers of Tallahatchie drainage commission	178	1,300	115.70	1,760
March 3	W. A. Lamb	254	4,470	132.65	11,800
March 11	Engineers of Tallahatchie drainage commission	306	6,480	135.83	a12,500
March 19	do			136.20	b20,300
March 26	do			136.85	c20,900
May 1	do	210	4,740	129.70	8,710
May 22	do	204	2,850	122.60	5,560
June 4	do	300	6,030	133.2	11,800
August 23	E. H. Swett	139	998	113.2	1,180

a Does not include overflow.
b Including overflow of 7,000 second-feet.
c Including overflow of 7,640 second-feet.

Daily gage height, in feet, of Tallahatchie River at Philipp, Miss., for 1909—Continued.

[G. R. Young, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	116.5	115.0	131.9	136.4	129.9	131.3	131.7	113.7	112.2	115.1	111.8	113.4
2	116.0	114.9	132.2	136.2	129.5	132.0	131.2	113.6	112.1	114.6	111.8	113.2
3	115.9	114.9	132.6	133.9	129.3	132.5	130.5	113.7	112.1	113.9	111.8	113.0
4	115.5	115.0	132.8	135.0	129.1	133.0	129.5	113.9	112.0	113.2	111.8	112.8
5	115.3	115.2	133.1	134.1	129.1	133.3	128.5	113.8	112.0	112.9	111.8	112.6
6	115.1	115.4	133.4	133.5	129.1	133.5	127.1	113.6	111.9	112.5	111.8	112.5
7	115.6	115.9	133.6	132.8	129.1	133.7	125.9	113.5	112.0	112.3	111.8	112.6
8	115.9	116.1	134.0	132.0	129.1	133.9	124.2	113.8	113.0	112.0	111.8	113.9
9	116.0	116.8	134.3	131.8	129.0	134.0	122.6	114.4	113.4	111.9	111.8	114.5
10	116.1	117.6	134.6	130.6	128.9	134.0	121.0	115.3	113.5	111.9	111.8	115.2
11	116.3	119.0	134.8	129.3	128.6	134.1	120.7	115.5	113.6	111.8	111.8	115.5
12	116.3	120.0	135.0	128.0	128.3	134.2	119.4	115.6	113.8	111.8	111.8	116.9
13	116.3	120.6	135.4	127.4	127.7	134.3	118.5	115.7	114.0	111.8	111.8	117.2
14	115.9	121.0	135.6	127.0	126.8	134.3	118.4	116.0	114.2	111.8	111.8	119.9
15	115.9	122.4	135.8	127.5	125.7	134.3	118.2	116.0	113.9	111.8	111.8	121.0
16	116.3	123.7	135.9	127.7	124.5	134.3	117.8	115.8	113.5	111.8	111.8	121.2
17	116.5	125.0	136.0	128.0	123.3	134.3	117.6	115.3	113.3	111.8	111.8	121.7
18	116.6	126.0	136.1	128.3	122.4	134.3	117.2	114.5	113.0	111.8	112.0	122.0
19	116.7	126.8	136.2	128.5	121.4	134.3	116.8	114.1	112.7	111.8	112.7	122.2
20	117.3	127.4	136.4	128.6	121.4	134.2	116.6	113.9	112.4	111.8	112.9	122.4
21	117.3	128.0	136.5	128.8	122.7	134.1	116.3	113.8	112.5	111.8	113.8	122.6
22	117.7	128.6	136.6	128.9	122.5	134.0	116.2	113.6	113.4	111.9	114.5	122.6
23	117.6	129.1	136.7	129.0	122.8	133.9	116.2	113.3	114.3	111.9	115.0	122.5
24	117.4	129.6	136.8	129.2	123.0	133.8	116.1	113.0	114.7	111.9	115.0	122.4
25	116.9	130.1	136.8	129.4	124.1	133.7	115.0	112.8	115.3	111.8	114.8	122.4

Daily gage height, in feet, of Tallahatchie River at Philipp, Miss., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
26	116.5	130.6	136.8	129.6	125.8	133.6	114.7	112.6	115.3	111.8	114.4	122.7
27	116.0	131.1	136.8	130.0	127.0	133.2	114.5	112.4	115.5	111.8	113.9	123.0
28	115.6	131.6	136.8	130.3	128.3	132.9	114.3	112.2	115.5	111.8	113.6	123.1
29	115.3	....	136.75	130.3	129.0	132.6	114.0	112.2	115.4	111.8	113.5	123.6
30	115.3	....	136.7	130.0	129.5	132.1	113.9	112.2	115.4	111.8	113.5	123.7
31	115.1	....	136.5	....	130.5	....	113.8	112.2	....	111.8	....	123.7

Daily discharge, in second-feet, of Tallahatchie River at Philipp, Miss., for 1908–9.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1908.					1908.				
1	....	1,350	1,030	1,380	16	1,110	1,030	1,130	2,570
2	....	1,320	1,030	1,470	17	1,110	1,030	1,150	2,260
3	....	1,300	1,030	1,560	18	1,090	1,030	1,150	2,060
4	....	1,250	1,030	1,600	19	1,090	1,030	1,130	1,840
5	....	1,220	1,030	1,800	20	1,070	1,030	1,130	1,740
6	1,220	1,170	1,030	1,940	21	1,070	1,030	1,110	1,560
7	1,200	1,150	1,030	2,180	22	1,070	1,030	1,090	1,560
8	1,170	1,150	1,030	2,800	23	1,220	1,030	1,090	1,660
9	1,150	1,130	1,030	3,150	24	1,270	1,030	1,090	1,840
10	1,130	1,110	1,030	3,150	25	1,320	1,030	1,110	1,980
11	1,130	1,070	1,050	3,040	26	1,380	1,030	1,130	1,940
12	1,130	1,050	1,050	3,040	27	1,410	1,030	1,170	1,840
13	1,130	1,050	1,050	3,040	28	1,350	1,030	1,320	2,340
14	1,110	1,050	1,130	2,940	29	1,350	1,030	1,250	2,480
15	1,110	1,050	1,130	2,800	30	1,350	1,030	1,350	2,520
					31	....	1,030	....	2,440

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	2,260	1,700	11,300	20,000	9,940	10,800	11,100	1,300	972	1,740	910	1,220
2	2,060	1,660	11,600	19,500	9,700	11,400	10,700	1,270	956	1,560	910	1,170
3	2,020	1,660	12,000	13,900	9,580	11,900	10,300	1,300	956	1,350	910	1,130
4	1,880	1,700	12,200	16,500	9,460	12,500	9,700	1,350	940	1,170	910	1,090
5	1,800	1,770	12,600	14,300	9,460	12,900	9,100	1,320	940	1,110	910	1,050
6	1,740	1,840	13,000	13,200	9,460	13,200	8,260	1,270	925	1,030	910	1,030
7	1,910	2,020	13,400	12,200	9,460	13,500	7,540	1,250	940	990	910	1,050
8	2,020	2,100	14,100	11,400	9,460	13,900	6,520	1,320	1,130	940	910	1,350
9	2,060	2,390	14,800	11,200	9,400	14,100	5,560	1,500	1,220	925	910	1,530
10	2,100	2,750	15,500	10,400	9,340	14,100	4,600	1,800	1,250	925	910	1,770
11	2,180	3,460	16,000	9,580	9,160	14,300	4,420	1,880	1,270	910	910	1,880
12	2,180	4,000	16,500	8,800	8,980	14,500	3,680	1,910	1,320	910	910	2,440
13	2,180	4,360	17,500	8,440	8,620	14,800	3,200	1,940	1,380	910	910	2,570
14	2,020	4,600	18,000	8,200	8,080	14,800	3,150	2,060	1,440	910	910	3,950
15	2,020	5,440	18,500	8,500	7,420	14,800	3,040	2,060	1,350	910	910	4,600
16	2,180	6,220	18,700	8,620	6,700	14,800	2,840	1,980	1,250	910	910	4,720
17	2,260	7,000	19,000	8,800	5,980	14,800	2,750	1,800	1,200	910	910	5,020
18	2,300	7,600	19,200	8,980	5,440	14,800	2,570	1,530	1,130	910	940	5,200
19	2,340	8,080	19,500	9,100	4,840	14,800	2,390	1,410	1,070	910	1,070	5,320
20	2,620	8,440	20,000	9,160	4,840	14,500	2,300	1,350	1,010	910	1,110	5,440
21	2,620	8,800	20,200	9,280	5,260	14,300	2,180	1,320	1,030	910	1,320	5,560
22	2,800	9,160	20,500	9,340	5,500	14,100	2,140	1,270	1,220	925	1,530	5,560
23	2,750	9,460	20,700	9,400	5,680	13,900	2,140	1,200	1,470	925	1,700	5,500
24	2,660	9,760	21,000	9,520	5,800	13,700	2,100	1,130	1,600	925	1,700	5,440
25	2,440	10,100	21,000	9,640	6,460	13,500	1,700	1,090	1,800	910	1,630	5,440
26	2,260	10,400	21,000	9,760	7,480	13,400	1,600	1,050	1,800	910	1,500	5,620
27	2,060	10,700	21,000	10,000	8,200	12,700	1,530	1,010	1,880	910	1,350	5,800
28	1,910	11,000	21,000	10,200	8,980	12,300	1,470	972	1,880	910	1,270	5,860
29	1,800	....	20,900	10,200	9,400	12,000	1,380	972	1,840	910	1,250	6,160
30	1,800	....	20,700	10,000	9,700	11,500	1,350	972	1,840	910	1,250	6,220
31	1,740	....	20,200	....	10,300	....	1,320	972	....	910	....	6,220

NOTE.—The above daily discharges are based on a rating curve fairly well defined between discharges 1,130 and 9,400 second-feet. For higher discharges the rating curve is only approximate.

Monthly discharge of Tallahatchie River at Philipp, Miss., for 1908-9.

Month.	Discharge in second-feet.			Accuracy.
	Maximum.	Minimum.	Mean.	
1908.				
September 6-30	1,410	1,070	1,190	B.
October	1,350	1,030	1,090	B.
November	1,350	1,030	1,110	B.
December	3,150	1,380	2,210	B.
1909.				
January	2,800	1,740	2,160	B.
February	11,000	1,660	5,650	B.
March	21,000	11,300	17,500	C.
April	20,000	8,200	10,900	C.
May	10,300	4,840	8,010	B.
June	14,800	10,800	13,600	C.
July	11,100	1,320	4,280	B.
August	2,060	972	1,410	B.
September	1,880	925	1,300	B.
October	1,740	910	997	B.
November	1,700	910	1,100	B.
December	6,220	1,030	3,770	B.
The year	21,000	910	5,890	

YAZOO RIVER AT GREENWOOD, MISS.

This station, which is located at the highway bridge at Greenwood, a point about 1 mile below the junction of Yalobusha River, was established July 15, 1908, for the purpose of obtaining general run-off data applicable to navigation and drainage problems, and is maintained in cooperation with the Tallahatchie drainage commission.

There are no artificial diversions of water above the station, and all natural diversions return to river above unless at extreme floods some overflow water may be lost to Sunflower River. The conditions at the station are favorable for accurate discharge measurements at all stages, but it is expected that the relation between gage heights and discharges will be greatly disturbed by changes in slope of Yazoo River, caused by varying stages of Mississippi River.

The chain gage is fastened to the downstream handrail of the bridge. Its datum is mean sea level and has not been changed. Discharge measurements are made from this bridge. The United States Weather Bureau has maintained a gage here since November 1, 1904, the datum of which was 92.5 feet above sea level.

The gage heights from January 1 to July 15, 1908, are from the United States Weather Bureau gage and have been adjusted to conform to the sea-level datum of the new gage.

Discharge measurements of Yazoo River at Greenwood, Miss., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 27	W. A. Lamb	411	7,860	115.60	17,100
March 4	.....do	416	8,270	116.55	19,000
March 12	Engineers of Tallahatchie drainage commission	660	9,690	118.51	21,900
March 27	.....do	662	13,300	122.72	28,600
April 3	.....do	659	11,500	121.65	24,300
August 24	E. H. Swett	260	1,540	94.67	1,690
August 26	.....do	259	1,430	94.28	1,450
August 27	.....do	258	1,400	94.16	1,410

Daily gage height, in feet, of Yazoo River at Greenwood, Miss., for 1909.

[W. T. Davis, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	97.56	95.36	115.85	122.18	116.25	120.34	115.59	95.50	93.72	96.19	93.31	94.52
2	97.20	95.26	115.62	121.94	116.28	121.01	115.07	95.75	93.69	95.89	93.28	94.50
3	96.82	95.18	116.28	121.58	115.76	121.42	114.47	95.82	93.67	95.55	93.27	94.41
4	96.48	95.10	116.55	121.17	115.56	121.67	113.76	95.72	93.63	95.11	93.26	94.28
5	96.22	95.19	116.80	120.70	115.36	121.86	113.28	95.64	93.59	94.68	93.26	94.22
6	96.02	95.65	117.35	120.20	115.20	121.98	111.98	95.48	93.55	94.35	93.26	94.08
7	95.88	96.70	117.33	119.73	115.05	122.11	110.94	95.34	93.52	94.08	93.26	94.41
8	96.02	97.29	117.60	119.26	114.85	122.14	109.75	95.40	93.52	93.87	93.26	94.68
9	96.25	97.56	117.96	118.53	114.56	122.09	108.51	95.54	94.03	93.72	93.24	95.14
10	96.32	99.60	118.25	117.68	114.33	122.25	107.20	95.99	94.44	93.61	93.22	95.78
11	96.30	102.30	118.41	116.72	113.55	121.89	106.16	96.58	94.44	93.52	93.22	96.19
12	96.30	103.36	118.52	115.63	112.75	121.75	104.39	96.68	94.62	93.46	93.20	96.53
13	96.32	103.47	119.06	115.42	111.82	121.60	102.98	96.56	94.88	93.41	93.19	97.11
14	96.32	103.80	119.81	115.54	110.80	121.42	101.88	96.52	95.10	93.35	93.18	98.48
15	96.30	106.72	120.30	115.21	109.78	121.19	100.92	96.68	95.12	93.31	93.19	99.90
16	96.28	108.79	120.12	114.90	108.68	120.89	100.08	96.78	95.07	93.30	93.26	100.71
17	96.47	108.90	120.20	114.62	107.64	120.55	99.45	96.63	94.92	93.27	93.42	101.14
18	96.65	109.25	120.28	114.50	107.52	120.29	99.18	96.25	94.69	93.25	93.48	101.42
19	96.75	109.95	120.45	114.35	107.10	120.28	98.44	95.82	94.35	93.22	93.50	101.69
20	96.91	110.85	121.44	114.23	106.78	119.70	97.85	95.53	94.13	93.24	93.58	101.87
21	97.09	111.45	122.09	114.26	106.76	119.34	97.33	95.30	94.37	93.49	93.94	101.96
22	97.33	111.81	122.38	113.92	106.82	119.03	97.05	95.07	95.34	93.38	94.53	101.98
23	97.50	112.67	122.51	114.00	106.97	118.92	96.76	94.82	95.57	93.34	95.04	101.98
24	97.54	114.0	122.59	114.50	107.55	118.67	96.68	94.57	96.86	93.30	95.37	102.03
25	97.52	115.12	122.64	114.32	110.26	118.22	96.57	94.41	96.90	93.30	95.52	102.51
26	97.27	115.43	122.68	115.95	113.80	117.83	96.34	94.23	96.79	93.30	95.45	103.30
27	96.98	115.62	122.72	116.76	116.33	117.45	96.38	94.10	96.57	93.30	95.30	103.73
28	96.59	115.65	122.72	117.30	117.27	116.99	95.90	93.97	96.36	93.30	95.01	103.82
29	96.27	....	122.66	116.92	117.65	116.54	95.72	93.88	96.29	93.30	94.72	103.85
30	95.88	....	122.56	116.58	118.03	116.07	95.58	93.80	96.25	93.32	94.56	103.89
31	95.55	....	122.38	....	119.18	....	95.50	93.73	....	93.35	....	103.87

COLDWATER RIVER AT SAVAGE, MISS.

This station is located at the Yazoo & Mississippi Valley Railroad bridge at Savage, about 5 miles below the place where the river leaves the hills and enters the delta. It was established July 1, 1908, for the purpose of determining the amount of water entering the delta from the foothills and is maintained in cooperation with the Tallahatchie drainage commission.

Although there are large overflow areas along the banks of the river, the flow is practically confined by the railroad embankments to the channel under the bridge and can be conveniently measured at all stages.

The gage, which consists of two vertical sections just below the bridge, is set on sea level datum so as to read actual elevations. Measurements are made from the downstream side of the bridge.

Discharge measurements of Coldwater River at Savage, Miss., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 11	M. R. Hall	255	3,490	182.99	5,190
December 2	W. A. Lamb	135	1,440	173.00	1,050
1909.					
January 20	Engineers of the Tallahatchie drainage commission.	114	946	170.36	449
February 6	do	180	1,630	174.35	1,310
February 9	do	197	2,170	176.87	1,910
February 15	do	253	2,740	179.81	2,230
February 18	do			185.85	[a] 10,800
February 27	do	260	3,570	183.98	5,140
March 1	W. A. Lamb	281	3,700	183.78	5,820
March 13	Engineers of the Tallahatchie drainage commission	265	3,360	182.70	4,920
March 18	do	265	3,280	182.53	4,360
March 22	do	213	2,120	177.10	1,540
March 24	do	159	1,410	172.65	771
March 27	do	128	936	169.24	399
April 17	do	246	2,610	180.51	3,310
April 21	do	250	2,830	180.08	2,980
June 3	do			186.00	[b] 11,200

[a] Includes overflow of 2,640 second-feet. [b] Includes overflow of 2,950 second-feet.

Daily gage height, in feet, of Coldwater River at Savage, Miss., for 1909.

[O. F. Brock, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	168.0	170.9	183.8	167.9	173.2	185.45	170.5	166.1	165.8	166.3	166.0	166.9
2	168.2	170.0	183.6	167.6	175.85	185.8	170.8	166.0	165.8	166.1	166.0	166.8
3	167.9	169.8	183.5	167.5	176.3	186.1	170.8	166.0	165.8	166.1	166.0	167.0
4	167.6	168.7	182.95	167.4	177.2	185.85	170.9	166.0	165.8	166.0	166.0	167.0
5	167.5	167.15	182.5	167.2	176.2	185.5	170.4	166.0	166.0	166.0	166.0	167.9
6	169.0	173.5	181.8	167.2	174.9	184.8	170.1	166.0	166.3	165.9	166.0	168.0
7	171.3	175.2	181.2	168.75	172.0	184.2	169.5	166.85	169.2	165.9	166.0	170.5
8	172.7	176.1	180.65	172.5	170.4	183.5	168.5	172.2	170.2	165.9	166.0	173.5
9	172.0	176.85	180.5	174.5	169.4	182.55	168.2	173.8	173.1	165.9	166.2	174.3
10	170.6	177.6	180.8	175.6	172.1	180.85	167.5	174.4	172.2	165.9	166.3	175.5
11	168.8	177.9	181.4	175.0	172.2	178.5	168.4	173.85	171.1	165.9	166.3	175.8
12	167.7	177.85	182.15	173.5	172.8	178.0	168.8	175.5	166.2	165.9	166.3	180.2
13	167.2	177.35	182.6	175.2	172.5	177.6	167.85	168.9	166.1	165.9	166.1	180.7
14	167.1	177.85	182.8	178.4	171.1	177.1	166.85	168.1	166.0	165.9	166.1	181.5
15	167.2	179.65	183.05	179.3	169.4	176.85	167.0	170.1	165.9	165.9	166.9	184.3
16	167.8	......	183.0	180.05	168.5	176.9	166.7	170.7	165.9	165.9	173.1	185.0
17	170.0	184.1	182.85	180.45	167.7	176.9	166.8	169.0	165.9	165.9	174.9	183.2
18	170.9	185.75	182.55	181.0	167.2	176.6	166.8	168.5	165.8	165.9	175.5	183.2
19	171.75	186.0	182.0	181.4	167.7	175.0	167.2	166.9	165.7	165.9	174.7	183.2
20	170.9	185.85	181.0	181.2	170.8	173.0	167.2	166.8	165.7	166.0	173.4	183.2
21	169.7	185.45	179.4	180.3	172.2	171.0	167.0	166.2	166.0	166.4	169.4	180.7
22	168.1	185.2	177.2	178.0	174.0	169.3	166.7	166.2	169.0	166.3	169.0	178.8
23	167.5	184.8	174.5	174.2	175.0	169.5	166.4	166.1	170.1	166.3	168.5	176.0
24	167.2	184.6	172.7	172.4	176.1	168.8	166.1	165.1	170.8	166.0	169.5	173.0
25	166.9	184.3	171.2	170.5	177.2	171.3	166.1	165.9	170.9	166.0	170.5	176.0
26	166.9	183.95	170.0	172.2	178.0	172.5	166.1	165.9	170.8	166.0	170.4	178.0
27	166.9	183.95	169.2	172.8	179.0	172.5	166.1	165.9	167.9	166.0	169.2	178.5
28	166.8	183.9	169.0	173.2	180.0	172.5	166.2	165.9	167.4	165.9	168.3	178.6
29	167.2	......	168.75	173.6	181.75	169.4	166.1	165.8	166.5	165.9	167.5	178.5
30	168.25	......	168.5	172.0	184.0	168.8	166.0	165.8	166.3	165.9	167.0	178.4
31	169.9	......	168.2	......	184.9	......	166.0	165.8	......	165.9	......	177.4

Daily discharge, in second-feet, of Coldwater River at Savage, Miss., for 1908-9.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1908				1908.				1908.			
1	181	118	837	11	112	144	779	21	115	130	181
2	148	118	890	12	112	151	559	22	115	130	205
3	127	121	787	13	112	158	362	23	115	137	245
4	121	124	548	14	112	173	272	24	115	148	471
5	118	124	410	15	112	173	245	25	115	158	683
6	118	124	290	16	112	165	205	26	112	177	644
7	115	124	803	17	112	162	197	27	112	355	471
8	115	124	1,020	18	115	148	181	28	112	430	326
9	115	137	1,030	19	115	137	181	29	118	740	281
10	112	144	993	20	115	130	165	30	118	779	272
								31	118	......	281

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	290	583	6,970	281	926	10,100	537	137	118	151	130	197
2	308	482	6,590	254	1,520	10,800	571	130	118	137	130	189
3	281	460	6,400	245	1,650	11,300	571	130	118	137	130	205
4	254	353	5,360	237	1,910	10,900	583	130	118	130	130	205
5	245	217	4,660	221	1,620	10,200	526	130	130	130	130	281
6	380	983	4,020	221	1,296	8,870	493	130	151	124	130	290
7	631	1,360	3,620	358	720	7,730	430	193	400	124	130	537
8	837	1,590	3,320	803	525	6,400	335	755	504	124	130	983
9	725	1,800	3,240	1,190	420	4,730	308	1,040	908	124	144	1,150
10	548	2,040	3,390	1,460	740	3,420	245	1,170	755	124	151	1,430
11	362	2,140	3,740	1,310	755	2,360	326	1,050	607	124	151	1,510
12	263	2,130	4,300	983	854	2,180	362	1,430	144	124	151	3,090
13	221	1,960	4,800	1,360	803	2,040	276	371	137	124	137	3,340
14	213	2,130	5,100	2,320	607	1,880	193	299	130	124	137	3,800
15	221	2,840	5,540	2,680	420	1,880	205	493	124	124	197	7,920
16	272	5,190	5,450	3,020	335	1,820	181	559	124	124	908	9,250
17	482	7,540	5,180	3,220	263	1,820	189	380	124	124	1,290	5,830
18	583	10,700	4,730	3,500	221	1,730	189	335	118	124	1,430	5,830
19	690	11,200	4,180	3,740	263	1,310	221	197	112	124	1,240	5,830
20	583	10,900	3,500	3,620	571	890	221	189	112	130	964	5,830
21	450	10,100	2,730	3,140	755	595	205	144	130	158	420	3,340
22	299	9,630	1,910	2,180	1,080	410	181	144	380	151	380	2,480
23	245	8,870	1,190	1,130	1,310	430	158	137	493	151	335	1,560
24	221	8,490	837	787	1,590	362	137	76	571	130	430	890
25	197	7,920	619	537	1,910	631	137	124	583	130	537	1,560
26	197	7,260	482	755	2,180	803	137	124	571	130	526	2,180
27	197	7,260	400	854	2,560	803	137	124	281	130	400	2,360
28	189	7,160	380	926	3,000	803	144	124	237	124	317	2,400
29	221	......	358	1,000	3,980	420	137	118	165	124	245	2,360
30	312	......	335	725	7,350	392	130	118	151	124	205	2,320
31	471	......	308	......	9,060	......	130	118	......	124	......	1,980

NOTE.—The above daily discharges are based on a rating curve fairly well defined between discharges 380 and 5,450 second-feet.

Monthly discharge of Coldwater River at Savage, Miss., for 1908–9.

Month.	Discharge in second-feet.			Accuracy.
	Maximum.	Minimum.	Mean.	
1908.				
October	181	112	118	B.
November	779	118	199	B.
December	1,030	165	478	B.
1909.				
January	837	189	367	A.
February	11,200	217	4,760	B.
March	6,970	308	3,340	B.
April	3,740	221	1,440	A.
May	9,060	221	1,650	A.
June	11,300	362	3,600	A.
July	583	130	277	B.
August	1,430	76	342	B.
September	908	112	287	B.
October	158	124	130	B.
November	1,430	130	391	B.
December	9,250	189	2,620	A.
The year	11,300	76	1,600	

YALOBUSHA RIVER AT GRENADA, MISS.

This station, which was established June 14, 1906, for the purpose of obtaining general run-off data, is located in the western part of Grenada at the county highway bridge, about one-half mile from the depot and the same distance below the crossing of the Illinois Central Railroad. It is below the mouth of Bataupan Bogue, which comes in a short distance above the railroad bridge. The gage chain was stolen a second time on November 2, 1906, and the station was temporarily abandoned. On July 7, 1908, the station was again established in connection with the Tallahatchie drainage commission, using the same gage datum as formerly. The gage is located on the bridge.

The left bank is not liable to overflow. The ground on the right bank is low for a long distance, but is crossed by the public highway embankment, which is above high water except at a few bridged openings.

Conditions are favorable for accurate discharge measurements which are made from the bridge. It is probable that the station rating will be somewhat affected by backwater from Yazoo River and also by shifting of the stream bed.

Discharge measurements of Yalobusha River at Grenada, Miss., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 20	W. R. Wallis		2,360	16.46	6,840
February 26	W. A. Lamb	185	2,930	21.52	[a] 8,590
June 3	W. R. Wallis			24.17	[b] 15,200
August 28	E. H. Swett	58	62	1.15	60

[a] Overflow not measured. [b] Includes an overflow of 3,010 second-feet.

Daily gage height, in feet, of Yalobusha River at Grenada, Miss., for 1909.

[W. C. Carroll, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.35	1.75	21.5	3.8	17.4	24.2	2.65	2.15	1.1	1.3	0.95	1.1
2	2.2	1.7	20.5	3.8	16.4	24.4	2.6	1.75	1.0	1.05	1.0	1.2
3	2.2	1.65	20.0	3.7	16.0	24.2	2.35	2.25	1.0	1.3	1.0	1.65
4	2.25	1.5	19.2	3.4	15.0	23.2	2.6	1.8	.95	1.2	1.1	2.0
5	2.3	1.55	15.0	3.2	14.2	21.2	2.55	1.65	.95	1.15	.95	1.7
6	2.25	1.9	12.2	3.2	13.0	20.8	2.8	1.8	.95	1.15	1.0	1.65
7	2.2	2.7	11.0	5.4	8.4	20.4	2.35	1.55	.95	1.1	1.1	1.4
8	2.2	3.3	10.4	5.6	6.0	19.1	2.05	3.0	.9	1.1	1.1	1.3
9	2.15	8.0	9.2	5.6	5.8	17.6	1.85	3.6	.95	1.1	1.05	1.85
10	2.15	12.5	10.4	5.8	5.6	14.0	1.75	3.0	1.05	1.05	1.1	2.0
11	2.15	11.8	12.0	5.2	4.7	9.6	1.7	2.35	1.15	1.0	1.05	2.1
12	2.15	11.5	14.9	4.5	4.0	6.0	1.65	1.55	1.7	1.0	1.1	2.45
13	2.2	10.0	20.0	12.4	3.8	7.0	1.6	1.5	1.6	.95	1.1	2.3
14	2.2	10.5	20.5	17.0	3.4	10.4	2.05	1.35	1.5	1.05	1.1	2.85
15	2.2	18.4	21.4	15.0	3.2	8.0	2.55	1.65	1.35	1.05	1.05	3.0
16	2.25	18.1	22.0	14.4	3.0	7.0	3.2	1.6	1.35	1.0	1.05	3.4
17	2.3	17.0	22.4	13.8	2.9	6.2	2.85	1.55	1.25	1.0	1.1	3.2
18	2.45	16.9	22.2	13.6	4.1	5.8	2.35	1.45	.95	.95	1.1	2.9
19	2.6	16.8	21.4	13.6	7.2	4.0	2.05	1.45	.9	.95	1.0	2.65
20	2.5	16.6	22.0	13.4	8.0	4.0	1.8	1.4	.9	1.0	.9	2.6
21	2.5	15.4	22.6	11.0	10.4	3.8	1.65	1.35	7.3	1.05	1.0	2.1
22	2.4	15.4	21.5	8.0	11.2	3.8	1.5	1.25	4.2	1.05	1.3	2.5
23	2.35	17.0	20.4	7.4	11.1	3.6	1.55	1.25	3.8	1.0	1.35	2.55
24	2.35	22.3	19.1	7.8	10.8	3.0	2.05	1.2	3.2	1.0	1.45	2.6
25	2.1	22.0	18.2	9.4	21.2	4.0	1.45	1.2	2.85	1.0	1.45	3.0
26	2.05	21.6	17.1	17.4	23.8	4.4	1.4	1.15	2.45	1.1	1.45	2.85
27	2.05	21.0	16.6	18.0	24.6	4.2	1.35	1.15	2.25	1.15	1.4	2.7
28	1.95	22.8	14.1	19.8	23.0	4.2	1.35	1.15	2.1	1.1	1.4	3.1
29	1.95	......	13.3	18.0	22.9	3.9	1.4	1.15	1.95	1.1	1.3	3.4
30	1.9	......	9.1	17.6	23.0	2.8	1.4	1.15	1.7	1.1	1.2	3.2
31	1.95	......	5.3	......	23.9	......	1.4	1.15	......	.95	......	2.9

Daily discharge, in second-feet, of Yalobusha River at Grenada, Miss., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	302	160	11,500	690	7,600	15,300	378	252	55	80	40	55
2	265	150	10,300	690	6,980	15,600	365	160	45	50	45	65
3	265	140	9,750	660,	6,750	15,300	302	278	45	80	45	140
4	278	110	8,980	570	6,200	13,800	365	170	40	65	55	215
5	290	120	6,200	515	5,760	11,100	352	140	40	60	40	150
6	278	190	4,660	515	5,100	10,600	415	170	40	60	45	140
7	265	390	4,000	1,240	2,570	10,200	302	120	40	55	55	95
8	265	540	3,670	1,310	1,470	8,890	228	465	35	55	55	80
9	232	2,350	3,010	1,310	1,390	7,720	180	630	40	55	50	180
10	232	4,820	3,670	1,390	1,310	5,650	160	465	50	50	55	215
11	232	4,440	4,550	1,160	990	3,230	150	302	60	45	50	240
12	232	4,280	6,140	920	750	1,470	140	120	150	45	55	328
13	265	3,450	9,750	4,770	690	1,880	130	110	130	40	55	290
14	265	3,720	10,300	7,340	570	3,670	228	88	110	50	55	428
15	265	8,300	11,400	6,200	515	2,350	352	140	88	50	50	465
16	278	8,080	12,100	5,870	465	1,880	515	130	88	45	50	570
17	290	7,340	12,700	5,540	440	1,550	428	120	72	45	55	515
18	328	7,280	12,400	5,430	780	1,390	302	102	40	40	55	440
19	365	7,220	11,400	5,430	1,970	750	228	102	35	40	45	378
20	340	7,110	12,100	5,320	2,350	750	170	95	35	45	35	365
21	340	6,420	13,000	4,000	3,670	690	140	88	2,020	50	45	240
22	315	6,420	11,500	2,350	4,110	690	110	72	815	50	80	340
23	302	7,340	10,200	2,060	4,060	630	120	72	690	45	88	352
24	302	12,500	8,890	2,250	3,890	465	228	65	515	45	102	365
25	240	12,100	8,150	3,120	11,100	750	102	65	428	45	102	465
26	228	11,600	7,400	7,600	14,700	885	95	60	328	55	102	428
27	228	10,900	7,100	8,000	15,900	815	88	60	278	60	95	390
28	202	13,200	5,700	9,550	13,500	815	88	60	240	55	95	490
29	202	......	5,260	8,000	13,400	720	95	60	202	55	80	570
30	190	......	2,960	7,720	13,500	415	95	60	150	55	65	515
31	202	......	1,200	......	14,800	......	95	60	......	40	......	440

NOTE.—The above daily discharges are based on a rating curve which is fairly well defined.

Monthly discharge of Yalobusha River at Grenada, Miss., for 1909.

Month.	Discharge in second-feet.			Accuracy.
	Maximum.	Minimum.	Mean.	
January	365	190	267	C.
February	13,200	110	5,380	B.
March	13,000	1,200	8,030	B.
April	9,550	515	3,720	B.
May	15,900	440	5,400	B.
June	15,600	415	4,670	B.
July	515	88	224	C.
August	630	60	157	C.
September	2,020	35	230	C.
October	80	40	51.9	C.
November	102	35	61.5	C.
December	570	55	321	C.
The year	15,900	35	2,380	

SUNFLOWER RIVER NEAR RULEVILLE, MISS.

This station, which was established June 15, 1908, and is maintained in cooperation with the Tallahatchie drainage commission, is located at the new iron wagon bridge 3 miles southwest of Ruleville, Miss. The gage was not installed until early in October, 1908, and readings were then intermittent until the end of 1908.

The drainage area above the station is very flat and is cut by a number of small tributaries and bayous. The river at the station and below has a very small amount of slope, making the current too sluggish for measurements at times. The amount of slope and consequently of velocity varies greatly with the stage of Mississippi River, making it impossible to rate the station in the usual way by basing daily discharges upon the daily gage heights.

As the gage, which consists of two vertical sections below the bridge, is set to sea-level datum, the gage readings are actual elevations above the sea. Measurements are made from the downstream side of the bridge.

Discharge measurements of Sunflower River near Ruleville, Miss., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet.*	*Sec.-ft.*
February 21	W. A. Lamb	229	3,640	106.53	2,380
February 22	do	229	3,660	106.65	2,280
August 25	E. H. Swett	196	1,080	97.70	175

Daily gage height, in feet, of Sunflower River near Ruleville, Miss., for 1909.

[W. E. McMathe, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	98.0	97.9	103.4	99.4	104.3	112.75	99.32	98.0	97.8	97.75	97.7	97.7
2	98.0	97.85	102.75	99.5	103.9	113.25	99.3	97.95	97.8	97.7	97.7	97.7
3	98.0	97.75	102.0	99.3	103.15	112.98	99.25	97.9	97.8	97.7	97.7	97.7
4	98.0	97.65	101.25	99.3	102.5	112.22	99.08	97.85	97.8	97.7	97.7	97.7
5	98.0	97.65	100.8	99.3	101.95	110.8	98.88	97.82	97.8	97.7	97.7	97.7
6	98.0	97.7	100.35	99.3	101.95	109.6	98.78	97.8	97.8	97.7	97.7	97.7
7	98.0	97.9	100.05	99.3	101.95	108.25	98.68	97.8	97.8	97.7	97.7	97.7
8	98.0	97.95	99.85	99.3	101.88	107.0	98.58	97.8	97.8	97.7	97.7	97.7
9	98.0	98.1	99.8	99.3	101.5	105.4	98.48	97.8	97.8	97.7	97.7	97.7
10	98.0	98.25	101.1	99.3	101.02	104.3	98.38	97.8	97.8	97.7	97.7	97.7
11	98.0	98.3	101.95	99.3	100.5	103.25	98.28	97.8	97.8	97.7	97.7	97.8
12	98.0	98.4	102.15	99.3	100.15	102.75	98.2	97.8	97.78	97.7	97.7	98.65
13	98.0	98.5	103.35	99.82	99.4	103.45	98.2	97.8	97.75	97.7	97.7	99.55
14	98.1	99.3	106.05	101.6	99.65	104.65	98.2	97.8	97.72	97.7	97.7	100.15
15	98.1	101.0	108.1	102.25	99.42	105.5	98.2	97.8	97.7	97.7	97.7	100.32
16	98.1	104.45	108.7	102.35	99.4	105.55	98.2	97.8	97.68	97.7	97.7	100.32
17	98.1	105.9	106.9	101.9	99.5	104.65	98.2	97.8	97.65	97.7	97.7	100.28
18	98.1	105.6	105.9	101.28	99.75	104.15	98.12	97.8	97.6	97.7	97.7	100.2
19	98.0	106.45	104.35	100.92	100.05	103.8	98.0	97.8	97.6	97.7	97.7	100.2
20	98.0	106.5	104.5	100.3	100.3	102.55	98.0	97.8	97.6	97.7	97.7	100.2
21	98.0	106.65	105.2	99.72	100.65	101.8	98.0	97.8	97.62	97.7	97.7	100.32
22	98.0	106.8	105.4	99.5	100.75	101.45	98.0	97.8	97.72	97.7	97.7	100.55
23	98.0	106.65	105.15	99.4	100.6	101.3	98.0	97.8	97.78	97.7	97.7	100.9
24	98.0	106.4	104.3	99.3	100.4	101.3	98.0	97.8	97.85	97.7	97.7	100.75
25	98.0	105.55	103.55	100.48	103.05	101.3	98.0	97.8	97.85	97.7	97.7	100.5
26	98.0	105.7	102.8	102.28	106.8	100.65	98.0	97.8	97.85	97.7	97.7	101.95
27	98.0	104.7	102.1	102.98	110.95	100.75	98.0	97.8	97.85	97.7	97.7	102.55
28	98.0	104.9	101.45	104.22	111.75	100.35	98.0	97.8	97.85	97.7	97.7	102.75
29	98.0	......	101.75	104.5	111.35	99.9	98.0	97.8	97.8	97.7	97.7	102.8
30	98.0	......	101.55	104.05	110.42	99.52	98.0	97.8	97.78	97.7	97.7	102.25
31	98.0	......	100.75	......	111.28	......	98.0	......	......	97.7	......	101.25

SUNFLOWER RIVER AT BAIRD, MISS.

This station, which is located at the Southern Railway bridge one-half mile west of Baird, Miss., was established June 16, 1908, but the gage was not put in until October 4, 1908. It is maintained in cooperation with the Tallahatchie drainage commission.

Owing to the great variation in height of the outlet of Sunflower River into the Mississippi through the lower portion of Yazoo River and consequently in the slope of Sunflower River, there is no relation whatever between gage heights and discharge at this station.

As the gage, which consists of two vertical sections above the bridge, is set on sea level datum, the readings are elevations above sea level. Measurements are from the downstream side of the bridge.

The United States Army Engineers have maintained a gage at this station for a portion of the time, and the gage heights prior to October 4, 1908, are from their records corrected to the sea level datum of the new gage.

Discharge measurements of Sunflower River at Baird, Miss., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 23	W. A. Lamb	234	3,100	94.25	4,120
August 26	E. H. Swett	172	697	82.90	416

Daily gage height, in feet, of Sunflower River at Baird, Miss., for 1909.

[C. H. Cooper, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	83.5	83.0	94.5	96.5	98.0	103.9	92.0	87.2			82.7	82.8
2	83.5	83.0	93.9	96.5	97.5	104.3	91.8	87.3			82.7	82.8
3	83.4	82.9	93.4	96.5	96.9	104.4	91.5	87.3			82.7	82.8
4	83.3	82.9	92.6	96.5	96.4	104.1	91.3	87.0			82.7	82.8
5	83.3	82.9	91.8	96.5	95.8	103.8	91.0	86.8			82.7	82.8
6	83.2	83.1	91.5	96.5	95.3	103.0	90.7	86.4			82.7	82.9
7	83.1	83.1	90.9	96.4	94.8	102.3	90.3	85.7			82.7	83.0
8	83.1	83.1	90.5	96.0	94.3	101.5	89.8	85.0			82.7	83.0
9	83.1	83.3	90.5	95.8	93.8	100.2	89.5	84.4			82.7	83.0
10	83.0	83.5	90.8	95.6	93.0	99.0	89.2	84.2		82.7	82.7	83.0
11	83.0	83.6	91.3	95.4	92.8	98.5	88.6	83.6		82.7	82.7	83.0
12	83.0	83.6	91.7	95.2	92.3	98.0	88.0	83.4		82.75	82.65	83.2
13	83.0	83.7	93.0	95.8	91.9	97.3	87.5	83.3		82.7	82.65	83.3
14	83.0	83.9	94.8	96.0	91.5	96.9	87.0	83.2		82.7	82.8	83.4
15	83.0	87.0	96.5	96.0	91.2	97.0	86.5			82.7	82.8	84.1
16	83.0	89.4	97.4	95.9	91.0	97.0	86.1			82.7	82.8	84.5
17	83.1	91.3	97.5	95.6	90.8	96.7	85.6			82.7	82.8	84.7
18	83.1	92.3	97.5	95.2	90.8	96.5	85.2			82.7	82.8	84.7
19	83.2	93.0	97.7	94.7	91.0	96.0	85.0			82.7	82.8	84.5
20	83.2	93.5	97.7	94.3	91.8	95.6	84.5			82.7	82.8	84.3
21	83.2	93.9	98.5	93.9	92.4	95.2	84.3			82.75	82.8	84.1
22	83.2	94.0	98.7	93.4	92.6	94.6	84.2			82.75	82.8	84.1
23	83.2	94.3	98.8	93.0	92.7	94.3	84.0			82.75	82.8	84.2
24	83.1	95.0	98.4	92.8	92.8	93.9	84.0			82.7	82.8	84.3
25	83.1	95.5	97.9	92.4	95.5	93.5	85.1			82.7	82.8	84.4
26	83.1	95.6	97.5	95.2	99.5	93.3	85.5			82.7	82.75	84.7
27	83.1	95.5	97.1	96.7	101.7	93.0	85.9			82.7	82.75	85.8
28	83.0	95.0	96.9	97.8	102.6	92.8	86.4			82.7	82.7	86.7
29	83.0		96.8	98.3	103.5	92.5	86.6			82.7	82.7	87.0
30	83.0		96.6	98.3	103.6	92.3	87.0			82.7	82.7	87.0
31	83.0		96.5		103.7		87.1			82.7		86.7

MISCELLANEOUS MEASUREMENTS IN THE LOWER MISSISSIPPI RIVER DRAINAGE BASIN.

The following miscellaneous discharge measurements were made in the lower Mississippi River drainage basin during 1909:

Miscellaneous measurements in lower Mississippi River Basin.

Arkansas River Basin.

Date.	Stream.	Tributary to—	Locality.	Gage height.	Discharge.
				Feet.	*Sec.-ft.*
June 8	Grape Creek	Arkansas River	At mouth, Colo		24.6
May 6	De Wesse-Dye Ditch	Grape Creek	Canon City, Colo	a 0.50	18.4
June 28	do	do	do	a .30	13.8
May 6	Oil Creek	Arkansas River	Denver & Rio Grande R. R. crossing, Canon City, Colo.		10
Do	Oak Creek	do	Florence, Colo		2

a Temporary gage one-half mile below headgate.

Miscellaneous measurements in lower Mississippi River Basin—Continued.

Arkansas River Basin—Continued.

Date.	Stream.	Tributary to—	Locality.	Gage height.	Discharge.
				Feet.	*Sec.-ft.*
Feb. 14	Fountain Creek	Arkansas River	Colorado Springs, Colo.		a 5
Do	Cheyenne Creek	Fountain Creek	do		a 1.5
May 19	Cucharas River	Arkansas River	8 miles above LaVeta, Colo.	b 1.30	59
Do	do	do	La Veta, Colo	c 2.13	31
Do	Veta Creek	Cucharas River	do		b .5
September 15	Purgatory River	Arkansas River	Higbee, Colo	2.95	48.2
October 23	Canadian River	do	French, N. Mex		a 6.5
January 23	Rayado River	Canadian River	Springer, N. Mex	.40	.12
April 8	do	do	do		a .5
May 25	do	do	do	.40	a .4
January 23	Farmer's Development Canal.	Rayado River	Miami, N. Mex	.70	3.4
May 25	do	do	do	.72	5.6
October 27	Cebolla Creek	Mora River	La Cueva, N. Mex		a 3.0
June 25	do	do	At mouth, N. Mex		a 1.0

Yazoo River Basin.

Date.	Stream.	Tributary to—	Locality.	Gage height.	Discharge.
February 15	Tallahatchie River	Yazoo River	Polkville, Miss	148.25	7,430
February 21	do	do	do	153.70	12,600
March 2	do	do	do	156.60	17,600
March 7	do	do	do	156.90	16,300
March 17	do	do	do	156.40	15,700
March 23	do	do	do	156.17	15,200
March 29	do	do	do	153.95	11,800
April 24	do	do	do	150.10	8,680
May 5	do	do	do	150.09	8,680
May 7	do	do	do	150.12	8,180
Do	do	do	do	150.08	8,250
June 11	do	do	do	156.40	16,700
January 26	do	do	Locopolis, Miss	125.90	2,140
March 17	do	do	do	145.80	14,800
March 31	do	do	do	144.70	9,520
May 1	do	do	do	138.86	7,880
May 18	do	do	do	129.85	3,620
June 5	do	do	do	143.19	11,400
March 18	do	do	Swan Lake, Miss	142.39	14,500
February 8	Coldwater River	Tallahatchie River	Pratts Bridge, Miss	195.00	2,010
February 17	do	do	do	198.00	15,300
April 16	do	do	do	196.80	4,890
May 28	do	do	do	197.60	10,700
June 1	do	do	do	197.91	12,100
March 24	do	do	Sarah, Miss	170.83	838
February 27	do	do	Askew, Miss	176.80	2,050
March 22	do	do	do	173.15	1,490
February 21	do	do	Hinchcliffe, Miss	155.36	5,740
March 1	do	do	do	158.60	6,660
March 16	do	do	do	158.19	5,880
March 22	do	do	do	157.80	5,400
March 29	do	do	do	154.79	2,710
April 24	do	do	do	153.11	3,460
June 5	do	do	do	157.30	6,050
February 25	Tillatoba Creek	do	South Fork, Charleston, Miss.	164.50	161
Do	do	do	North Fork, Charleston, Miss.	165.55	36
March 15	do	do	Both forks, Charleston, Miss.	166.10	402
March 20	do	do	do	178.60	2,150
Do	do	do	do	177.30	2,130
February 16	Sunflower River	Yazoo River	Clarksdale, Miss	135.91	4,620

Red River Basin.

Date.	Stream.	Tributary to—	Locality.	Gage height.	Discharge.
April 6	Ouachita River	Red River	Arkadelphia, Ark	d 3.8	822

a Estimated.
b Distance below brass tack in end of log at right abutment, downstream side.
c Temporary rod gage on bridge one-half mile below mouth of Veta Creek.
d Gage on downstream side of highway bridge.

INDEX.

D.

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F.

G.

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