9

SECOND

BIENNIAL REPORT

OF THE

STATE ENGINEER

TO THE

GOVERNOR OF UTAH.

1899 AND 1900.

SALT LAKE CITY.
THE DESERET NEWS.
1901.

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SALT LAKE CITY, UTAH,
December 31st, 1900.

Honorable Heber M. Wells, Governor of Utah.

SIR—In compliance with Section 2458, Chapter 8, Revised Statutes of Utah, 1898, I have the honor to submit a report of the work of this office during the past two years, with such recommendations as to amendments of the existing laws relating to irrigation and the enactment of new laws as will, I trust, promote the public welfare.

Respectfully,
ROBERT C. GEMMELL,
State Engineer.

Work of Office in 1899-1900.

PREPARATION OF PLANS.

Section 2451 of the revised Statutes provides that the State Engineer shall, under the direction of the State Board of Land Commissioners, prepare plans and specifications for, and have general supervision over, any works relating to irrigation in which the State may have any interest. No work of this kind has yet been attempted by the State.

RECORD OF STREAM MEASUREMENTS.

Section 2452 provides that the State Engineer shall keep a record of measurements of streams, etc., but no funds are provided for this purpose. The records of such measurements as have been made by the Division of Hydrography of the U. S. Geological Survey are being kept in this office. Measurements of the discharges of City Creek, Emigration Creek, Parley's Creek, Mill Creek, and Big Cottonwood Creek, all situated in Salt Lake County, have been made by Mr. F. C. Kelsey, City Engineer of Salt Lake City. Mr. Kelsey has kindly furnished this office with the results of his measurements, and they are shown in Tables I, II, III, IV, and V.

TABLE I.

DISCHARGE OF CITY CREEK, 1900.

In cubic feet per second.

MONTH	MAXIMUM	MEAN	MINIMUM
January.....	11.30	8.01	7.73
February ...	8.06	7.43	7.02
March	11.03	9.23	7.79
April.....	14.68	10.90	8.84
May.....	31.91	23.90	14.41
June	25.00	16.08	11.37
July	11.90	9.81	7.58
August	9.89	7.56	6.38
September ..	7.27	6.48	6.09
October	7.12	6.51	6.24
November ...	7.27	6.43	5.57
December....			

TABLE II.

DISCHARGE OF EMIGRATION CREEK, 1900.

In cubic feet per second.

MONTH	MAXIMUM	MEAN	MINIMUM
May.....	3.92	3.79	3.46
June..	3.46	2.41	1.27
July	1.52	.90	.51
August.....	.57	.54	.50
September...	.54	.52	.48
October	1.26	.68	.48
November ...	2.96	1.30	.82
December....			

TABLE III.

DISCHARGE OF PARLEY'S CREEK, 1900.

In cubic feet per second.

MONTH	MAXIMUM	MEAN	MINIMUM
January.....	16.04	11.91	3.96
February....	15.65	10.36	8.36
March	20.14	16.43	11.90
April.....	33.16	20.89	14.49
May	39.00	27.54	22.05
June...	25.71	15.84	8.71
July.....	14.43	9.46	5.87
August.....	10.79	7.25	5.87
September...	10.40	6.96	4.37
October.....	12.77	8.93	7.17
November ...	12.26	7.75	5.26
December....			

TABLE IV.

DISCHARGE OF MILL CREEK, 1900.

In cubic feet per second.

MONTH	MAXIMUM	MEAN	MININUM
January.....	13.04	12.04	8.09
February....	11.33	10.39	8.09
March	13.04	11.84	10.49
April.....	13.95	12.60	11.74
May	30.79	21.63	13.95
June	22.92	16.18	13.04
July.....	13.95	10.39	8.79
August.....	10.49	9.44	8.76
September...	8.86	8.56	8.09
October.....	8.86	8.56	8.49
November ...	9.66	8.75	8.49
December			

TABLE V.

DISCHARGE OF BIG COTTONWOOD, 1900.

In cubic feet per second.

MONTH	MAXIMUM	MEAN	MINIMUM
May*	316.40	222.02	126.51
June	287.82	171.07	83.38
July	87.10	47.63	35.12
August	39.14	33.72	27.15
September ..	31.61	25.36	21.45
October	33.17	27.26	23.38
November ...	32.65	29.07	24.41
December ...	29.48		

* Beginning May 14.

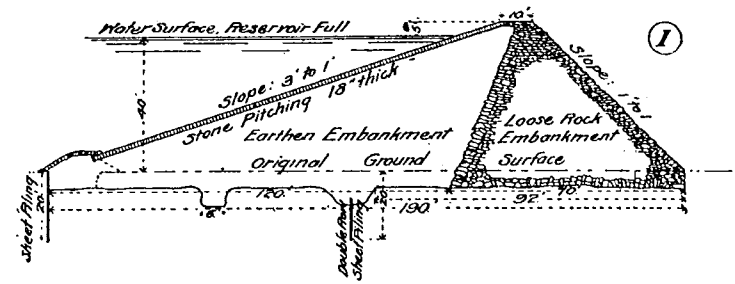
APPROVAL OF PLANS.

Section 2453 provides that all plans of dams or dikes, when the same are more than ten feet in height, shall be approved by the State Engineer. The following is a description of the dams and reservoirs, the plans and specifications for which have been approved during the years 1899 and 1900:—

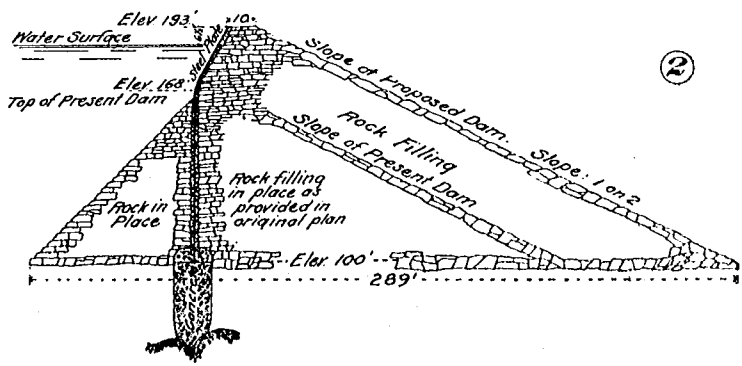
The dam of the Otter Creek Reservoir Co. is located in Section 28, T. 30 S., R. 2 W., Piute Co., at a point about 100 yards above the junction of Otter Creek with the East Fork of Sevier River. The original plans called for a dam with maximum height of 40 feet. The construction of the dam was begun during the Fall of 1897. A description of it was given in the First Biennial Report of the State Engineer. Early in 1900 the Company decided to add five feet to the height of the dam, and thus increase the storage capacity of the reservoir by about 12,000 acre-feet.

PLATE I.

OTTER CREEK RESERVOIR DAM



EAST CAÑON CREEK DAM



GUNNISON IRRIGATION Co. DAM

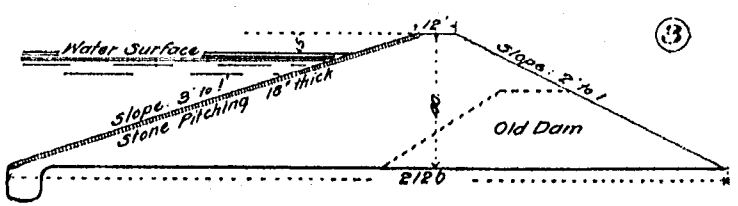
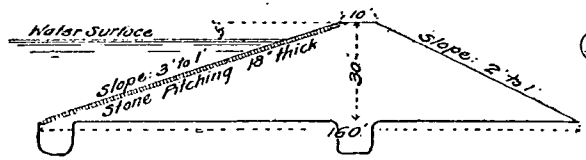


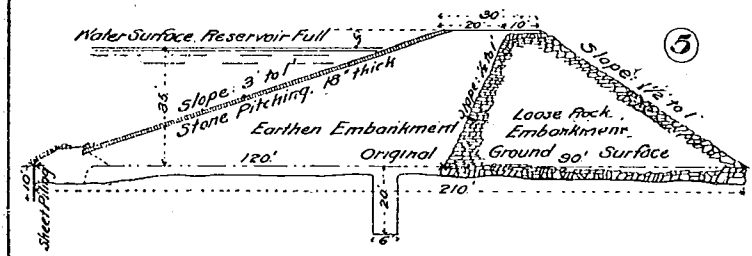
PLATE 2.

GUNNISON HIGHLAND Co. DAM



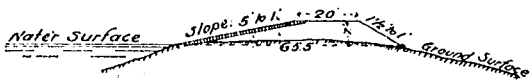
(4)

UPPER SEVIER RIVER R. & F. S. Co. DAM



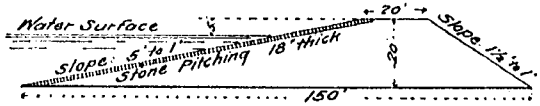
(5)

FOOS CREEK RESERVOIR No 1



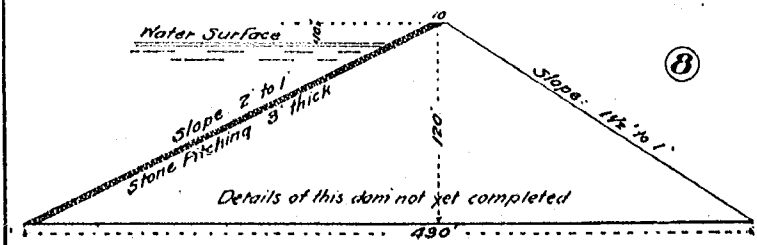
(6)

FOOS CREEK RESERVOIR No 2



(7)

MAMMOTH RESERVOIR

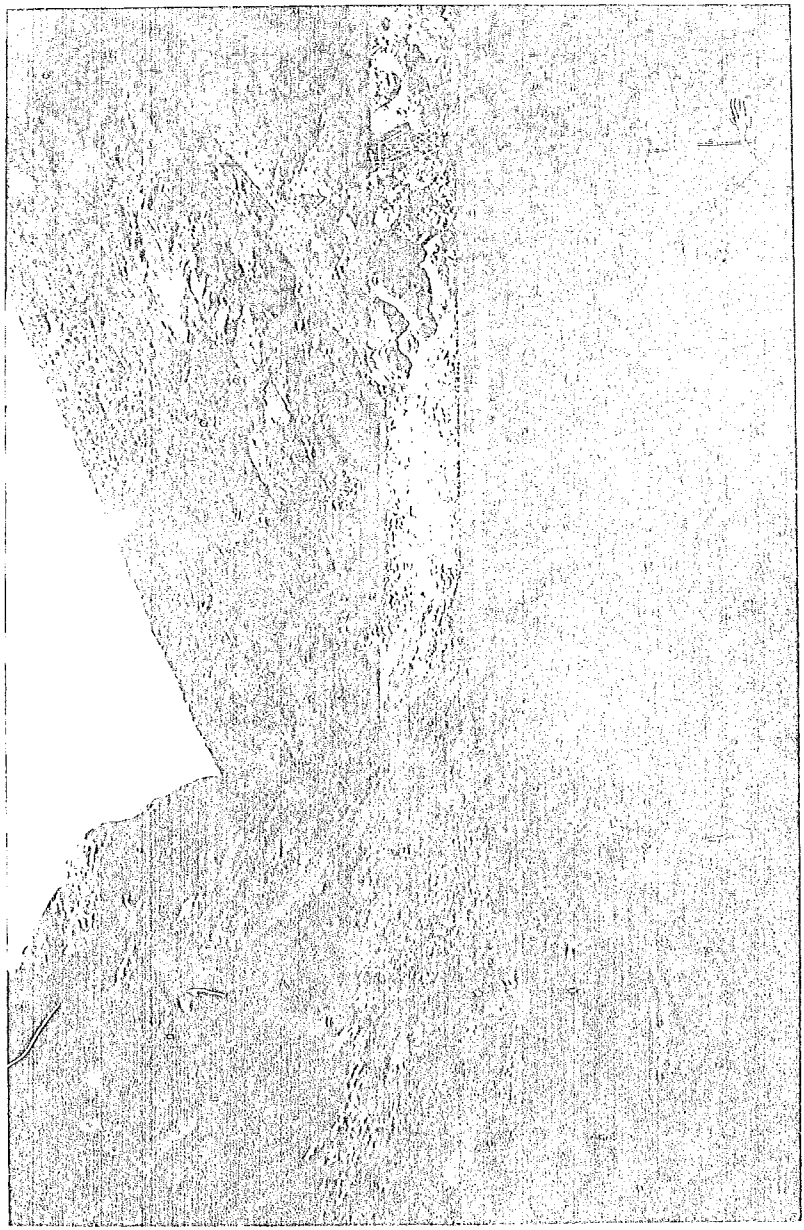


(8)

When completed, the dimensions of the dam will be as follows: Maximum height, 45 ft.; maximum width at base, 190 ft.; width on top, 10 ft.; length on top, 1,200 ft. The dam is a combination of a homogeneous earthen dam on the up-stream side with a loose rock dam on the down-stream side. The maximum height of 45 ft. extends for a length of about 170 ft., at the central portion of the dam, across the creek channel. At the south side of this channel is a vertical solid rock bluff about 25 ft. in height. At this point the bluff is only obut 50 feet. wide, but, going south, it grows wider and rises gradually until the south end of the dam is reached. At the north side of the channel is a vertical solid rock bluff about five ft. in height. Like the bluff on the south side of the channel, the bluff on the north side is narrow next to the channel and gradually widens as it rises gently toward the north end of the dam. Away from the bluffs the solid rock is covered to a depth of a few feet with soil. The dam is so located that the earthen embankment lies almost entirely on the up-stream side of these rock bluffs, overlapping them in such a manner as to make a practically water-tight joint between the embankment and solid rock. The 170 ft. of creek channel is filled with silt to a depth of about 14 ft. below the surface of the ground, at which point a stratum of clay is encountered. Borings to a depth of 24 ft. below surface of ground in the channel showed no signs of rock. The up-stream slope of dam is 3 ft. horizontal to 1 ft. vertical, and the down-stream slope 1 ft. horizontal to 1 ft. vertical. The up-stream slope is rip-rapped with stone pitching 18 inches thick. The wasteway is to be over solid rock at the north end of the dam, and the water is drawn from the reservoir through an open cut and tunnel in solid rock near the south end of the dam. The open cut is arched over with concrete. The tunnel is about 6 ft. square, and is connected with top of dam by means of a circular tower of concrete and a wooden bridge. The flow of water through the tunnel is controlled by two 2½x 5 ft. cast iron gates, operated by worm gearing. The bottom of the wasteway is 7 ft, below top of dam, but provision is made to store the water to within 5 ft. of the top by means of flash boards. The reservoir formed by this dam will be about 6 miles long, with a surface area of

about 2,400 acres and a storage capacity of about 53,000 acre-feet of water. The drainage area tributary to Otter Creek will ordinarily not furnish enough water to fill the reservoir, and water from the East Fork of Sevier River is conducted into the reservoir by means of a canal about 5 miles in length. A typical cross-section of the dam is shown by Fig. 1, Plate 1.

The dam of the Davis and Weber Counties Canal Co. is located on East Canyon Creek in Sec. 10, T. 2 N., R. 3 E., Morgan County. During the years 1898 and 1899 this dam was built to a height of 68 ft., and a description of it was given in the First Biennial Report of the State Engineer. During 1900 the Company decided to add 25 ft. to the height of the dam, and thus increase the storage capacity of the reservoir by about 4,665 acre-feet. When completed, the dimensions of the dam will be as follows: Maximum height, 93 ft.; maximum width at base, 289 ft.; width on top, 10 ft.; length on top, 173 ft. The dam is of the type known as a rock-filled dam, with a cut-off wall of Portland cement concrete extending from the ground surface at base of the rock-filled dam 30 ft. to bed-rock. Imperviousness is secured by means of a core wall of riveted steel plates imbedded in asphalt and cement concrete, extending from the concrete cut-off wall to the top of the dam. The steel plate, for a height of 20 ft. from the bottom, is 3-8 of an inch thick; from 20 to 40 ft. up, it is 5-16 of an inch thick; and above 40 ft.,it is all 1-4 of an inch thick. The up-stream slope is 1 ft. horizontal to 1 vertical, and the down-stream slope is 2 ft. horizontal to 1 vertical. The wasteway is constructed of wood at the south end of the dam, resting on masonry laid in cement mortar which, in turn, is founded on solid rock. The wasteway will be 190 ft. long, 30 ft. wide at upper end and 20 ft. wide at lower end, with grade of 1 in 8 and with bottom of wasteway 6.5 ft. below top of dam. The water is drawn from the reservoir through a tunnel 5½ by 6 ft. by 180 ft., in solid rock, at the north end of the dam. At a point 120 ft. from the upper portal of the tunnel, a valve chamber, 8 ft. square in section, is excavated from the natural surface to the bottom of the tunnel. A side cut is made in the solid rock into the valve chamber, at a point 20 ft. above the bottom of the tunnel, leading to a suitable platform, from which the valves are operated. A roof, with



suitable doors, covers the valve chamber. The water flowing from the reservoir through the tunnel is carried across the valve chamber in two lines of 30-inch cast iron pipes. Each line consists of two pipes 12 ft. long with a valve between them. The cast iron pipes project into the tunnel on each side of the valve chamber, and are imbedded in cement concrete, which forms a water-tight bulkhead in the tunnel. Two 30-inch medium pressure gate valves, with hub ends, are leaded to the 30-inch cast iron pipes. Each valve is placed in a vertical position, with a spur wheel on the axis, to which is attached the valve stem. The valve stem extends up to a convenient platform and is attached to a 24-inch handwheel for operating the valves. To admit of repairs being made to the main valves and the tunnel, two auxiliary valves are placed at the upper portal of the tunnel. These valves are similar to the main valves and are bolted to 30-inch steel pipes, which are constructed of steel plates 3-8 of an inch in thickness. Like the main valve pipes, these steel pipes project into the tunnel, and are imbedded in cement concrete, forming a water-tight bulk-head. A wooden platform, supported on a steel framework, is constructed above the surface of the water in the reservoir, when full, to which the stems of the valves are carried, and from which the valves are operated by hand-wheels. The reservoir formed by this dam will have a maximum length of 1½ miles, a surface area of about 240 acres, and a storage capacity of about 8,510 acre- feet. With height of dam of 68 ft., the storage capacity was 3,845 acre-feet. A typical cross-section of the dam is shown by Fig. 2, Plate I.

The dam of the Gunnison Irrigating Co. is located on the San Pitch River, in Sec. 32, T. 18 S., R. 2 E., near Sterling, Sanpete Co. This dam was constructed during the year 1890 to a maximum height of 23 ft. In the summer of 1900 the company decided to raise the dam 17 ft., and thus increase the storage capacity of the reservoir by about 11,000 acre-feet. When completed, the dimensions of the dam will be as follows: Maximum height, 40 ft.; maximum width at base, 212 ft.; width on top, 12 ft.; length on top, 1200 ft. The dam is of the type known as a homogeneous earthen dam. The up-stream slope is to be 3 ft. horizontal to 1 ft. vertical, and the down-stream slope 2 ft. horizontal to 1 vertical. The material used in

the construction of the embankment will be a mixture of clay, sand and gravel in the proportions of 1 part each of clay and sand to 2 parts of gravel. The up-stream slope of the dam will be rip-rapped with rock for a thickness of 18 inches. The wasteway will be near the east end of the dam and will have a length of 250 ft. from the upper end above the gates to the head of the lower drop, and a width of 50 ft. on the bottom. The embankment will be 12 ft. above the bottom of the wasteway and will have slopes of 1½ horizontal to 1 vertical on either side. There will be two drops of 7 ft. each in the wasteway. The sides and bottom of the wasteway will be rip-rapped to a depth of 18 inches, and it will discharge into a creek which will deliver the water into the San Pitch River at a point about 400 ft. below the dam. The bottom of the waste way will be 12 ft. below top of dam, but provision will be made to store water to within 5 ft. of top of dam by means of flash boards. The water will be drawn from the reservoir through a tunnel in solid rock at the west end of the dam. This tunnel will be 3 by 6 ft. in the clear, with an open cut approach at each end. The open cut from the lower end of the tunnel to the bed of the stream will be rip-rapped to a depth of 18 inches. At the lower end of the tunnel will be placed a sluice gate 2½ by 5 ft. in the clear, firmly set in concrete, and operated by a worm gear. The reservoir formed by this dam will have a surface area of about 1,300 acres and a storage capacity of about 20,000 acre-feet. With the height of 23 ft., the storage capacity was about 9,000 acre- feet. A typical cross-section of the dam is shown in Fig 3, Plate I.

The dam of the Gunnison Highland Canal Co. is located on Nine Mile Creek near Sterling in Sec. 8, T. 19 S., R. 2 E., Sanpete Co. The dimensions of this dam will be as follows: Maximum height, 30 ft.; maximum width at base, 160 ft.; width on top, 10 ft.; length on top, 744 ft. It will be of the type known as a homogeneous earthen dam. The material used in the construction of the dam will be a sandy clay. The up-stream slope will be 3 horizontal to 1 vertical and the down-stream slope will be 2 horizontal to 1 vertical. The up-stream slope of the dam will be rap-rapped with rock for a thickness of 18 inches. The wasteway will be constructed at a point about 200 ft. south of the south end of the dam, with a length of 395 ft. and a width on bottom of 24 ft. The bottom of the waste-

way will be 8 ft. below the top of the dam, but 3 ft. of flash boards will be used to hold the water up to within 5 ft. of the top of the dam. A high hill intervenes between the south end of the dam and the location of the waste-way, and the waste water will be discharged into a draw which will deliver it into the creek at a point about 1,000 ft. below the dam. The water will be drawn from the reservoir through a wood-stave pipe 2 ft. in diameter, provided with 2-inch wooden collars every 25 ft., and laid on a concrete base through the center of the dam in solid ground. The flow of water will be controlled by a valve at the lower end of the pipe line. The reservoir formed by this dam will be about one mile long, with a surface area of about 131 acres and a storage capacity of about 1,520 acre-feet. The drainage area tributary to this reservoir will not furnish enough water to fill it, but water will be conducted to the reservoir through a canal from Six Mile Creek. A typical cross-section of the dam is shown by Fig. 4, Plate II.

The dam of the Upper Sevier Reservoir, Irrigation and Fish Stock Co. is to be constructed across the Sevier River above Assays, Garfield Co. The dimensions of this dam will be as follows: maximum height, 40 ft.; maximum width at base, 210 ft.; width on top, 30 ft.; length on top, 777.5 ft. The dam will be a combination of a homogeneous earthen dam on the up-stream side with a loose rock dam on the down-stream side. The up-stream slope is 3 horizontal to 1 vertical, and the down-stream slope is 1½ horizontal to 1 vertical. The up-stream slope will be rip-rapped with rubble stone pitched 18 inches thick, laid dry by hand, with the interstices between the stones well packed with fine gravel. The material used for the earthen embankment will be a mixture of clay, sand and gravel in the proportion of 1 part each of clay and sand to 2 parts gravel. The spillway will be excavated at the east end of the dam, and its sides and bottom will be rip-rapped with stone pitching. The water will be drawn from the reservoir through a solid masonry culvert 4 ft. in diameter built through the center of the dam, and the flow of water will be controlled by means of an iron gate in this culvert. The gate will be operated through a masonry tower extending from the top of the culvert to the top of the dam. The surface area of the reservoir will be

about 640 acres, and its storage capacity about 9,600 acre-feet. A typical cross-section of the dam is shown by Fig. 5, Plate II.

The Salt Lake and Deseret Irrigation Co., The Deseret Irrigation Co. and the Leamington Irrigation Co. propose to combine forces and construct two large reservoirs on Foos Creek in Millard County. The members of these companies are Salt Lake business men and the farmers living in the vicinity of Leamington, Oasis and Deseret. The water will be conducted to these reservoirs through a canal from the Sevier River. This canal will have a bottom width of 20 ft., a top width of 35ft. and a depth of 5 ft. The total cost of construction is estimated at $104,396.00, about $100,000.00 of which will be spent on the canal.

The dam of Foos Creek Reservoir No. 1 is located on Foos Creek about 5 miles south of Leamington, in Millard County. The dimensions of this dam will be as follows: Maximum height, 7 ft.; maximum width at base, 65.5 ft.; width on top, 20 ft.; length on top, 1,000 ft. The up-stream slope will be 5 ft. horizontal to 1 vertical and the down-stream slope 1½ ft. horizontal to 1 vertical. It will be a homogenous dam, construced of a mixture of clay, sand and gravel. The wasteway will be through a natural "draw," leading to Reservoir No. 2. This draw has an average width at bottom of about 15 ft. and a depth of 8 ft. below top of the dam. The up-stream slope of the dam will be rip-rapped with rock. The water will be drawn from the reservoir through a wooden flume outlet, provided with proper headgates. The maximum depth of water in the reservoir will be 20 ft. As the dam is to have a maximum height of only 7 ft., it will be noted that this is practically a natural reservoir. The surface area of this reservoir will be 3,165 acres and its storage capacity 47,475 acre-feet. A typical cross-section of the day is shown by Fig. 6, Plate II.

The dam of Foos Creek Reservoir No. 2 is located on Foos Creek about 7 miles south of Leamington, Millard County. The dimensions of this dam will be as follows: Maximum height, 20 ft.; maximum width at base, 150 ft.; width on top, 20 ft.; length on top, 1600 ft. It will be a homogeneous dam, constructed of a mixture of clay, sand and gravel. The up-stream slope will be 5 ft. horizontal to 1 vertical, and the down-stream slope 1½ ft. horizontal

to 1 vertical. The up-stream slope will be rip-rapped with rock. This reservoir will be connected with Reservoir No. 1 by the draw which constitutes the wasteway of the latter. This reservoir will have the same kind of an outlet as Reservoir No. 1. The wasteway will be about 1½ miles north of the dam, through a wooden flume, and will discharge into the Sevier River through a natural "draw." The maximum depth of water in the reservoir will be 24 ft.; its surface area will be 9,385 acres and storage capacity 140,775 acre-feet. A typical cross-section of the dam is shown by Fig. 7, Plate II.

Surveys are now being made, and plans and specifications prepared, for The Mammoth Reservoir in Sanpete Co. This reservoir will be located on Sec. 12, T. 13 S., R. 5 E., and Secs. 5, 6, 7, 8, 18 and 19, T. 6 S., R. 6 E., at the head of Fish Creek in Gooseberry Valley, near Fairview. The location of the dam is on Sec. 6, T. 13 S., R. 6 E., and its dimensions will be about as follows: Maximum height, 120 ft.; maximum width at base, 430 ft.; width on top, 10 ft.; length on top, 600 ft. It will be of the type known as a homogeneous dam. The up-stream slope will be 2 horizontal to 1 vertical, and the down-stream slope 1½ horizontal to 1 vertical. The material used in the construction of the embankment will be a mixture of 1 part of earth to 1 part of gravel and rock. The up-stream slope of the dam will be rip-rapped with rock for a thickness of about 3 ft. The wasteway will be over a "saddle," located about one-half a mile north of the dam; it will be about 25 ft. wide and 200 ft. long, in solid rock, and will discharge into a draw, which will deliver the water back into the creek at a point about 2 miles below the dam. The water will be drawn out from the reservoir through a tunnel in solid rock at one end of the dam. The gates will be placed in this tunnel and will be operated through a vertical shaft sunk in solid rock from the surface to the outlet tunnel. The reservoir will have a length of about four miles, a surface area of about 1,000 acres and a storage capacity of about 36,000 acre-feet. The water will be brought from the Price River watershed, through a tunnel 2 miles in length, to the San Pitch River watershed. An extensive canal system will be constructed, in connection with this reservoir, and the water will be used for irrigating part of Sanpete Valley and part of Juab Co., near Nephi.

The total storage capacity of the six reservoirs just described is 316,880 acre-feet, but it will be noted that three of them were built previous to 1899 and their capacities have simply been increased by raising the dams. The increased storage capacity of reservoirs planned during the past two years is 263,035 acre-feet. After allowing for losses by seepage and evaporation, this amount of water when economically handled and distributed, should suffice to irrigate about 80,000 acres. The prevailing idea that a storage reservoir will supply about one-half as many acres of land as there are acre-feet of water stored in the reservoir is an evanescent dream.

MAP FOR PARIS EXPOSITION.

During January, 1900, this office prepared, for the Paris Exposition, a map showing the principal industries, the farming lands and the mineral resources of the State of Utah. This map will be returned, and it may be advisable to have it lithographed, as it presents considerable information in a convenient and condensed form.

IN FORMATION AS TO WATER MEASUREMENTS.

In compliance with the provisions of Section 2457, this office has been giving information as to measurements of water to anyone desiring it. Many letters of inquiry as to methods of measurement have been answered, and it is believed that considerable has been accomplished in the way of educating the people as to the proper methods of measuring water.

There has been a great demand for the book giving "Special Instructions to Watermasters," which was published by this office during the latter part of the year 1898. Practically all of the watermasters in the State have been furnished with a copy of it, and no doubt many of them have derived benefit from the information it contains. Each watermaster was requested to keep measments of the water flowing in the ditches under his charge, and send them to this office for permanent record. It was hoped that in this way some valuable information would be obtained,but the law does not require the watermasters to make these measurements and they have not done it.

In addition to the Utah demand for this book of instructions to watermasters, requests for it have come from all parts of the United States, and even a few have come from Mexico, Canada and England. The tables of rectangular weir discharges have proven very useful, but it was soon discovered that the table giving discharges of trapezoidal weirs were not only incomplete, but also incorrect, some serious errors having crept in through carelessness in proof reading and printing. It was therefore thought best to calculate a new and complete table of discharges for trapezoidal weirs, and this has been done for lengths of weir from 1 to 20 feet and for heads of water from 0.01 feet to 3 feet. This made much work for this office, involving, as it did, thousands of computations; but the trapezoidal form of weir is becoming quite popular, and it is believed that this table will be very useful. It has been printed, and will be distributed among the watermasters. A copy of the table is attached to this report, marked "Appendix B." The stereotypes from which the table was printed have been preserved, for use when this report is printed.

FEES FOR EXAMINATIONS.

Section 2459 provides that the State Engineer shall collect fees for services rendered in the location or examination of dam sites. No work of this kind was done during the years 1899 and 1900, and no fees were collected.

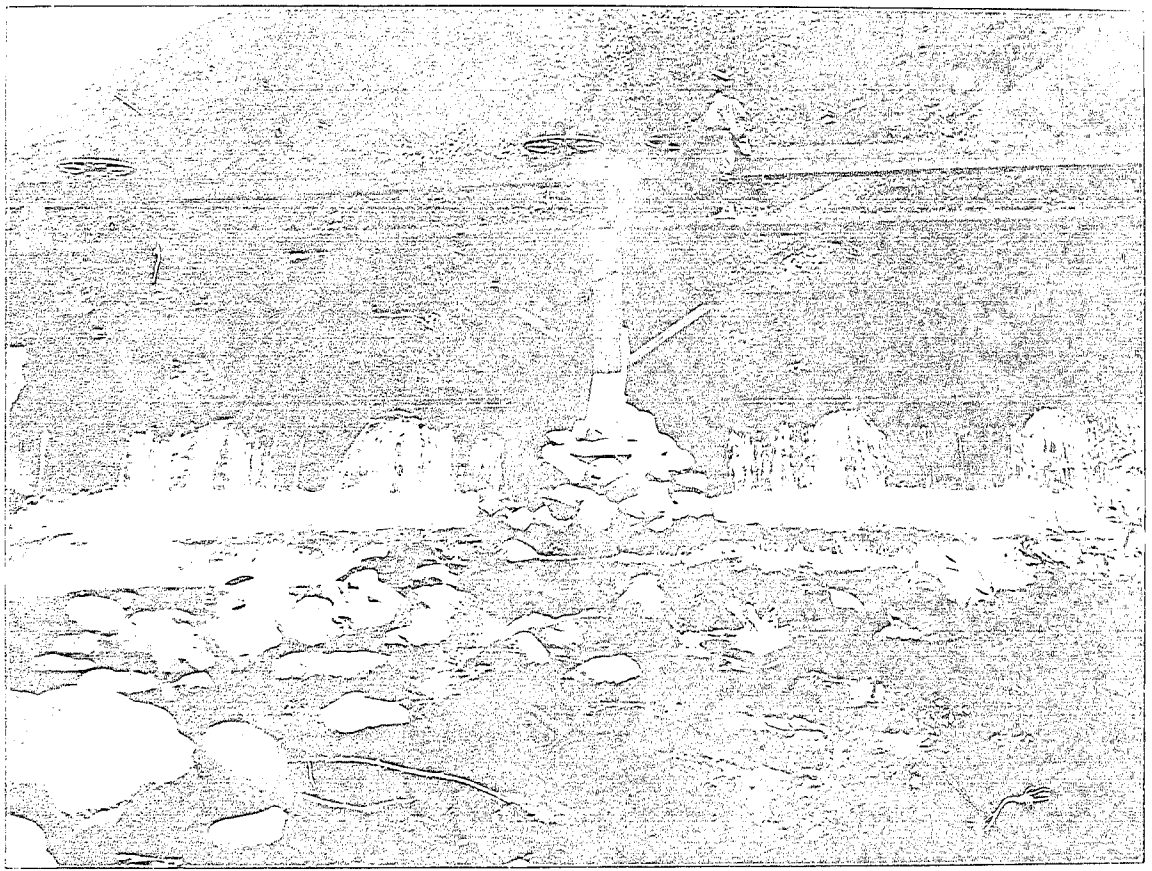
EXPENDITURES.

Section 2451 provides that the sum to be expended for expenses of the office should not exceed five hundred dollars per annum. The last Legislature, without consulting the State Engineer, cut the appropriation down to $300.00 per annum. This should not have been done, and it shows the entire absence of appreciation of the good that could be accomplished by this office, if sufficient funds were provided to conduct it properly.

The following is a list of the expenses incurred during 1899-1900:

EXPENSES FOR 1899-1900.

Apr. 20, 1899. Pembroke Sta., Co., supplies.....	$ 1.50
May 25, 1899. Postage on Instructions to Water-masters	7.00
Aug. 25, 1899. Putting in weirs, Big Cotton-wood Creek	95 42
Oct. 25, 1899. Measuring water, Big Cotton-Wood Creek	88 85
Dec. 20, 1899. Measuring lands, Big Cotton-wood Creek	122.00
Dec. 20, 1899. Pembroke Sta. Co., supplies..	4.50
Jan. 29, 1900. Map of State, showing indus-tries	127.50
Jan. 29, 1900. Pembroke Sta. Co., supplies....	4.20
Jan. 29, 1900. Eng. Dep't. S. L. C., services	7.55
Mar. 29, 1900. Pembroke Sta. Co., supplies	5.25
Apr. 25, 1900. Eng. Dep't. S. L. C., services.....	21.00
July 10, 1900. G. W. Stealey, checking weir calcu-lations	12.00
Aug. 15, 1900. R. C. Gemmell, expenses.....	8.45
Aug. 15, 1900. C. R. Savage, current meter.....	70.50
Sept. 19, 1900. Pembroke Sta. Co., supplies.....	9.05
Oct. 18, 1900. Deseret News, printing.....	4.48
Total	$600.00



MEA[illegible] WEIR[illegible]

IRRIGATION INVESTIGATIONS.

In the First Biennial Report of this office mention was made of the work that the office of Experiment Stations of the U. S. Department of Agriculture proposed to do. The main purpose of the work is to aid the farmers now living on irrigated land.

One object of the work is, to determine the duty of water; that is, the volume of water used in the growth of various crops under varying conditions of soil and climate. This information is needed by administrative officers, in order that they may make a proper division of the flow of streams; it is needed by engineers, in order that they may properly design irrigation works; it is needed by the farmers, in order to promote the saving of water; it is needed by the courts, in order that they make just and proper decrees; it is needed by reservoir builders, in order that they may be able to calculate about how many acres of land a reservoir of a given capacity will redeem.

Other objects of this work of irrigation investigations, as regards the laws and institutions of the irrigated region, are: To aid courts and administrative officers in the adjudication of water-right claims; to detect the defects in existing laws and methods of administration, and to furnish impartial and adequate information upon which wiser and more equitable decisions may be based; to assist farmers in the acquirement of water rights, and to protect their interests in the appropriation and use of water for irrigation.

Irrigation investigations were started in this State about June 1st, 1899, on Logan River near Logan, and on Big Cottonwood Creek near Salt Lake City. The work at Logan was put in charge of Prof. G. L. Swendsen, and the work at Salt Lake City in charge of F. C. Kelsey, A. F. Doremus and the writer. During the year 1900 the investigation were continued at the places above mentioned, and in addition, other investigations were made near Provo by Messrs. A. P. Stover and W. B. Searle. Similar work has been carried on in other western states during the past two years. Prof. Elwood Mead is the irrigation ex-

MEASURING WEIRS ON BIG COTTONWOOD CREEK.

pert in charge of all of these investigations for the U. S. Department of Agriculture.

The following is a description of the investigations on Big Cottonwood Creek, during the year 1899:

DUTY OF WATER ON BIG COTTONWOOD CREEK.

Big Cottonwood Creek is a beautiful mountain stream, rising in the heart of the Wasatch Mountains, about 20 miles southeast of Salt Lake City, and having a drainage area of about 49.5 square miles. At its head are a number of small picturesque lakes, situated at an elevation of from 8,500 to 10,000 feet above sea level. Some of these lakes have been segregated by the United States for reservoir sites, viz, Silver Lake, Twin Lakes, and Mary's Lake. From its source this stream flows about 12 miles in a general westerly direction, through a rugged, magnificent canyon, at the mouth of which the first irrigation ditches are taken out; thence it flows in a general northwesterly direction about ten miles, to its junction with the Jordan River. The lands irrigated by the water diverted from this stream are at an elevation of from 4,250 to 5,000 feet above sea level.

CANALS AND DITCHES.

The location of canals and ditches diverting water from Big Cottonwood Creek, and of the lands irrigated, is shown on map accompanying this report. (Plate III.) Cross sections and grades of the various canals and ditches are shown on Plate IV. None of these canals and ditches, except the Upper Canal, were surveyed or constructed by an engineer, and there is no regularity or uniformity in their cross sections or grades. Frequently the principal instrument used in laying out the ditches was a plow. Starting at the stream, a furrow would be plowed, following as nearly as possible a grade contour. After a short length of furrow had been plowed, water would be turned in from the creek. If the water ran to the lower end of the furrow it was assumed that the grade was all right, and the furrow was continued. If the water would not run the full length of the furrow, it was easy to locate and cut down the high points. In

some instances an attempt to have a uniform grade line was made by setting grade pegs with a triangle and plumb bob, or with a carpenter's level and straightedge, and the ditches were supposed to have certain bottom widths. As a matter of fact, however, the cross section and grade of any given ditch varies between rather wide limits, as may readily be imagined from the methods of construction.

PLATE III

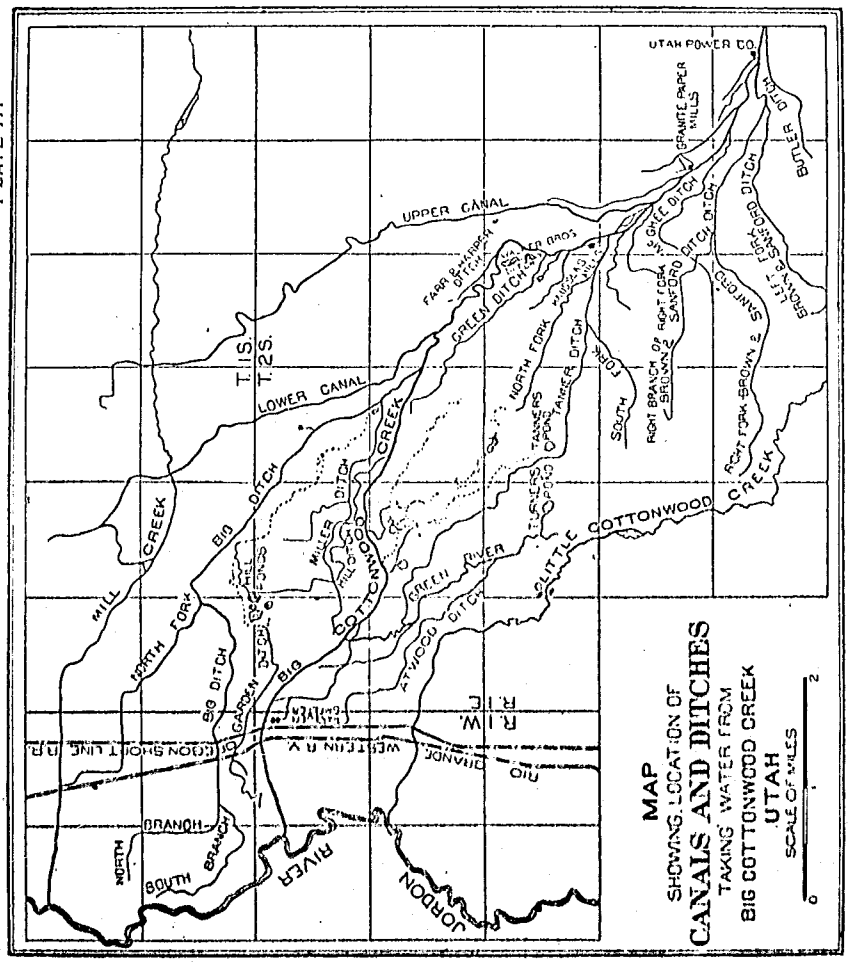


PLATE IV.

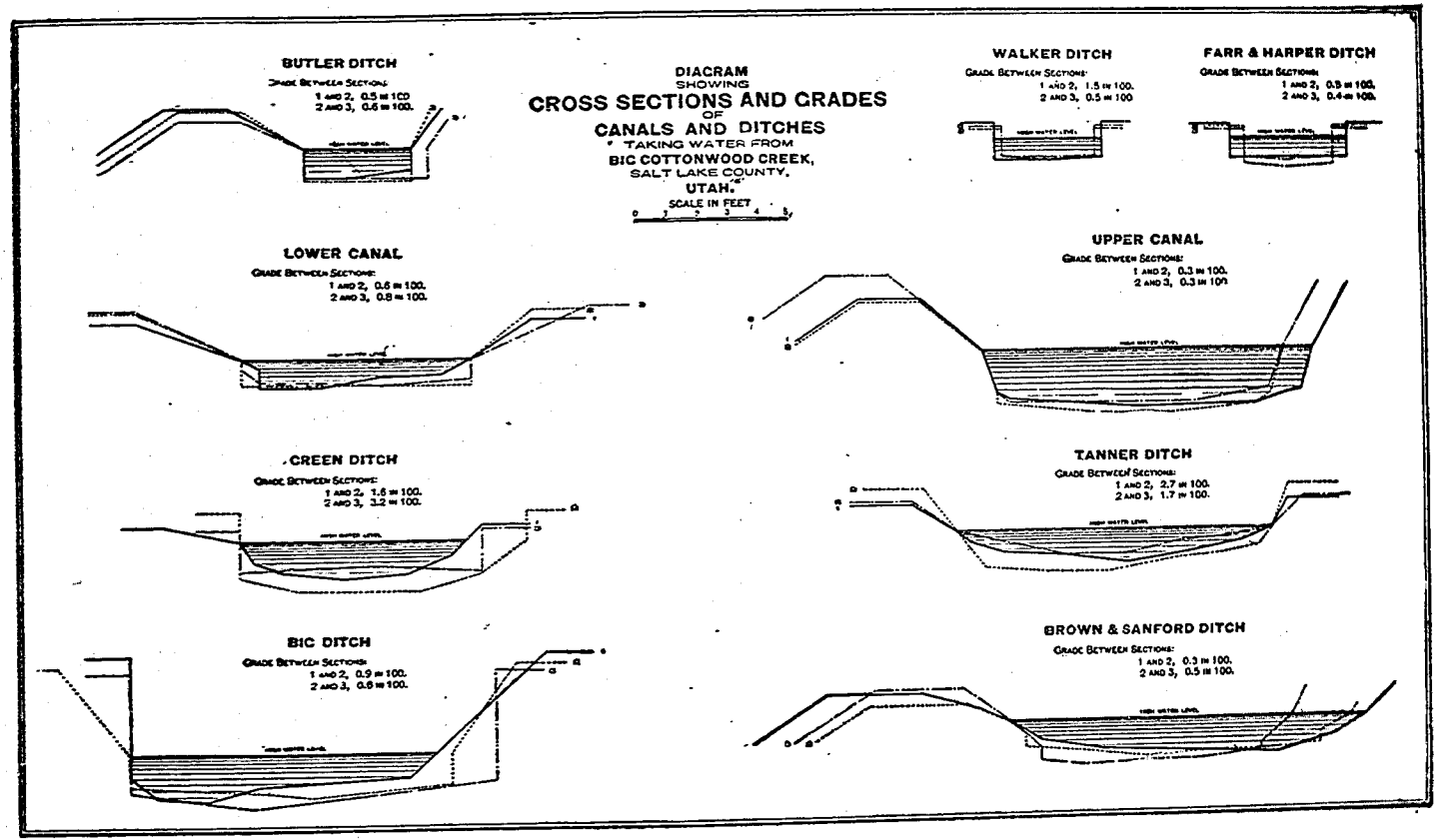


DIAGRAM
SHOWING
CROSS SECTIONS AND GRADES
OF
CANALS AND DITCHES
TAKING WATER FROM
BIG COTTONWOOD CREEK,
SALT LAKE COUNTY,
UTAH.
SCALE IN FEET
0 1 2 3 4 5
BUTLER DITCH
GRADE BETWEEN SECTIONS:
1 AND 2, 0.5 IN 100
2 AND 3, 0.6 IN 100.
WALKER DITCH
GRADE BETWEEN SECTIONS:
1 AND 2, 1.5 IN 100.
2 AND 3, 0.5 IN 100
FARR & HARPER DITCH
GRADE BETWEEN SECTIONS:
1 AND 2, 0.5 IN 100.
2 AND 3, 0.4 IN 100.
LOWER CANAL
GRADE BETWEEN SECTIONS:
1 AND 2, 0.6 IN 100.
2 AND 3, 0.8 IN 100.
UPPER CANAL
GRADE BETWEEN SECTIONS:
1 AND 2, 0.3 IN 100.
2 AND 3, 0.3 IN 100
GREEN DITCH
GRADE BETWEEN SECTIONS:
1 AND 2, 1.6 IN 100.
2 AND 3, 3.2 IN 100.
TANNER DITCH
GRADE BETWEEN SECTIONS:
1 AND 2, 2.7 IN 100.
2 AND 3, 1.7 IN 100.
BIG DITCH
GRADE BETWEEN SECTIONS:
1 AND 2, 0.9 IN 100.
2 AND 3, 0.6 IN 100.
BROWN & SANFORD DITCH
GRADE BETWEEN SECTIONS:
1 AND 2, 0.3 IN 100.
2 AND 3, 0.5 IN 100.

HISTORY OF ARBITRATION.

On September 13, 1879, the district court of the Territory of Utah appointed Joseph S. Rawlins, Reuben Miller, and D. B. Brinton, after they had previously been chosen by the water owners of Big Cottonwood Creek, a board of arbitrators to adjust all claims to the water of said creek and report its findings to said district court. This board, for convenience, divided the creek into 60 parts. One part would entitle its owner to irrigate 127.25 acres during time of low water. Each part, or share, was taken to mean one-sixtieth of the waters flowing in the creek at the highest point thereon where water is diverted by any of the canals or ditches mentioned in said agreement for arbitration. Only those holding primary rights were allotted shares during low-water season. The board classified the different canals and ditches, and parts, or shares, were alloted as follows:

Division of the Water of Big Cottonwood Creek.

Class.	NAME OF DITCH.	Number of parts.	
		January 1 to July 1.	July 1 to January 1.
		0.5	0.2
1	Butler Ditch	4.5	2.1
2	Brown & Sanford Ditch	10.5	10.2
3	Upper Canal	12.6	12.9
4	Tanner Ditch	3.5	3.8
5	Green Ditch	0.6	0.6
6	Farr & Harper Ditch	5.6	6.1
7	Lower Canal	19.6	21.3
8	Big Ditch	2.6	2.8
9	Hill Ditch		
	Total	60.0	60.0

A formal printed report showing the results of the action of the board of arbitration was made to the district court, and was properly filed. Each owner of a primary right in the stream was served with a written or printed notice of the arbitration, and a time was set by the court for hearing objections to said arbitration. No one appeared or objected, and the judgment of the court was rendered in accordance with the terms of the arbitration.

Nearly all of the owners of primary water rights appeared before the board of arbitrators and signed, under-

oath, an agreement to accept the division made by the board as binding and final. This agreement was properly filed with the district court, but has since disappeared and can not now be found. There were a few who did not sign this agreement, notably the Walker Brothers and a few owners on the Green Ditch. Others now claim that they did not sign the agreement, but the records of the proceedings of the board of arbitrators show that they did.

The division made by this board of arbitrators is supposed to be the basis upon which the water is divided, and is considered binding by all of the owners of primary rights, although those on the Green Ditch and part of the Tanner Ditch claim more water than was allotted to them by the board. As a matter of fact, the upper canals have always had more than their allotments and some of the lower canals less.

The following table shows the quantities of water actually diverted by six of the canals and ditches, together with the quantity that would have been diverted by each canal if the total quantity of water had been divided in accordance with the allotments of the board of arbitrators. During the season of 1899 there was an unusually large amount of water flowing in the creek, and as there was an abundance of water for all, very litle attention was paid to the manner of dividing it.

Table showing the quantity of water actually diverted by each canal during the irrigating season of 1899, together with the quantity that would have been diverted if the water had been divided in accordance with the allotments of the board of arbitrators.

[Flow given in cubic feet per second.]

Month.	Butler Ditch		Brown & Sanford.		Upper Canal		Green Ditch.		Lower Canal.		Big Ditch.	
	Allotted.	Diverted.	Allotted.	Diverted.	Allotted.	Diverted.	Allotted.	Diverted	Allotted.	Diverted	Allotted.	Diverted.
April	0.75	1.50	6.68	8.60	15.59	19.60	5.20	6.28	8.32	6.72	29.11	22.95
May.....	1.17	2.35	10.57	21.65	24.67	86.00	8.22	8.30	13.16	8.20	16.06	26.85
June.... ..	1.07	4.39	15.00	34 62	35.00	52.87	11.66	12.41	18.67	10.72	65.33	35.24
July	.51	3.73	5.81	25.24	25.77	41.08	9.60	4.45	15.41	6.91	53.83	28.02
August.....	.23	.93	2.40	6.84	11.72	15.13	4.36	8.88	7.00	4.90	24.48	14.01
September.	.15	.49	1 58	1.32	7.70	10.06	2.87	7.03	4.60	2.11	16.07	8.36

The Big Ditch, Lower Canal, and Hill Ditch, being the last on the creek, claim that they have never received *the amounts allotted by arbitration. As a water master on one of the upper canals naively remarked: "In high water they can't take it, and in low water they never get* it. We take what we want and let them have the balance."

This division by arbitration was contested by suit in the third district court in 1891 and 1892 by the owners of the Green Ditch. In this suit they got judgment for enough water to irrigate 400 acres. Under this judgment they have usually taken all the water they needed, except at short intervals, when the owners of the Big Ditch would shut off part of the water flowing into the Green Ditch and turn it down the creek.

It would seem that the root of all the trouble was the method pursued by the board of arbitration in making the division. It appears that the board did not make any measurements of lands irrigated under each ditch. It simply called upon owners of primary rights to state under oath for how many acres they claimed water rights. The acreage was footed up for each ditch and the division made upon that basis. People owning primary rights turned in the acreage they thought they had. Afterwards, when surveyed, it was found in some cases that they had not turned in enough. For instance, the people on the Upper Canal now claim that their allotment was about 100 acres short. In the case of the Big Ditch, other canals claim that the stockholders in the Big Ditch, in order that they might receive a large allotment of water by the arbitration, turned in all the land they had in the district, whether it had been irrigated or not. In that way much wet pasture land is said to have been listed, which they did not irrigate before and have not since. Again, it is claimed that much of the land turned in by owners on the Big Ditch was, and always has been, irrigated from springs.

The whole matter of division of the water seems to be in a very unsatisfactory condition. So much so that the troubles will probably culminate in a lawsuit involving all of the rights on the creek.

WATER RIGHTS.

The records used in making distribution of the water are those kept by the water masters. The water master of each ditch keeps a record of all the rights under his ditch, which is generally conceded to be correct by the owners on that particular ditch, but not necessarily so by the owners on other ditches.

The water master on a ditch is elected by the owners of water rights in the ditch, who hold a meeting annually for that purpose. The county commissioners used to appoint the water masters, but the district court ruled that they should be elected annually by the farmers themselves.

The ownership of water rights is based mainly upon the records of the water masters, each owner being supposed to have a right to water a certain number of acres. A right does not mean any certain quantity of water, nor does it mean any certain portion of the water flowing in the creek. This is owing to the manner in which the water is divided.

In the spring when the creek rises the upper ditches are filled full, and kept full as long as possible. If they do not take too much no objection is made, but if they take so much that the lower ditches do not get all they want, then the owners of the latter call for a division. Some seasons when there is a wet spring a division of the water is not necessary until July 1. Other years when there is a dry spring it may be necessary to have a division as early as in April. Users of surplus water are generally shut off on July 1, but it depends upon the season—that is, when the water in the creek gets low.

When the division is made the water masters of all the canals and ditches owning primary rights meet at the lowest point on the creek where water is diverted, and proceed upstream, measuring the width and depth of water flowing at the head of each canal as they go. In this way the number of "square inches" flowing into each canal is obtained. These are added together to obtain the total number of "square inches" diverted. Then the water masters usually proceed downstream, regulating the quantities of water diverted, so that each canal will have its proper number of "square inches," according to the

shares allotted by the arbitration, although this rule is not always closely followed. This regulation of the water holds good until another division is called for. They realize that there is nothing accurate about this method of meaurement, but have always made it in that way. The measurement was usually made over a board at the head of the canal. This year it was made over Cippoletti weirs. A stream 100 inches wide and 5 inches deep would be 500 "inches," according to their method, and a stream 50 inches wide and 10 inches deep would also be 500 "inches." No allowance is made for differences in velocity in the various canals. The upper ditches take out their full number of "inches," and the lower ditches take what they can get.

The division of the water among the owners of any ditch is made by the water master. A description of the ownership and method of dividing the water on the Brown & Sanford Ditch will serve as an illustration.

Ownership in the water goes by shares or "rods," each rod representing that length of the main ditch built by the first owners. The water master kept track of the construction work, calculated the acreage to which different ones were entitled according to such work, and made out certificates for the same. Usually the farmers do not form a regular company, but simply club together and furnish labor for the construction of the main ditch. Water enters all the main branches by self-dividing gates, the widths being proportioned to the shares, no attempt being made to attain accuracy. During low water these branches usually take turn about in carrying the full flow allowed to the main ditch, as the water will go much farther by thus using a large head.

For the individual owners on each main branch there is an allotment to each of the full flow for a certain number of hours, beginning at the one nearest the head and following down in regular order. Usually seven and one-half days or one hundred and eighty hours is the period for one rotation, the watering then beginning at the head again. Each owner's gate is fixed so that he can take the full flow, and his water ticket shows the date and number of hours he is entitled to all of the water, so that he can at once divert it when his time begins, at which time the one above is to cease diverting it. Where there is harmony

among the owners, all this is done without need of superintendence on the part of the water master, his main work being in making out the tickets of time for such distribution. The "rods" or shares are sometimes divided into quarters, and even smaller fractions, to suit the various holdings.

From what has been said it will be noted it would not be easy to obtain a legally defined title to water on this stream, and that it would be impossible to determine how much water any given right represents.

STUDIES OF DUTY OF WATER IN 1899.

Instructions to measure the water diverted from Big Cottonwood Creek by canals and ditches were not received until about June 1, 1899. As soon as possible thereafter, Cippoletti trapezoidal weirs were put in the canals and ditches at points near the headgates, and the measurements were begun. It required considerable persuasion in some instances to obtain permission to put in the weirs. There has been more or less friction among the owners of the various canals and ditches, and some of them did not want the water measured at all. The owners of the Tanner Ditch would not allow a weir to be put in where all of the water they diverted could be measured. During part of the season they ran water from the creek through a small branch, turning it into their ditch at a point about 50 yards below the weir. At the time the weir was put in owners of other ditches said they would shut off this branch, claiming that the Tanner Ditch had no right to take water through it; but this was not done until the creek had fallen to low-water stage. The measurements made in the Tanner Ditch are, therefore, of little or no value. The weir on the Farr & Harper Ditch was torn out by the ditch owners after being in only one day, and arrangements were not completed for replacing it until early in July. Most of the water measured in the Walker Ditch was merely run through a fish pond, only a small portion of it being used for irrigation purposes.

The heads on the weirs were measured once a day with a hook gage. Probably the heads should have been measured at least twice a day, as there is generally a

slight variation between morning and evening in the discharge of the creek. But as the weir measurements were made at all hours of the day, and not at any particular time for each ditch, it is believed that a fair average of the flow was obtained.

In order to calculate the duty of water it has been necessary to estimate the flow in the canals and ditches during April, May, and the early part of June. In doing this use has been made of gagings of the discharge of the creek. These gagings were made by Mr. F. C. Kelsey, city engineer of Salt Lake City, over a Cippoletti weir, the head being measured twice a day with a hook gage. The estimates of flow in canals and ditches during that part of the irrigating season when weir measurements were not taken have been thoughtfully and carefully made, and it is believed that they are pretty close to the truth. For reasons previously stated, no attempt has been made to calculate the duty of water under the Tanner, Farr & Harper, or Walker ditches.

The irrigating season usually begins about April 15 and ends about September 30. The date when irrigating is begun varies with the seasons; with a dry spring it may begin as early as April 1, and with a wet spring it may begin as late as May 1.

During the winter of 1898-99 there was an unusually heavy snow fall in the mountains on the drainage area tributary to this creek. For this reason there was an abundance of water for all ditches during the early part of the irrigating season, and it is believed that more water was taken out then than was needed, and that the duty of water was therefore lower than usual.

The following table shows the precipitation as recorded by the Weather Bureau at Salt Lake City:

Precipitation at Salt Lake City, Utah, October, 1898, to September, 1899.

MONTH.	Rainfall.	Above Normal.	Below Normal.
1898.	Inches.	Inches.	Inches.
October	1.57	0.03	.....
November	1.95	.59	.....
December	1.28	.....	0.36
1899.			
January	.84	.....	.60
February	2.98	1.70	.....
March	2.93	.90	.....
April	.81	.....	1.40
May	2.59	.87	....
June	.96	.17	.....
July	.42	.....	.11
August	1.06	.34	.....
September	.....	.....	.23
Total	17.39	4 60	2.70

From the above table it will be noted that the precipitation from October, 1898, to March, 1899, inclusive, was 2.26 inches in excess of the normal; while during the irrigating season, from April to September, 1899, inclusive, it was 0.36 inch below the normal.

In order to make an intelligent comparison of the duty of water under the various canals, it is necessary to know what kinds of lands were irrigated in each case. As a general statement, it may be said that bench land requires about 50 per cent more water than bottom land.

BUTLER DITCH.

The acreage irrigated by the Butler Ditch is all sandy, gravelly bench land, requiring much water. The area irrigated under this ditch is 123.50 acres. The following table shows the daily use of water on lands under this ditch from April 15, when irrigation began, to September 30, when irrigation closed. The flow from April 15 to June 8 is estimated, as previously explained:

Water used in irrigating lands under the Butler Ditch, 1899

DAY.	April.	May.	June.	July.	August.	September.
	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet
1	.....	4.6611	5.1570	9.5207	1.7851	0.7934
2	.....	4.6611	5.1570	9.5207	1.7851	.7934
3	.....	4.6611	5.1570	9 7190	2.7769	.5950
4	.....	4.6611	5.1570	9.9174	5.5537	.7934
5	.....	4.6611	5.1570	9.9174	6.1488	.5950
6	.....	4.6611	5.1570	10.1157	5.5537	.5950
7	.....	4.6611	5.1570	10.3140	4.3636	.7934
8	.....	4.6611	5.1570	10.5124	3.1736	.9917
9	.....	4.6611	5.1570	9.7190	1.9835	.7934
10	.....	4.6611	5.9504	10.7107	1.9835	.9917
11	.....	4.6611	6.7438	9.9174	1.7851	1.1901
12	.....	4.6611	7.5372	10.7107	1.7851	1.1901
13	.....	4.6611	8.3306	9.7190	2.3802	1.3884
14	.....	4.6611	9.1240	11.9008	2.1818	1.3884
15	2.9752	4.6611	9.9174	7.5372	1.1901	1.1901
16	2.9752	4.6611	10.7107	12.4959	1.3884	.9917
17	2.9752	4.6611	11.1074	7.1405	1.1901	.7934
18	2.9752	4.6611	11.7025	5.5537	.9917	.9917
19	2.9752	4.6611	11.7025	6.3471	.7934	.7934
20	2.9752	4.6611	13.4876	4.1653	.5950	.7934
21	2.9752	4.6611	13.0909	3.5702	.5950	.9917
22	2.9752	4.6611	12.6942	3.7686	.....	.9917
23	2.9752	4.6611	11.6041	3.9669	.....	.7934
24	2.9752	4.6611	10.7107	3.7686	.....	.7934
25	2.9752	4.6611	11.9008	5.3554	.7934	1.3884
26	2.9752	4.6611	10.9091	5.5537	.5950	1.3884
27	2.9752	4.6611	9.7190	5.3554	1.1901	1.1901
28	2.9752	4.6611	9.5207	3.5702	.9917	1.1901
29	2.9752	4.6611	9.3223	3.7686	1.3884	.9917
30	2.9752	4.6611	9.3223	3.5702	1.1901	.9917
31	.....	4.6611	.....	1.7851	.9917	.....
Total	47.6032	144.4941	261.4212	229.4875	57.1238	29.1567

Duty of water under the Butler Ditch, 1899.

MONTH.	Area.[1]	Water used.		Area per cubic foot per second.[2]
		Quantity.	Depth.	
	Acres.	Acre-feet.	Feet.	Acres.
April	123.5	47.6032	0.39	.....
May	123 5	144.4941	1.17	.....
June	123.5	261.4212	2.12	.....
July	123.5	229.4875	1.86	.....
August	123.5	57.1238	.46	.....
September	123.5	29.1567	.24	.....
Total irrigation	.....	769.2865	6.24	53.72
Rainfall	.....	.....	.49	.....
Total water received	.....	.....	6.73	.....

[1] It is impossible to tell just how much of the land under the canal is irrigated each month. For the purpose of computing the depth of water used, the whole area is assumed to have been irrigated each month.

[2] Continuous flow for 100 days.

BROWN & SANFORD DITCH.

The acreage under the Brown & Sanford Ditch is nearly all sandy, gravelly bench land, requiring much water. The area irrigated is 1,108.5 acres. The following table shows the daily flow of this ditch from April 15 to September 30, the period during which water was used in irrigation. The flow from April 15 to June 15 is estimated.

Water used in irrigating lands under the Brown & Sanford Ditch, 1899.

DAY.	April.	May.	June.	July.	August.	September.
	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.
1	.....	42.9421	67.3851	69.0248	16.8595	8.5289
2	.....	42.9421	67.3851	69.0248	15.2727	8.9256
3	.....	42.9421	67.3851	69.2231	17.2562	8.9256
4	.....	42.9421	67.3851	69.2231	22.0165	8.5289
5	.....	42.9421	67.3851	69.4215	19.8347	8.1322
6	.....	42.9421	67.3851	69.4215	18.2479	7.7355
7	.....	42.9421	67.3851	69.6198	17.8512	8.1322
8	.....	42.9421	67.3851	69.6198	17.8512	8.5289
9	.....	42.9421	67.3851	65.0578	17.8512	8.5289
10	.....	42.9421	67.3851	66.4463	17.2562	8.1322
11	.....	42.9421	67.3851	64.2645	16.8595	8.9256
12	.....	42.9421	67.3851	70.4132	17.2562	8.5289
13	.....	42.9421	67.3851	55.9389	15.2727	8.9256
14	.....	42.9421	67.3851	69.6198	13.4876	10.7107
15	17.0579	42.9421	67.3851	48.5950	14.8760	10.7107
16	17.0579	42.9421	65.6529	52.1654	14.8760	10.3140
17	17.0579	42.9421	68.0301	42.4463	13.4876	9.9174
18	17.0579	42.9421	70.4132	41.0578	12.8926	8.1322
19	17.0579	42.9421	71.4050	45.0248	12.8926	8.5289
20	17.0579	42.9421	73.5868	42.4463	12.4957	8.5289
21	17.0579	42.9421	74.3802	44.4298	8.5289	8.1322
22	17.0579	42.9421	71.4050	42.4463	8.5289	8.1322
23	17.0579	42.9421	65.6529	43.0413	10.3140	8.5289
24	17.0579	42.9421	74.3802	42.4463	10.3140	8.1322
25	17.0579	42.9421	72.1983	29.5537	8.5289	6.7488
26	17.0579	42.9421	67.4380	28.9587	8.9256	6.7488
27	17.0579	42.9421	69.6198	31.9339	8.5289	7.7355
28	17.0579	42.9421	67.4380	18.2479	12.0992	8.1322
29	17.0579	42.9421	68.8264	17.8512	5.5537	8.5289
30	17.0579	42.9421	68.8264	17.2562	6.8471	8.9256
31	.....	42.9421	.....	17.8512	8.1322	.....
Total	272.9264	1,331.2051	2,060.0297	1,552.0660	420.4952	257.0571

Duty of water under Brown & Sanford Ditch, 1899.

MONTH.	Area. [1]	Water used.		Area per cubic foot per second. [2]
		Quantity.	Depth.	
	Acres.	Acre-feet.	Feet.	Acres.
April	1,108.5	272.9264	0.25	.....
May	1,108.5	1,331.2051	1.20	.....
June	1,108.5	2,060.0297	1.86	.....
July	1,108.5	1,552.0660	1.40	.....
August	1,108.5	420.4952	.38	.....
September	1,108.5	257.0571	.23	.....
Total irrigation	.....	5,893.7795	5.32	63.01
Rainfall	.....	.....	.49	.....
Total water received	.....	.....	5.81	.....

[1] For the purpose of estimating depth of water used, the whole area is assumed to have been irrigated each month.
[2] Continuous flow for 169 days.

UPPER CANAL.

Under the Upper Canal about 300 acres is sandy, gravelly bench land, about 1,200 acres is clayey bench land, not requiring quite so much water as the gravelly bench land, and about 90 acres is bottom land, requiring still less water than the clayey bench land. The total area is 1,590.5 acres. The following table shows the daily use of water on these lands. The flow of the canal from April 20 to June 3 is estimated.

Water used in irrigating lands under the Upper Canal, 1899.

DAY.	April.	May.	June.	July.	August.	September.
	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.
1	.....	71.4050	103.1402	104.9256	37.8843	23.2066
2	.....	71.4050	105.1237	104.3306	39.8678	19.2397
3	.....	71.4050	107.1072	103.7355	39.2727	18.2479
4	.....	71.4050	116.0331	103.1405	47.2066	21.0248
5	.....	71.4050	111.4711	102.5455	37.0909	19.2397
6	.....	71.4050	107.1074	101.9504	36.4959	23.2066
7	.....	71.4050	107.7025	101.3554	37.8843	24.3967
8	.....	71.4050	108.4959	102.3471	37.4876	23.8017
9	.....	71.4050	109.0909	108.0992	37.0909	23.2066
10	.....	71.4050	109.8843	105.1240	36.4959	23.8017
11	.....	71.4050	110.4793	108.0992	34.5124	21.6198
12	.....	71.4050	111.2727	107.1074	34.1157	19.2397
13	.....	71.4050	111.8678	107.1074	31.1405	18.2479
14	.....	71.4050	112.6612	97.5868	26.7769	19.2397
15	.....	71.4050	113.4545	98.5785	27.3719	18.8430
16	.....	71.4050	114.0496	103.3388	26.7769	18.2479
17	.....	71.4050	121.9835	85.6859	26.7769	19.2397
18	.....	71.4050	101.3554	89.2562	24.9917	21.6198
19	.....	71.4050	102.3471	89.2562	24.3967	19.2397
20	38.8760	71.4050	103.3388	85.6859	23.8017	18.8430
21	38.8760	71.4050	103.3388	84.6942	24.9917	19.2397
22	38.8760	71.4050	83.9008	83.9008	24.3967	18.8430
23	38.8760	71.4050	89.2562	84.6942	22.2149	19.2397
24	38.8760	71.4050	83.9008	79.3388	24.9917	18.8430
25	38.8760	71.4050	84.6942	68.2314	24.9917	17.6529
26	38.8760	71.4050	101.3554	60.0992	24.3967	18.2479
27	38.8760	71.4050	102.3471	60.0992	24.9917	17.6529
28	38.8760	71.4050	97.5868	47.8017	24.9917	18.2479
29	38.8760	71.4050	106.1167	47.2066	23.2066	18.8430
30	38.8760	71.4050	105.5207	44.2314	24.3967	18.2479
31	.....	.....	.....	40.6612	19.2397	.....
Total	427.6360	2,213.5550	3,145.9827	2,710.2148	930.2480	598.8101

Duty of water under the Upper Canal, 1899.

MONTH.	Area.[1]	Water used.		Area per cubic foot per second.[2]
		Quantity.	Depth.	
	Acres.	Acre-feet.	Feet.	Acres.
April	1,590.5	427.6360	0.27	.....
May	1,590.5	2,213.5550	1.39	.....
June	1,590.5	3,145.9827	1.98	.....
July	1,590.5	2,710.2148	1.70	.....
August	1,590.5	930.2480	.58	.....
September	1,590.5	598.8101	.38	.....
Total irrigation	.....	10,026.4466	6.30	51.63
Rainfall	.....	.....	.49	.....
Total water received	.....	.....	6.79	.....

[1] For the purpose of computing the depth of water used, the whole area is assumed to have been irrigated each month.
[2] Continuous flow for 181 days.

GREEN DITCH.

The acreage under the Green Ditch is all bottom land. About 200 acres of it is gravelly land, requiring much water; the remainder is rich, loamy soil, requiring less water. The total area irrigated under this ditch is 586.25 acres. The daily use of water from this ditch is shown by the following table. The flow from April 20 to June 4 is estimated.

Water used in irrigating lands under the Green Ditch, 1899.

DAY.	April.	May.	June.	July.	August.	September.
	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet
1	.....	16.4628	19.8347	17.0579	8.7273	12.4959
2	.....	16.4628	19.8347	15.8678	6 1488	12.4959
3	.....	16.4628	19.8347	14.4793	5.7521	12 0992
4	.....	16.4628	19.8347	13.2893	6.1488	11.7025
5	.....	16.4628	24.1983	11.9008	5.7521	12.0992
6	.....	16.4628	23.0083	10.5124	6.5537	11.7025
7	.....	16.4628	21.6198	9.1240	4.7603	10.7107
8	.....	16.4628	22.6116	6.3471	15.8678	16.6612
9	.....	16.4628	23.6033	9.5207	26.9752	17 8512
10	.....	16.4628	24.5950	9.5207	26 1818	18.4463
11	.....	16.4628	25.5868	3.7686	25.1901	18.4463
12	.....	16.4628	26.5785	6.1488	24.7934	17.8512
13	.....	16 4628	27.5702	6.3471	24.7934	17.8512
14	.....	16.4628	28.5620	8.7273	24.1988	18.4463
15	.....	16.4628	29.5537	6 1488	24.7934	18.4463
16	.....	16.4628	33.9174	12.0992	23.8017	17.8512
17	.....	16.4628	38.2810	8.7273	22.0165	17.4545
18	.....	16.4628	42.4463	10.3140	21.0248	17.8512
19	.....	16.4628	33.3213	10.7107	20.4298	17.8512
20	12.4562	16.4628	32.3306	7.1405	19.8347	16.6612
21	12.4562	16.4628	31.3388	6.1488	19.8347	15.4711
22	12.4562	16.4628	30.5455	6.1488	19.4380	14.2810
23	12.4562	16.4628	25.3884	6.3471	16.6612	14.2810
24	12.4562	16.4628	24.7934	6.3471	16.2645	13.8843
25	12.4562	16.4628	21.2231	6.1488	16.2645	12.8926
26	12.4562	16.4628	9.5207	8.7686	15.8678	12.8926
27	12.4562	16.4628	8.5289	3.5702	14.6777	13.0909
28	12.4562	16.4628	11.7025	10.7107	13.8843	13.8843
29	12.4562	16.4628	19.6364	9.1240	13.8843	13.8843
30	12.4562	16 4628	18.4462	9.1240	13.0909	14.2810
31	.....	16.4628	.....	8.7273	12.8926	.....
Total	137.0182	510.3468	754.5116	273.9177	515 5045	453.8183

Duty of water under the Green Ditch, 1899.

MONTH.	Area.[1]	Water used.		Area per cubic foot per second.[2]
		Quantity.	Depth.	
	Acres.	Acre-feet	Feet.	Acres.
April	586.25	137.0182	0.23	.....
May	586.25	510.3468	.87	.....
June	586.25	754.5116	1.30	.....
July	586.25	273.9177	.47	.....
August	586.25	515.5045	.88	.....
September	586.25	453.8183	.77	.....
Total irrigation	.....	2,645.1171	4.52	71.97
Rainfall	.....	.....	.49	.....
Total water received	.....	.....	5.01	.....

[1] For the purpose of estimating the depth of water used, the whole area is assumed to have been irrigated each month.
[2] Continuous flow for 164 days.

LOWER CANAL.

The acreage under the Lower Canal is all bottom land. It is all good, rich soil except that which has become swampy by irrigation above. The pasture land is watered only once or twice during the irrigating season. A number of small springs, caused by seepage from higher irrigated lands, rise on this land, and serve to slightly increase the calculated duty, as they were not taken into account in the water measurements. There are 717.25 acres irrigated from this canal. The following table shows the flow of the canal from April 25 to September 20, when irrigation closed. The flow from April 25 to June 19 is estimated:

Water used in irrigating lands under the Lower Canal, 1899.

DAY.	April.	May.	June.	July.	August.	September.
	Acre-feet.	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet
1	.....	16.2645	21.9852	16.2645	16.2645	9.5207
2	.....	16.2645	21.9852	15.8678	15 6694	6.3471
3	.....	16.2645	21.9852	15.2727	15.6694	6.1487
4	.....	16.2645	21.9852	14.6777	18.4463	3.5702
5	.....	16.2645	21.9852	14.0826	16.6612	3.5702
6	.....	16.2645	21.9852	13.4876	16.2645	3.3719
7	.....	16.2645	21.9852	12.8926	18.4463	4.7603
8	.....	16.2645	21.9852	13.6859	15.0744	3.5702
9	.....	16,2645	21.9852	12.8926	11.9008	3.3719
10	.....	16.2645	21.9852	12.4959	10.3140	3.5702
11	.....	16.2645	21.9852	5.7521	9.5207	3.5702
12	.....	16.2645	21.9852	6.1488	9.5207	3.3719
13	.....	16.2645	21.9852	14.4793	10.3140	2 9752
14	.....	16.2645	21.9852	12.4959	9.5207	4.5620
15	.....	16.2645	21.9852	12.4959	6.3471	4.5620
16	.....	16.2645	21.9852	14.4793	6.1487	3.5702
17	.....	16.2645	21.9852	12.4959	6.3471	3.5702
18	.....	16.2645	21.9852	13.8843	9.5207	3.5702
19	.....	16.2645	21.9852	12.4959	9.1240	3.1736
20	.....	16.2645	22.0165	12.8926	8.7273	2.9752
21	.....	16.2645	20.4298	14.4793	7.5372	.....
22	.....	16.2645	20.4298	12.0992	4.7603	.....
23	.....	16.2645	14.8760	12.4959	4.5620	.....
24	.....	16.2645	25.5868	12.0992	5.5537	.....
25	13.3289	16.2645	23.8017	12.0992	6.1487	.....
26	13.3289	16.2645	20.4298	13.8843	3.5702	.....
27	13.5289	16.2645	19.8347	12.4959	4.5620	.....
28	13.3289	16.2645	18.4463	19.6864	4.7603	.....
29	13.3289	16.2645	17.4545	19.8347	4.5620	.....
30	13.3289	16.2645	16.8595	20.8264	6.9421	.....
31	.....	16.2645	.....	15.4711	8.5289	.....
Total	79.9734	504.1995	637.8842	424.6615	301.2892	83.7021

Duty of water under the Lower Canal, 1899.

MONTH.	Area.[1]	Water used.		Area per cubic foot per second.[2]
		Quantity.	Depth.	
	Acres.	Acre-feet	Feet.	Acres.
April	717.25	79.9734	0.11	.....
May	717.25	504.1995	.70	.....
June	717.25	637.8842	.89	.....
July	717.25	424.6615	.59	.....
August	717.25	301.2892	.42	.....
September	717.25	83.7021	.12	.....
Total irrigation	.....	2,031.7099	2.83	104.43
Rainfall	.....	.....	.49	.....
Total water received	.....	.....	3.32	.....

[1] For the purpose of estimating the depth of water used, the whole area is assumed to have been irrigated each month.
[2] Continuous flow for 149 days.

BIG DITCH.

The acreage under the Big ditch is all bottom land except about 250 acres of sandy bench land near the Jordan river. It is all good, rich soil except the pasture, which is wet land, requiring only one or two waterings during the irrigating season. A number of springs also rise on this land and serve to slightly increase the calculated duty, as in the case of the Lower Canal. The total area irrigated from this ditch is 2,243.13 acres.

The daily flow of the Big Ditch is given in the following table. The flow from April 25 to June 6 is estimated:

Water used in irrigating lands under the Big Ditch, 1899.

DAY.	April.	May.	June.	July.	August.	September.
	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.
1	.....	53.2562	55.5372	65.8512	40.6612	23.8017
2	.....	53.2562	55.5372	65.0578	39.8678	23.2066
3	.....	53.2562	55.5372	64.2645	37.8843	18.8430
4	.....	53.2562	55.5372	63.4711	52.3636	18.2479
5	.....	53.2562	55.5372	62.6777	51.5702	17.6529
6	.....	53.2562	45.6198	62.0826	50.7769	16.0661
7	.....	53.2562	54.5455	61.6859	50.7769	14.0826
8	.....	53.2562	63.6694	59.8058	40.8595	14.0826
9	.....	53.2562	72.5950	78.5455	31.1405	16.0661
10	.....	53.2562	81.5207	60.0992	30.5455	15.6694
11	.....	53.2562	80.7273	50.7769	23.8017	16.0661
12	.....	53.2562	79.9339	55.3388	24.9917	15.6694
13	.....	53.2562	79.1405	55.3388	27.3719	14.0826
14	.....	53.2562	78.3471	54.7438	26.7769	15.6694
15	.....	53.2562	77.3554	76.7603	24.3967	16.0661
16	.....	53.2562	76.5620	88.2645	21.6198	15.0744
17	.....	53.2562	75.7686	68.2314	21.0248	14.0826
18	.....	53.2562	74.9752	60.0992	27.3719	16.0661
19	.....	53.2562	74.1818	51.5702	26.7769	15.6694
20	.....	53.2562	75.9669	50.7769	24.3967	15.6694
21	.....	53.2562	75.9669	52.3636	21.6198	.....
22	.....	53.2562	70.8099	43.4380	13.6859	.....
23	.....	53.2562	65.6512	44.2314	13.6859	.....
24	.....	53.2562	77.7541	43.4380	13.6859	.....
25	45.4807	53.2562	78.5455	26.7769	19.2397	.....
26	45.4807	53.2562	78.5455	31.1405	14.0826	.....
27	45.4807	53.2562	79.3368	31.1405	13.6859	.....
28	45.4807	53.2562	67.4380	54.7438	14.0826	.....
29	45.4807	53.2562	67.4380	52.3636	19.2397	.....
30	45.4807	53.2562	66.6446	51.5702	18.8430	.....
31	.....	53.2562	.....	86.4959	24.3967	.....
Total	272.8842	1,650.9422	2,096.9256	1,722.6445	861.2231	831.8344

Duty of water under the Big Ditch, 1899.

MONTH.	Area.[1]	Water used.		Area per cubic foot per second.[2]
		Quantity.	Depth.	
	Acres.	Acre-feet.	Feet.	Acres.
April	2,243.13	272.8842	0.12	.....
May	2,243.13	1,650.9422	.74	.....
June	2,243.13	2,096.9256	.93	.....
July	2,243.13	1,722.6445	.77	.....
August	2,243.13	861.2231	.38	.....
September	2,243.13	331.8344	.15	.....
Total irrigation	.....	6,936.4540	3.09	95.64
Rainfall	.....	.....	.49	.....
Total water received	.....	.....	3.58	.....

[1] For the purpose of estimating the depth of water used, the whole area is assumed to have been irrigated each month.
[2] Continuous flow for 149 days.

ACREAGE, CROPS, AND YIELD.

The following table shows the acreage and the yield for the lands under each canal and ditch:

Table showing the acreage and the yield for each canal and

CROP.	Butler Ditch.		Brown & Sanford.		Upper Canal.		Green Ditch.		Lower Canal.		Big Ditch.	
	Acres.	Yield.	Acres.	Yield	Acres.	Yield.	Acres.	Yield.	Acres.	Yield.	Acres.	Yield.
Wheat	30.00	385	155.50	3,645	174.88	5,668	44.75	1,018	107.25	3,428	313.00	10,028
Oats	.....	.....	6.50	150	87.00	1,395	6.50	265	18.00	776	129.75	5,285
Barley	.....	.....	.....	.....	1.50	40	6.00	190	2.50	196	7.50	384
Corn	2.50	85	87.00	940	97.00	3,157	46.50	2,525	76.25	3,050	143.50	5,150
Hay	85.00	255	747.00	2,187	1,049.25	3,840	221.50	672	314.25	1,182	829.00	2,538
Pasture	.....	.....	87.50	.....	12.00	.....	207.50	.....	68.25	.....	570.75	.....
Small fruit	.50	1,428	4.25	5,499	10.62	28,223	3.00	4,415	10.62	15,825	4.25	4,478
Orchard	4.00	.....	26.00	40	155.75	813	29.00	260	58.25	90	71.00	659
Vegetables	.25	$30	4.25	$230	3.75	$363	6.75	$330	625	$780	34.88	$2,166
Potatoes	1.25	150	20.50	3,640	89.75	6,964	14.75	2,700	55.63	10,215	140.00	25,688
Nursery	.....	.....	70.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	123.50	.....	1,108.50	.....	1,590.50	.....	586.25	.....	717.25	.....	2,243.13	.....

[1] In this table the yields of wheat, oats, barley, corn, orchard, and potatoes are given in bushels; the yields of hay in tons; the yields of small fruit in quarts; the yields of vegetables in dollars. The pastures and nurseries were irrigated, and therefore their acreage is included in the total areas watered.

A period of warm weather late in the winter, followed by freezing weather, injured some of the crops. Large fruit was almost an entire failure. Small fruit was about three-fourths of the usual crop; alfalfa, about

three-fourths; fall wheat and potatoes, about two-thirds of a crop. Other crops were not injured.

CONCLUSIONS.

From the information obtained by this investigation the following conclusions may be drawn:

(1) The canals and ditches are improperly located and poorly constructed.

(2) The work of the board of arbitration was improperly done and its findings are not really considered binding by the water owners.

(3) The water rights are not properly recorded and such records as they have are not recognized by all as being correct.

(4) The water is improperly divided and distributed, and a right does not carry with it any certain quantity of water nor any certain portion of the water flowing in the creek.

(5) The duty of water for cultivated bench land should be at least 70 acres per cubic foot per second, and for cultivated bottom land at least 100 acres per cubic foot per second—pasture not being considered as cultivated land.

The investigations on Big Cottonwood Creek were continued during the irrigating season of 1900, with the following results:

DUTY OF WATER ON BIG COTTONWOOD CREEK, 1900.

NAME OF CANAL	AREA	WATER USED		Area per cu. ft. per sec.
		Quantity	Depth	
	Acres	Acre-Feet	Feet	Acres
Butler Ditch	126.5	655.5345	5.18	60.10
Brown & Sanford Ditch .	1028.5	4191.0592	4.07	80.78
Upper Canal	1533.9	6013.8746	3.92	83.98
Tanner Ditch	1576.8	6197.9198	3.93	83.77
Farr & Harper Ditch . . .	75.0	432.5230	5.77	55.37
Green Ditch	482.0	2863.1999	5.94	52.09
Lower Canal	585.3	1791.0716	3.06	107.59
Big Ditch	1813.5	5987.1806	3.30	99.78
Totals	7221.5	28133.2632	3.90	
Average duty of Water . .				86.50

The length of the irrigating season differed on the several canals, varying from 156 to 166 days. In each case water was measured at the head of the canal.

KINDS OF LANDS.

The acreage irrigated by the Butler Ditch is all sandy, gravelly bench land, requiring much water. The irrigating season began April 20 and closed September 23. The principal crops raised were lucerne and potatoes. The yield of potatoes was good, but the lucerne made only about one-half of a good crop, on account of damage done to the second and third cuttings by grasshoppers. The probability is that a duty of 60 acres per second-foot is about right for this porous bench land.

The acreage irrigated by the Brown & Sanford Ditch is all sandy, gravelly bench land, requiring much water. The irrigating season began April 11 and closed September 23. Grain and fruit made about two-thirds of a good crop; lucerne and potatoes about one-half of a crop. The second and third cuttings of lucerne were badly damaged by grasshoppers. It would seem that a duty of 80 acres per second-foot is too high for this porous bench land.

Of the land irrigated during 1900 by the Upper Canal, about 300 acres is gravelly bench land; about 800 acres is a light, clayey bench land, not requiring quite so much water as the gravelly bench land; about 90 acres is loamy bottom land, requiring still less water than the light, clayey bench land; and the remainder is sandy bench land. The irrigating season began April 11, and closed September 23. Grain made a fair crop, being about five-sixths of what is called a good crop; lucerne made about three-fourths of a good crop; fruit about one-half of a crop; potatoes about two-fifths of a crop; and vegetables about one-fifth of a crop. It would seem that a duty of 84 acres per second-foot is too high for this kind of land.

Of the land irrigated during 1900 by the Tanner Ditch, about 700 acres is gravelly bench land; about 300 acres is a sandy, loamy bottom land; and the remainder is a light, clayey bench land. The irrigating season began April 11, and closed September 23. Grain made a fair crop, being about three-fourths of what is called a good

crop; fruit made about one-half of a good crop; lucerne about two-thirds of a crop; potatoes about three-fifths of a crop;and sugar beets about two-thirds of a crop. It would therefore seem that the duty of 84 acres per second-foot was too high to produce good crops.

The acreage under the Farr &Harper Ditch is all bottom land of a sandy character. The irrigating season began April 16 and closed September 23. Grain made about two-thirds of a crop; lucerne about one-half of a crop; potatoes about two-fifths of a crop. The duty of water, 55 acres per second-foot, is very low and good crops should have been raised.

The acreage under the Green Ditch is all bottom land. About 200 acres of it is gravelly land, requiring much water; the remainder is gravelly or sandy loam, requiring less water. Irrigation began on April 21 and closed on September 23. Grain made about two-thirds of a crop; lucerne about five-eights of a crop; fruit about two-fifths of a good crop; potatoes a little over one-half of a crop. The duty of water, 52 acres per second-foot, is very low and good crops should have been raised.

The acreage under the Lower Canal is all bottom land. About two-thirds of it is black loam and the remainder light clay land. It is all good, rich soil, except that which has become swampy by irrigation above, which was not irrigated. Irrigation began on April 11 and closed on September 23. Grain and fruit made about five-sixths of a good crop; lucerne about two-thirds of a crop; potatoes about three-fifths of a crop. The probability is that a duty of 100 acres per second-foot is about right for this land.

The acreage under the Big Ditch is all bottom land, except about 250 acres of sandy bench land near the Jordan River. About 900 acres of the bottom land is a light, clayey soil; the remainder is a sandy loam. It is all good, rich soil, except 320 acres of pasture, which is wet land, requiring only one or two irrigations during the season. Irrigation began on April 11 and closed on September 23. Grain made about five-sixths of a good crop; lucerne about five-eights of a crop; fruit and potatoes about one-half a crop; sugar beets made a good crop.

LOGAN INVESTIGATIONS.

The investigations made by Prof. G. L. Swendsen during 1899 on the Logan and Richmond Canal gave the following results: An average flow of 44.37 cubic feet per second during the four principal irrigation months irrigated 2,894 acres, giving a duty of 65.22 acres for each cubic foot per second. The loss by seepage and evaporation in the canal was estimated to be about 28 per cent.

During 1900, Prof. Swendsen continued his investigations of loss by seepage and evaporation in canals, with the following results: On the Logan and Richmond Canal, there was an average loss of 9.0 per cent in the first 7,600 feet, and an average loss of 11.68 per cent in the next 41,000 feet, making a total loss of 20.68 per cent of the volume taken in at the head of the canal. On the Logan, Hyde Park and Smithfield Canal, the loss in the first 7,180 feet, which is constructed along a steep mountain-side where the conditions are such that seepage is considerable, was found to be 9.7 per cent, and the loss in the next 36,900 feet was found to be 10.51 per cent, making a total loss of 20.21 per cent of the volume taken in at the head of the canal.

UTAH LAKE VALLEY INVESTIGATIONS.

The work done by Messrs. A. P. Stover and W. B. Searle has been mainly the investigations of water rights. It is the desire of the irrigators of Utah to secure some simpler, cheaper and more effective means of establishing titles to streams, and put an end to the litigation which now prevails. In order to do this, it is necessary to know the exact conditions which exist. The results of these investigations cannot now be obtained, but will be published next year by the Office of Experiment Stations.

A few stream measurements were made by Mr. Stover, which are given below in Table VI:

TABLE VI.

MEASUREMENTS MADE ON STREAMS TRIBUTARY TO UTAH LAKE, 1900.

AMERICAN FORK RIVER.

Date.	Gage Height.	Discharge Cu. ft. per Sec.
May 29	0.90	241.64
June 29	0.50	85.52
July 13	0.40	46.18
July 28	0.32	38.17
August 10	0.28	32.51
August 14	0.30	28.85
August 27	0.27	30.33

PROVO RIVER.

June 28	4.30	248.21
July 14	4.21	187.91
July 23	4.25	220.66
August 6	4.23	204.79
Aug. 24	4.18	175.04
September 20	4.20	184.09

SPANISH FORK RIVER.

June 23	2.05	84.65
July 5	1.96	63.89
July 18	1.94	59.16
July 31	1.90	50.66
August 7	1.91	52.71
August 17	1.89	49.60
August 31	1.88	49.07

IRRIGATION LAWS.

Two very important questions, closely associated with irrigation in Utah, will soon force themselves upon the attention of the people of the State. The future growth and prosperity of the State depend largely upon how these questions are decided. They are: (1) How shall the water rights on the various streams be adjudicated, and (2) how shall the water be divided and distributed?

RECORDS OF WATER RIGHTS.

At the present time the offices of the various county recorders are the proper places of record for water rights. As a matter of fact, however, only a small percentage of the number of water rights have been so recorded, and in some localities practically none of them are recorded.

The records used in making distribution of the water are those kept by the watermasters. The watermaster of each ditch keeps a record of all the rights under his ditch, which is generally conceded to be correct by the owners on that particular ditch, but not necessarily so by the owners on other ditches. Thus it comes to pass that in Utah the ownership of water is based mainly upon the records of the watermasters, each owner being supposed to have a right to water a certain number of acres. A right does not mean any certain quantity of water, nor does it mean any certain portion of the water flowing in the stream. This is on account of the inaccurate manner in which the water is divided.

There should be one office of record for all the water rights in the State, and such provisions should be made in the law as would compel water owners to record their rights. All claims to the use of water for any purpose whatever should also be recorded at this same office, and this office should be the State Engineer's office. The convenience of such an arrangement is patent to anyone.

PERMITS TO APPROPRIATE WATER.

No person or corporation should be allowed to appropriate any of the waters of the State, without first obtaining a permit to do so from the State Engineer. This provision alone would put a stop to considerable of the litigation that is now going on in various parts of the State. As it is now, the waters of a stream may be entirely appropriated, and yet there is no way of preventing persons from going higher up on the stream, building ditches and diverting a portion of its waters to their own uses. Such persons will at first claim that they only intend to divert the surplus during high water, but gradually they will encroach upon the normal flow and, unless interfered with, will eventually acquire rights to a portion of it. In such cases the only recourse of prior appropriators, to prevent their water from being stolen, is to go to the expense of tearing out the dams and headgates of the new ditches and of bringing actions in some court of law. If the matter were in the hands of the State Engineer and Board of Control, prior appropriators would be relieved of all such trouble and expense.

ADJUDICATION BY THE COURTS.

In nearly every part of the State the rights on some of the streams have been, or are now being, adjudicated by the courts, and much time and money are being spent in litigation—uselessly spent, because very few decrees of court are satisfactory to anyone. This is owing to the fact that the courts usually have no series of stream measurements and no reliable information either as to the acreage irrigated or the duty of water, upon which to base a decree. The writer, himself, has heard judges solemnly decree the right to five or six times the amount of water flowing in the streams. The cases are tried in a court room fifteen or twenty miles distant from the streams and lands in question, masses of unreliable testimony are recorded, and then the judges write decrees that are unsatisfactory to the majority of the litigants.

ADJUDICATION BY ARBITRATION.

On some streams the rights have been adjudicated by Boards of Arbitration, the members of which are first chosen by the people and then apppointed by the courts. Usually, the findings of such a board are more satisfactory to the majority of the water owners on a stream than would be the decree of a court, because the members of the board investigate the case and take the testimony right on the ground. But, judging from the cases that have come under the writer's notice, the arbitrators have always failed to secure sufficiently accurate information upon which to base their findings, and they do not provide for a proper and accurate administration of their decisions. Their findings are therefore liable to be unsatisfactory. They do not, for one thing, obtain accurate data as to the acreage irrigated. Usually they simply call upon owners to state, under oath, the number of acres of water rights claimed. The acreage is then footed up for each ditch, and the division made upon that basis. People turn in the acreage they think they have; afterwards, actual surveys are likely to show serious errors in thus estimating the acreages. Sometimes water owners, in order that they may receive a large allotment of water by the arbitration, turn in all the land they have in the district, whether it has been irrigated or not. In that way much wet pasture land may be listed, which the owners have no intention whatever of watering. Again, sometimes owners will turn in land that is, and always has been, irrigated from springs. The information upon which the arbitrators base their decisions being inaccurate, the decisions are soon found to be unjust and unsatisfactory.

DIVISION AND DISTRIBUTION OF WATER.

The waters of very few of the streams in this State are accurately divided. Courts and Boards of Arbitration have rendered decisions on various streams all over the State, granting a certain water right to each ditch, and yet it is safe to say that not a single decree of court, or decision of arbitrators, is being properly carried out. The methods used by the farmers for dividing and distributing water are usually very crude. The following is one

of the methods commonly used: When the division is made, the watermasters of all the ditches and canals owning primary rights meet at the lowest point on the stream where water is diverted and proceed up-stream, measuring the width and depth of water flowing at the head of each canal as they go. In this way the number of "square inches" flowing into each canal is obtained. These are added together, to obtain the total number of "square inches" diverted. Then the watermasters usually proceed down-stream, regulating the quantity of water diverted so that each canal will have its proper number of "square inches," according to the number of shares allotted by decree, by arbitration, or by mutual agreement, as the case may be. A stream 100 inches wide and 5 inches deep would be 500 "inches," according to this method, and a stream 50 inches wide and 10 inches deep would also be 500 "inches." No allowance is made for differences in the velocity in the various canals. The farmers sometimes realize that this is not an accurate way of dividing the water, but they will not go to the trouble and expense of doing it properly.

In distributing the water to the various ditch owners, sometimes even cruder methods are used. The water is controlled by the watermaster and frequently he distributes it among the users by the eye, using a stone or a few shovels of mud to divide the water. In some instances, more care is used and the water enters all the main branches by self-dividing gates, the widths being proportioned to the shares, but no attention being paid to the velocity of approach of the water and no real attempt being made to attain accuracy.

THE REMEDY.

In order to remedy the difficulties described, changes in the water laws of Utah should be made as follows:

1. The office of the State Engineer should be made the office of record of all claims to water, and the law should compel all owners of existing rights to record their claims.

2. All county records of all claims to appropriations of water should be transferred to the office of the State Engineer, who should file and classify the same.

3. All persons or corporations desiring to appropriate water should be required to secure a permit for the same, before beginning the construction of any ditch or canal.

4. The State should be divided into four water divisions, provision being made for the appointment of one superintendent for each division, who should report to the State Engineer. Division superintendents should have authority to make such regulations as will secure the proper distribution of the water, reserving the right of appeal from the regulations of the superintendents to the State Engineer.

5. The State Engineer and division superintendents should be constituted a board of control, to adjudicate the rights to all the public waters of the State, reserving the right of appeal from the decisions of the board of control to the courts.

6. The State Engineer should be authorized and directed to make an examination of any stream to be so adjudicated, such examination to include measurements of discharge of stream, surveys of canals or ditches diverting water therefrom, measurements of lands irrigated by the said canals or ditches and the securing of any other information that would be of assistance in the adjudication.

7. The board of control should be authorized and directed to divide each water division into water districts, said water districts to be so arranged as to secure the best protection to the claimants of water, and the most economical supervision on the part of the State. For each water district thus created, there should be appointed one water commissioner, whose duty it would be to divide the water in the natural stream or streams of his district among the several ditches taking water therefrom, according to the prior rights of each, as determined by the adjudications of the board of control.

8. All appropriations of water for reservoir purposes should be filed in the office of the State Engineer, who should keep a record of same separate and apart from the record of rights to the direct use of water from the natural flow of streams. Every water right filing for reservoir purposes should state the purpose, give the capacity of the proposed reservoir, and designate the months of the year during which the water will be stored. As between

appropriations for storage, the first in time should be first in right; but stored rights should be inferior to rights to water for direct application to beneficial uses.

The first users of water from a storage reservoir should have preference over others; in other words, the oldest customers should have the first rights to the use of the water, provided they promptly pay the agreed rates charged for it. In case of disagreement between customers and reservoir owners as to said rates, the matter should be submitted to three arbitrators, one to be chosen by the water users, another by the reservoir owners, and the third by the State Engineer. The rate to be charged for stored water should be determined by the arbitrators on the basis of the cost of constructing and maintaining the reservoir and canals; in other words, the rate should be so fixed as to insure to the reservoir owners a fair interest on the money invested in the works.

Where stored water is mingled with the natural flow of streams, or with the water of another storage reservoir, provision should be made for reclaiming it without interfering with the rights of others. The owners of the reclaimed water should be compelled to construct and maintain, under the direction of the State Engineer, accurate means of measuring the water, both at the point of turning in and the point of reclamation. Before the stored water is turned into a natural stream, the water commissioners should be notified, and, under general instructions from the State Engineer, said water commissioner should measure the volume turned in and supervise distribution to those entitled to its use, giving them the amount turned in less the loss by seepage and evaporation in transit.

CONCLUSION.

The writer is well aware that numerous objections to this method of handling the waters of the State will be conjured up in the minds of some. A statement of what these objections might be, and of the arguments that could be used to refute them, would make this report too long. Suffice it to say that all objections can be refuted, and that, too, in a few sentences: The method here recommended has been in operation in Wyoming for about

ten years. Out of 3,887 water rights that have been adjudicated by the board of control, only one case has been appealed to the courts. No better practical proof of the success of the method could be given.

The writer is also well aware that this method of adjudicating water rights will materially reduce his income as an expert witness in water suits, but notwithstanding that, he advocates the method because he believes it to be the proper way to solve the water right problem in this State, and trusts that it will be brought the attention of the members of the Legislature in a very forcible manner during the coming session. In order that there may be no unnecessary delay in getting the subject before the Legislature, the writer has drafted, and compiled from the Wyoming statutes, a law that he believes will meet the exigencies of the case. It is attached to this report, marked "Appendix A." Much time and thought have been given to this work, and it is hoped that the proposed law will be printed with this report.

APPENDIX A.

PROPOSED IRRIGATION AND WATER LAWS.

Providing for the proper measurement and division of water; creating Water Divisions in the State of Utah; creating a Board of Control of Irrigation for the State of Utah, and defining its duties; defining the duties of the State Engineer; providing for the adjudication of water rights and for the recognition of existing rights; providing for the proper handling of stored water; and repealing Chapter 8, Title 63, Revised Statutes of Utah, 1898.

IRRIGATION AND WATER RIGHTS.

Water Control in State—

Sec. 1. Water being essential to industrial prosperity, of limited amount, and easy of diversion from its natural channels, its control must be in the State, which, in providing for its use, shall equally guard all the various interests involved.

Water is Property of State—

Sec. 2. The waters of all natural streams, springs, lakes or other collections of still water, within the boundaries of the State, are hereby declared to be the property of the State; but all existing rights to the use of any of the waters of this State for any useful or beneficial purpose are hereby recognized and confirmed.

Appropriation—

Sec. 3. Priority of appropriation for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interests.

MEASUREMENT OF APPROPRIATED WATER.

Diverted Water to be Measured. Records—

Sec. 4. Hereafter every corporation, company or individual who diverts the whole, or any part, of the waters of any public stream for any useful or beneficial purpose shall cause the same to be properly measured once a week during the time it is being diverted, and shall cause a careful and accurate record of each such measurement to be made and preserved. Copies of the records of all such measurements shall be furnished annually, and not later than December 1st, to the state engineer, for file in his office.

How Measured—

Sec. 5. In all cases where practicable, such measurements of flow must be made by means of sharp-crested rectangular weirs, with free fall, and with full contraction, or with no contraction; or by means of sharp-crested Cippoletti trapezoidal weirs; and, in either case, with the velocity of approch less than six inches per second. The state engineer shall, free of charge, give any information desired by any person as to weir methods of measuring water, or as to the methods of constructing weirs, upon proper application being made. Where the weir method is not practicable, special instructions will be given by the State Engineer as to the best available method for making the required measurements in each particular case.

Computations, How Made—

Sec. 6. For the sake of uniformity, all computations of weir discharges shall be made as follows:

For rectangular weirs,

$$\text{Discharge} = 3.33 \times \left(\text{length} - \frac{\text{number of end contractions}}{} \times \frac{\text{head, H}}{10}\right) \times \text{H}^{\frac{3}{2}}$$

For trapezoidal weirs,

$$\text{Discharge} = 3.3\tfrac{2}{3} \times \text{length} \times \text{H}^{\frac{3}{2}}$$

The length and head are to be taken in feet and decimals of a foot, and the formulas will then give the discharge in cubic feet per second. If the velocity of approach cannot be kept below six inches per second, proper correction must be made therefor.

DIVISION OF APPROPRIATED WATER.

Method for Canals—

Sec. 7. Wherever the water flowing in any canal is to be divided in varying portions by means of lateral ditches taken out at different points, the division shall be made by measuring the flow in cubic feet per second, by means of a weir in each lateral, and taking the total of the measurements as the total available flow in the canal,

and then apportioning the water amongst the several laterals accordingly.

Method for Laterals and Small Ditches—

Sec. 8. Where, as in the case of laterals or small ditches owned or used in common, it is desired to give to the several parties interested some definite proportion of the water flowing in the ditch, without measuring the flow in cubic feet per second, the division shall be made in the following manner:

The water in the ditch shall be brought to a complete state of rest, or very nearly so, and then be allowed to flow, with free fall, over a rectangular weir without lateral contraction, or over a Cippoletti trapezoidal weir, the crest of the weir in either case to be truly horizontal. One or more thin edged partition boards shall be placed at right angles to the weir and directly below it, to divide the falling waters. The division thus made will be taken to be in direct proportion to the distances intercepted on the crest of the weir by the said partition boards.

If the ditch or stream is of considerable size, so that the proper proportion between depth and length can be maintained, the depth being at least four inches, the division may be made by separate weirs whose lengths are in direct proportion to the division to be made. Rectangular weirs without end contractions, or the Cipoletti trapezoidal weir, must be used, and great care must be exercised to see that the crests are truly horizontal and at exactly the same level, one with the other.

Time Method—

Sec. 9. In cases where several parties are interested in a small lateral or ditch, in which the amount of water is only sufficient for one user at a time, the division shall be made by the time method. Each user shall have the whole stream of water for a time proportionate to his interest in the ditch, and the period shall be so arranged that the rotation will be complete within such a space of time as the experience of the locality has shown to be most desirable for an irrigation to be repeated. The water shall be taken at night or day according to schedule, and in order that the inconveniences may be fairly

distributed, the period of rotation may be made with a fractional day, so that those who had the water in the night during the first rotation will have it in the day during the second, and vice versa. The user must be ready to take the water at the schedule time, or lose it until his turn at the next rotation.

WATER DIVISIONS.

Number of divisions—

Sec. 10. The State of Utah is hereby divided into four water divisions, denominated Water Division Number One, Water Division Number Two, Water Division Number Three and Water Division Number Four.

Water Division No. 1—

Sec. 11. Water Division No. 1 shall consist of all lands within this State included in the following description: Beginning at the norherly northeast corner of the State, thence south along the eastern boundary of the State, to the southwest corner of the State of Wyoming; thence east along the northern boundary of this State, between Utah and Wyoming, to the summit of the watershed dividing the drainage of the Bear River from that of the Green River; thence southerly along the sumit of said watershed to the southern boundary of Summit County; thence, in a general southwesterly direction, along the southern boundary of Summit County and the western boundary of the Uintah Indian Reservation, and along the summit of the watershed dividing the drainage of the Great Salt Lake Basin from that of the Green River, to the southern boundary of Utah County; thence, in a general westerly direction, along the summit of the watershed dividing the drainage of the Great Salt Lake Basin from that of the Green River and the Sevier Lake Basin, to the southeast corner of Tooele County; thence westerly along the southern boundary of Tooele County, to the one-hundred and thirteenth meridian; thence southwesterly to the summit of the divide between Deep Creek and Pleasant Valley Creek, on the western boundary of the State, including Fish Springs and Birch Creek; thence north along the western boundary of the State,

to the northwest corner of the State; thence east along the northern boundary of this State between Utah and Idaho, to the place of beginning. In a general way, Water Division No. 1 shall consist of all lands within this State which are included in the drainage of the Great Salt Lake Basin.

Water Division No. 2—

Sec. 12. Water Division No. 2 shall consist of all lands within this State included in the following description: Beginning at the southeast corner of Water Division No. 1, on the southern boundary of Utah County, thence, in a general southwesterly direction, along the summit of the watershed dividing the drainage of the Sevier Lake Basin from that of the Green and Colorado Rivers, to the southern boundary of Garfield County; thence, in a general westerly direction along the summit of the watershed dividing the drainage of the Sevier Lake Basin from that of the Colorado River, to the western boundary of the State; thence north along the western boundary of the State, to the southwest corner of Water Division No. 1; thence, in a general easterly direction, along the southern boundary of Water Division No. 1, to the place of beginning. In a general way, Water Division No. 2 shall consist of all lands within this State which are included in the drainage of the Sevier Lake Basin.

Water Division No. 3—

Sec. 13. Water Division No. 3 shall consist of all lands within this State included in the following description: Beginning at the southerly northeast corner of the State, which is also the northeast corner of Uintah County, thence south along the eastern boundary of the State, to the summit of the watershed dividing the drainage of the Grand River from that of the San Juan River; thence, in a general northwesterly direction, along the summit of the watershed dividing the drainage of the Grand River from that of the San Juan River, and along the summit of the watershed dividing the drainage of the Green and San Rafael Rivers from that of the Fremont River and Muddy Creek, to the eastern boundary of Water Division No. 2; thence, in a general northeasterly direction, along the eastern boundaries of Water Divisions Nos. 2 and 1,

to the boundary line between Utah and Wyoming; thence east along said boundary line, to the place of beginning. In a general way, Water Division No. 3 shall consist of all lands within this State which are included in the drainage of the Green and Grand Rivers.

Water Division No. 4—

Sec. 14. Water Division No. 4 shall consist of all lands within this State included in the following description: Beginning at the southeast corner of Water Division No. 3, thence south along the eastern boundary of the State, to the southeast corner of the State; thence west along the southern boundary of the State, to the southwest corner of the State; thence north along the western boundary of the State, to the southwest corner of Water Division No. 2; thence, in a general easterly direction, along the southern boundary of Water Division No. 2, to the southeast corner of said Water Division No. 2, on the southern boundary of Garfield County; thence, in a general northeasterly direction, along the eastern boundary of Water Division No. 2, to the southwest corner of Water Division No. 3; thence, in a general southeasterly direction, along the southern boundary of Water Division No. 3, to the place of beginning. In a general way, Water Division No. 4 shall consist of all lands within this State which are included in the drainage of the Colorado River, below the junction of the Green and Grand Rivers.

SUPERVISION OF WATER.

Board of Control—

Sec. 15. There is hereby constituted a board of control, to be composed of the state engineer and superintendents of the water divisions, which shall have the supervision of the waters of the State and of their appropriation, diversion and distribution, and of the various officers connected therewith. Its decisions shall be subject to review by the courts of the State.

State Engineer—

Sec. 16. There shall be a state engineer, who shall be appointed by the Governor of the State and be con-

firmed by the Senate. He shall hold his office for the term of four years, or until his successor shall have been appointed and shall have qualified. He shall be president of the board of control, and shall have general supervision of the waters of the State and of the officers connected with its distribution. No person shall be appointed to this position who has not such theoretical knowledge and such practical experience and skill as shall fit him for the position.

Salary of Engineer—

Sec. 17. The state engineer shall receive a salary of three thousand dollars per annum, payable in quarterly installments, by the State Treasurer, upon warrants drawn by the State Auditor.

His Office—

Sec. 18. The state engineer shall keep his office at the State Capital.

His Oath and Bond—

Sec. 19. Before entering upon the duties of his office, he shall take and subscribe an oath before some officer authorized by the Laws of the State to administer oaths, to faithfully perform the duties of his office. He shall file with the Secretary of State said oath, and his official bond, in the penal sum of five thousand dollars, with not less than two sureties, to be approved by the Governor of the State, and conditioned for the faithful discharge of the duties of his office, and for delivery to his successor, or other officer appointed by the Governor to receive the same, all moneys, books and other property belonging to the State, then in his hands or under his control, or with which he may be legally chargeable as such officer.

Duties of Engineer—

Sec. 20. The state engineer shall perform such duties as are prescribed in the law defining the duties of the board of control, and, in addition, shall make, or cause to be made, measurements and calculations of the dis-

charge of streams, from which water shall be taken for beneficial purposes, commencing such work upon those streams as are most used for irrigation or other beneficial purposes. He shall collect facts, and make surveys to determine the suitable location for constructing works for utilizing the water of the State, and to ascertain the location of the lands best suited for irrigation. He shall examine reservoir sites, and shall, in his reports, embody all the facts ascertained by such surveys and examinations, including, wherever practicable, estimates of the costs of proposed irrigation works, and of the improvement of reservoir sites. He shall become conversant with the waterways of the State, and the needs of the State as to irrigation matters, and in his reports to the Governor he shall make such suggestions as to the amendment of existing laws, or the enactment of new laws, as his information and experience shall suggest. He shall keep in his office full and proper records of his work, observations and calculations, all of which shall be the property of the State.

Assistant Engineer—

Sec. 21. The state engineer shall have the power to employ an assistant engineer, at an expense not to exceed fifteen hundred dollars per annum, and to employ other assistants at a total additional expense not to exceed one thousand dollars per annum. Such assistant engineer, and such additional assistants, shall be paid in quarterly installments out of any money appropriated for that purpose, on certificates of the state engineer, showing the amount of such employment and the compensation therefor. On the presentation of such certificates to the State Auditor, he shall issue warrants on the State Treasurer for the amounts thereof.

Travelling Expenses Allowed—

Sec. 22. When the state engineer, or his assistant engineer, is called away from his office he shall be entitled to his actual travelling expenses, which shall be paid out of any money appropriated for that purpose, on the certificate of said state engineer. Such certificates shall be

presented to the State Auditor, who shall thereupon draw upon the State Treasurer for the amount thereof.

Report of Engineer—

Sec. 23. The state engineer shall prepare and render to the Governor, biennially, and oftener if required, full and true reports of his work, touching all matters and duties devolving upon him by virtue of his office; which report shall be delivered to the Governor on or before the 31st day of December of the year preceding the regular session of the Legislature.

DIVISION SUPERINTENDENTS.

Appointment and Term—

Sec. 24. There shall be one superintendent for each of the water divisions by this act created, who shall be appointed by the Governor, with the consent of the Senate; who shall hold his office for four years, or until his successor is appointed and shall have qualified, and who shall reside in the water division for which he is appointed.

Duties.

Sec. 25. Said division superintendent shall have general control over the water commissioners of the several districts within his division. He shall, under the general supervision of the state engineer, execute the laws relative to the distribution of water in accordance with the rights of priority of appropriations, and perform such duties as shall devolve upon him as a member of the board of control and such other functions as may be assigned to him by the state engineer.

May Make Regulations—

Sec. 26. Said division superintendent shall, in the distribution of water, be governed by this act, and acts now in force; but for the better discharge of his duties, he shall have authority to make such other regulations to secure the equal and fair distribution of water, in accordance with the rights of priority of appropriation, as

may, in his judgment, be needed in his division; provided, that such regulations shall not be in violation of any part of this act, or other laws of the State, but shall be merely supplementary to, and necessary to enforce, the provisions of the general laws and amendments thereto.

Appeal from—

Sec. 27. Any person, ditch company or ditch owner, who may deem himself injured, or discriminated against by any such order or regulation of such division superintendent, shall have the right to appeal from the same to the state engineer, by filing with the state engineer a copy of the order or regulation complained of, and a statement of the manner in which the same injuriously affects the petitioner's interest. The state engineer shall after due notice, hear whatever testimony may be brought forward by the petitioner, either orally or by affidavit, and, through the division superintendent, shall have power to suspend, amend or confirm the order complained of.

Water Commissioners to Report to Superintendent—

Sec. 28. All water commissioners shall make reports to the division superintendent of their division, as often as may be deemed necessary by said superintendent. Said reports shall contain the following information: The amount of water necessary to supply all the ditches, canals and reservoirs of that district; the amount of water actually coming into the district to supply such ditches, canals and reservoirs; whether such supply is on the increase or decrease; what ditches, canals and reservoirs are at that time without their proper supply; and the probability as to what the supply will be during the period before the next report will be required; and such other further information as the division superintendent of that division may require. Said division superintendent shall carefully file and preserve such reports, and shall from them ascertain what ditches, canals and reservoirs are, and what are not, receiving their proper supply of water; and if it shall appear that in any district of that division any ditch, canal or reservoir is receiving water, whose priority post-dates that of a ditch, canal or

reservoir in another district, as ascertained from his register, he shall at once order such post-dated ditch, canal or reservoir shut down, and the water given to the elder ditch, canal or reservoir. His order shall be directed at all times to the enforcement of priority of appropriation, according to his tabulated statement of priorities, in the whole division, and without regard to the district within which the ditches, canals or reservoirs may be located. The reports of water commissioners to the division superintendents of irrigation shall be filed and kept in the office of the state engineer.

Pay of Superintendent. His Oath and Bond—

Sec. 29. Each division superintendent of divisions numbers two, three and four shall be paid eight dollars per day, in quarterly installments, for every day actually consumed in the performance of his duties as such superintendent, and shall, in addition, be paid his actual travelling expenses when called away from home in the performance of his duties. The superintendent of water division No. 1 shall be the secetary of the state borad of control, and it shall be his duty to keep a full, true and complete record of the transactions of the said State board of control, and he shall certify, under seal, all certificates of appropriation of water made in accordance with the law. The superintendent of water division No. 1 shall receive annually a salary of eighteen hundred dollars, payable in quarterly installments, in full compensation for all services as water division superintendent and as secretary of the said state board of control, and shall, in addition, be paid his actual travelling expenses when called away from home in the performance of his duties.

Before entering upon the duties of his office, each division superintendent shall take and subscribe an oath, before some officer authorized by the laws of the State to administer oaths, to faithfully perform the duties of his office, and file with the Secretary of State said oath, and his official bond in the penal sum of two thousand five hundred dollars, with not less than two sureties, to be approved by the Governor of the State, and conditioned for the faithful discharge of the duties of his office.

DUTIES OF BOARD OF CONTROL.

Office. Meetings—

Sec. 30. The board of control shall have an office with the state engineer in the capital, and shall hold two meetings each year for the transaction of such business as may come before it. The first of said meetings shall begin on the second Wednesday in March, and the second on the second Wednesday in October. The state engineer shall be ex-officio president of said board and shall have the right to vote on all questions coming before it, and a majority of all the members of said board shall constitute a quorum to transact business.

Duty at First Meeting. Measurement of Streams. Taking Testimony. Notice to Claimants. Statement of Claimant—

Sec. 31. It shall be the duty of said board at its first meeting to make proper arrangements for beginning the determination of the priorities of right to the use of the public waters of the State, which determination shall begin on the streams most used for irrigation, and be continued as rapidly as practicable, until all the claims for appropriation now on record shall have been adjudicated. The method of determining the priority and amounts of the appropriation shall be as follows:

The members of the board of control shall decide at their first meeting the streams to be first adjudicated, and shall fix a time for beginning the taking of testimony and the making of such examinations as will enable them to determine the rights of the various claimants. Said board shall prepare a notice, setting forth the date when the engineer will begin a measurement of the streams and the ditches diverting the water therefrom, and a place and a day certain, when the superintendent of the water division in which the stream to be adjudicated is situated, shall begin the taking of testimony as to the rights of the parties claiming water therefrom. Said notice shall be published in two issues of a newspaper having general circulation in the county in which such stream is situated, the publication of said notice to be at least thirty days prior to the beginning of taking testimony by said divi-

sion superintendent, or of the measurement of the stream by the state engineer, or his assistant. The superintendent taking such testimony shall have the power to adjourn the taking of evidence from time to time, and from place to place; provided, that all places appointed and adjourned to by the superintendent shall be so situated, as related to the streams, as shall best suit the proper convenience of the persons interested in the determination of such priorities and appropriations. It shall also be the duty of said division superintendent to mail to each party having a recorded claim to the waters of such stream, by registered mail, a similar notice, setting forth the date when the state engineer, or his assistant, shall begin the examination of the stream and ditches diverting water therefrom, and also the date when the superintendent will begin the taking of testimony, and the date when the taking of such testimony by said division superintendent shall close, and he shall, in addition, inclose with said notice a blank form on which said claimant shall present in writing all the particulars showing the amounts and dates of appropriations to the use of water of said stream to which he lays claim; the said statement to include the following:

The name and postoffice address of the claimant.

The nature of the use on which the claim for an appropriation is based.

The time of commencement of such use, and, if distributing works are required: The date of beginning of survey; the date of beginning of construction; the date when completed; the date of beginning and completion of enlargements; the dimensions of the ditches originally constructed and as enlarged.

The date when water was first used for irrigation or other beneficial purposes, and if used for irrigation, the amount of land reclaimed the first year; the amount in subsequent years, with the dates of reclamation, and the amount of land each ditch is capable of irrigating; the character of the soil and the kind of crops cultivated, and such other facts as will show a compliance with the law in acquiring the appropriation and the rank of priority claimed.

Statements to be under oath. Administering oaths.

Sec. 32. Each of said claimants shall be required to certify to his statements under oath, administered by the superintendent of the water division in which the testimony is taken, which shall be done without charge to the claimant, as also shall be the furnishing of blank forms for said statements. If claimant himself cannot swear as to date of appropriation, he must produce at least one competent witness to establish date of appropriation with reasonable certainty. The members of the board of control are hereby authorized to administer oaths in all cases where is shall be necessary in the performance of their official duties.

Superintendent takes testimony. Notice upon completion of testimony.

Sec. 33. Upon the date named in the preceding notice, the division superintendent shall begin the taking of said testimony, and shall continue until said testimony shall be completed; provided, that in case the division superintendent of any water division is directly, or indirectly, interested in the water of any stream of his division, the taking of evidence in so far as relates to said stream, shall be under the direction of the division superintendent of the next nearest water division, or under the direct personal supervision of the state engineer, as may be deemed most expedient. Upon the completion of the taking of evidence by the division superintendent, it shall be his duty to at once give notice, in one issue of some newspaper of general circulation in the county where such evidence was taken, and by registered mail, to the various claimants, that upon a certain day and at a place named in the notice, all of said evidence shall be open to the inspection of the various claimants, and said superintendent shall keep said evidence open to inspection at said place not less than one day and not more than five days.

Contests.

Sec. 34. Should any person, corporation or associa-

tion of persons owning any irrigation works and claiming any interest in the stream or streams involved in the adjudication desire to contest any of the rights of the persons, corporations or associations who have submitted their evidence to the superintendent, as aforesaid, such persons, corporations or associations shall, within fifteen days after the testimony so taken shall have been open to public inspection, as provided in Section 33 of this act, in writing, notify the superintendent of the water division in which is located said irrigation works or stream or streams, stating with reasonable certainty the ground of their proposed contest, which statement shall be verified by the affidavit of the contestant, his agent or attorney. Said division superintendent shall notify the said contestant and the person, corporation or association whose rights are contested, to appear before him at such convenient place as the superintendent shall designate in such notice. Said superintendent shall also fix the time both as to day and hour for the hearing of said contest; which date shall not be less than thirty, nor more than sixty days from the date the notice is served on the party, association or corporation; which notice and the return thereof shall be made in the same manner as summons are served in civil actions in the district court of this State.

Superintendents of water divisions shall have power to adjourn hearings from time to time, upon reasonable notice to all parties interested, and to issue subpoenas and compel the attendance of witnesses to testify upon such hearings, which shall be served in the same manner as subpoenas issued out of the district courts of the State; and shall have the power to compel such witnesses so subpoenaed to testify and give evidence in said matter. Said witnesses shall receive fees as in civil cases, to be paid by the party or parties against whom the contest shall be finally determined.

The evidence on such proceeding shall be confined to the subject enumerated in the notice of contest.

The superintendent shall require a deposit of $5 from each party for each day he shall be engaged in taking evidence on said contest.

Upon the final determination of the adjudication of the matters by the board of control, an order shall be entered directing that the money so deposited shall be re-

funded to the persons, associations or corporations in whose favor such contest shall be determined, and that all moneys deposited by other parties therein shall be turned over by the superintendent to the State treasury to the credit of the fund provided for the maintainence of the board of control.

Upon the completion of the evidence in the original hearing before the superintendent, as provided in the previous section, and the evidence taken in all contests, it shall be his duty to transmit all the evidence and testimony in said adjudication to the office of the board of control, in person or by registered mail.

Measurement of stream and ditches.

Sec. 35. It shall be the duty of the state engineer, or some qualified assistant, to proceed at the time specified in the notice to the parties on said stream to be adjudicated, to make an examination of said stream, and the works diverting water therefrom, said examination to include measurements of the discharge of said stream, and of the carrying capacity of the various ditches and canals diverting water therefrom; an examination of the irrigated lands, and an approximate measurement of the lands irrigated, or susceptible of irrigation, from the various ditches and canals, which said observations and measurements shall be reduced to writing, and made a matter of record in his office. It shall be the duty of the state engineer to make, or cause to be made, a map or plat, on a scale of not less than one inch to the mile, showing with substantial accuracy, the course of said stream, the location of each ditch or canal diverting water therefrom, and the legal subdivisions of land which have been irrigated, or which are susceptible of irrigation, from the ditches and canals already constructed.

Order Determining Priorities.

Sec. 36. At the first regular meeting of the board of control, after the completion of such measurements by the state engineer and the return of said evidence by said division superintendent, it shall be the duty of the board of control to make, and cause to be entered of record in its office, an order determining and establishing the several

priorities of right to the use of water of said stream, and the amounts of appropriations of several persons claiming water from such stream, and the character and kind of use for which said appropriation shall be found to have been made. Each apropriation shall be determined in its priority and amount, by the time by which it shall have been made, and the amount of water which shall have been applied for beneficial purposes. Such appropriator shall at no time be entitled to the use of more water than he can make a beneficial application of on the lands for the benefit of which the appropriation may have been secured, and the amount of any appropriation made by reason of an enlargement of distributing works shall be determined in like manner.

Certificate of Appropriation.

Sec. 37. Within a reasonable time after the determination of the priorities of appropriation to the use of waters of any stream, it shall be the duty of the secretary to issue to each person, association or corporation represented in such determination, a certificate, to be signed by the state engineer, as president of the board of control, and attested under seal by the secretary of said board, setting forth the name and postoffice address of the appropriator; the priority number of such appropriation; the amount of water appropriated; and if such appropriation be for irrigation, a description of the legal subdivisions of land to which said water is to be applied. At the time of taking the testimony the division superintendent shall collect the fees for issuing certificates of appropriation and for recording the same in the offices of the County Clerks. The certificates, together with the County Clerk's fees, which shall be seventy-five cents for each certificate, shall be transmitted by the state engineer, or by a member of the board of control in person, or by registered mail, to the County Clerk of the County in which such appropriation shall have been made, and it shall be the duty of said County Clerk, on receipt of the certificates and fees, to record the same in a book specially prepared and kept for that purpose.

Re-hearing before Board of Control.

Sec. 38. Within one year after any final order of the

board of control adjudicating the priorities upon any stream, any party interested therein may apply for a re-hearing, for reasons to be stated in the application. Upon the filing of such application, the secretary of the board shall mail written notice thereof to every other party interested, therein fixing and stating the time when such application will be heard. Upon such hearing, the board shall have authority to modify or alter the original order in such respect as shall appear just and proper. But it shall not be necessary for an application for a re-hearing to be filed to entitle any party to an appeal. Upon such hearing, the board shall also have authority to permit, upon good cause shown, the correction of the testimony of any party or witness, if it shall appear that a mistake has occurred therein; but no other new evidence shall be received at such hearing, unless it shall be shown to the satisfaction of the board that the same is material and has been discovered since the taking of the original testimony, and could not with reasonable diligence have been discovered before that time.

Appeal from Board Allowed.

Sec. 39. Any party, or number of parties acting jointly, who may feel themselves aggrieved by the determination of the board of control, may have an appeal from the board of control to the District Court of the Judicial district within which the appropriation or appropriations of the party or parties so aggrieved may be situated. All persons joining in the appeal shall be joined as appellants, and all persons having interests adverse to the parties appealing, or either of them, shall be joined as appellees.

Proceeding on Appeal.

Sec. 40. The party or parties appealing shall, within sixty days of the determination of the board of control, which is apealed from, and the entry thereof on the records of the board, file in the District Court to which the appeal is taken, a notice in writing, stating that the party, or parties, appeals to such District Court from the determination and order of the board of control; and upon the filing of such notice, the appeal shall be deemed to have

been taken. The party or parties apealing shall, within the sixty days mentioned, enter into an undertaking, to be approved by the district court, or judge thereof, and to be given to all the parties in the said suit or proceeding, other than the parties appealing, and to be in such an amount as the court, or judge thereof, shall fix, conditioned that the parties giving their said undertaking shall prosecute their appeal to effect, without unnecessary delay, and shall pay all costs and damages which the party to whom the undertaking is given, or either, or any of them, may sustain in consequence of such appeal.

Notice of Appeal.

Sec. 41. The Clerk of the District Court shall immediately upon filing of said notice of appeal and the approval of the bond mentioned in Section 40, transmit to the secretary of the board of control a notice over the seal of the court to the effect that said appeal has been perfected; which notice shall be entered of record by the secretary in the records of the board of control, and the appellant or appellants shall cause a certified copy thereof to be served on each of the appellees; serving the same in the manner provided for the serving of a summons in the District Court.

Transcript and Petition to be Filed.

Sec. 42. The appellant or appellants, within six months after the appeal is perfected, as provided for in Sections 39, 40 and 41, shall file in the office of the Clerk of the District Court a certified transcript of the order of determination made by the board of control, which is appealed from; a certified copy of all the records of the board of control relating to such determination; and a certified copy of all the evidence offered before the board of control, including the measurements of streams, tributaries and ditches provided for by Section 35, together with the petition setting out the cause of complaint of the party or parties appealing, to which petition all parties joined as appellees shall be served with notice by the issuance of summons out of the office of the Clerk of such District Court within the time and manner provided

by law for the issuance and service of summons in actions of law. All proceedings of appeal shall be conducted according to the provisions of the civil code of procedure, and the practice of appeals from the District Courts of the State to the Supreme Court; provided that all hearings in the District Court on appeal be had upon the evidence theretofore taken, and certified from the office of the board of control; and no new evidence shall be permitted, unless it shall appear by proper and satisfactory showing that new evidence has been discovered which could not, with reasonable diligence, have been discovered prior to the final hearing before the board.

It shall be the duty of the Clerk of the District Court immediately upon the entry of any judgment, order or decree by the District Court, or by the judge thereof, in an appeal from the decision of the board of control, to transmit a certified copy of said judgment, order or decree to the secretary of the state board of control. It shall be the duty of the secretary to immediately enter the same upon the records of such office, and the state engineer shall forthwith issue to the superintendent or superintendents of water divisions instructions in compliance with, and in execution thereof, the said judgment, order or decree. All costs made and accruing by reason of such appeal shall be adjudged to be paid by the party or parties against whom such apeal shall be finally determined.

During the time an appeal from order of the board of control is pending in the District Court, and until a certified copy of the judgment, order or decree of the District Court is transmitted to the state engineer, the division of water from the stream involved in such appeal shall be made in accordance with the order of the board of control.

At any time after the appeal has been perfected, the appellant or appellants may stay the operations of said decree appealed from by filing a bond in the District Court wherein such apeal is pending, in such amount as the judge thereof may designate, conditioned that he will pay all damages that may accrue to the appellee or appellees by reason of such order or decree not being enforced, should the proceedings and appeal be decided against the appellant. And immediately upon the filing and

approval of such bond to stay the operations of the decree, the Clerk of the District Court shall transmit to the board of control a notice over the seal of the court to the effect that such bond has been filed, and that the operations of such decree are stayed during the pending of such appeal proceedings. This notice shall be recorded in the records of the board of control, and the state engineer shall immediately give proper notice to the superintendent of the water division wherein such appeal may have been taken.

Appeals to be advanced on docket.

Sec. 43. Upon any appeal being taken from the board of control to the district court of this State as is by this act provided, it shall be the duty of said court to advance such appeal to the head of its trial docket, and to give such appeal precedence over all civil causes in hearing and determination thereof. If an appeal be taken from the judgment or decree of the district court to the Supreme Court of the State, it shall in like manner be the duty of the Supreme Court to advance such appeal to the head of its docket for the trial of civil causes, and give it like precedence as to trial.

Transfer of county records to engineer.

Sec. 44. Within thirty days from the passage of this act, it shall be the duty of the County Clerk, in each of the counties of this State, to prepare a full and complete transcript of all the claims to appropriations of water now on file in their respective offices, and to transmit the same without delay to the state engineer, by express or registered mail, for which service he shall be paid by the county the sum of four dollars ($4.00) per day for each and every day required to prepare such transcript; provided, that the County Clerk shall, in place of such abstract, transmit such original records of claims to water as are recorded in books kept especially for that purpose. It shall also be the duty of the County Clerk and the Clerk of the District Court, within thirty days from the date of the passage of this act, to transmit to the state engineer, in like manner, any certificates of measurements of ditches made by the county surveyors, which may be

now on file in their offices, in the various counties of the State.

Engineer to file and classify.

Sec. 45. Immediately upon receipt of said transcripts and said original records, it shall be the duty of the state engineer to file them in his office, and to classify and arrange such claims, by placing all the claims to water of one stream and its tributaries together.

Whom to be notified.

Sec. 46. In issuing notices to claimants, in priority adjudications of the waters of any stream and its tributaries, as provided in Section 31 of this act, all parties named in said transcript, as claiming the waters of said stream or tributaries, shall be notified by mail as specified in said section.

Application for right to appropriate water.

Sec. 47. Any person, association or corporation, hereafter intending to acquire the right to the beneficial use of the public water of the State of Utah, shall, before commencing the construction, enlargement, or extension of any dam, ditch, canal or other works, or performing any work in connection with said construction, or proposed appropriation, make an application to the state engineer for permit to make such appropriation. Such application must set forth the name and postoffice address of the applicant; the source of the water supply; the nature of the proposed use; the location and description of the proposed dam, ditch, canal or other work; the time within which it is proposed to begin construction; the time required for the completion of construction; and the time required for the complete application of the water to the proposed use.

In case the proposed right of use is for agricultural purposes, the application shall give the legal subdivisions of land proposed to be irrigated, with the total acreage to be reclaimed, as near as may be. On receipt of this application, which shall be of a form prescribed by the state engineer, it shall be the duty of that officer to make an endorsement thereon of the date of its receipt, and

to make a record of such receipt in some suitable book in his office. It shall be his duty to examine said application and ascertain if it sets forth all the facts necessary to show the location, nature and amount of the proposed use. If upon such examination the application is found defective, it shall be the duty of the state engineer to return the same for correction. The date of such return, with the reasons therefor, shall be endorsed upon the application, and a record made thereof in the book kept for recording receipts of such applications. A like record shall be kept of the date of the return of corrected applications and of the date of the refusal and return of applications rejected.

All applications which shall comply with the provisions of this act and with the regulations of the engineer's office, shall be recorded in a suitable book kept for that purpose; and it shall be the duty of the state engineer to approve all applications made in the proper form, which contemplate the application of the water to a beneficial use and where the proposed use does not tend to impair the value of the existing rights, or be otherwise detrimental to the public welfare. But where there is no unappropriated water in the proposed source of supply, or where the proposed use conflicts with existing rights, or threatens to prove detrimental to the public interest, it shall be the duty of the state engineer to reject such application and refuse to issue the permit asked for.

The refusal or approval of an application shall be endorsed thereon and a record made of such endorsement in the state engineer's office. The application so endorsed shall be returned to the applicant. If approved, the applicant shall be authorized, on receipt thereof, to proceed with the construction of the necessary works and to take all steps required to apply the water to a beneficial use and to perfect the proposed appropriation. If the application is refused, the applicant shall take no steps toward the prosecution of the proposed work, or the diversion and use of the public water, so long as such refusal shall continue in force.

Before either approving or rejecting an application, the state engineer may require such additional information as will enable him to properly guard the public interests, and may, in the case of applications proposing to

divert more than 25 cubic feet of water per second of time, or to reclaim over 1,000 acres of land, require a statement of the following facts:

In case of incorporated companies, he may require the submission of the articles of incorporation; the names and places of residence of its directors and officers; the amount of its authorized and of its paid up capital.

If the applicant is not an incorporated company, he may require a showing as to the name or names of the party or parties proposing to construct the work, and a showing of facts necessary to enable him to determine whether or not they have the financial ability to carry out the proposed work, and whether or not the said application has been made in good faith.

In his endorsement of approval on any application, the state engineer shall require that actual construction work shall begin within one year from the date of such approval, and that the construction of any proposed irrigation work shall be completed within a period of five years from the date of such approval. He may limit the application to a less period of time for the completion of work than is asked for, and likewise the perfecting of the proposed right for a less period than named in the application. The state engineer shall have authority, for good cause shown, to extend the time within which irrigation or other works shall be completed, under any permit therefor issued by said engineer.

Any applicant feeling himself aggrieved by the indorsement made by the state engineer upon his application, may, in writing, in an informal manner, and without pleadings of any character, appeal to the board of control for an examination and reversal of the endorsement of the state engineer; and if he shall deem himself aggrieved by the order made by the board of control, with reference to his application, he may take an appeal therefrom to the District Court of the county in which the point of diversion of the proposed appropriation shall be situated. Such appeal shall be taken within sixty (60) days from the issuance of the order by the board of control, and shall be perfected when the applicant shall have filed in the office of the clerk of such district court a copy of the order appealed from, certified by the secretary of the board of control as a true copy, together with the

petition to such court setting forth the appellant's reason for appeal. Such appeal shall be heard and determined upon such competent proof as shall be adduced by the applicant, and such like proof as shall be adduced by the board of control, or some person duly authorized in its behalf.

Map to be filed.

Sec. 48. Each application for a permit to appropriate water for beneficial uses must be accompanied by a map or plat, in duplicate, showing accurately the location and extent of the proposed work.

These maps or plats must be drawn on tracing linen, on a scale of not less than two inches to the mile in the case of canals or ditches, and one thousand feet to an inch in the case of reservoirs. They must show the location of the headgate or point of diversion by courses and distances from some government corner; they must show the actual location of the ditch or canal, or water line of the reservoir, and must show wherever section lines are crossed, the distance to the nearest government corner. The map or plat must show the course of the river, stream or other source of supply; the location and area of all lands proposed to be reclaimed; the position and area of all reservoirs, or basins, intended to be created for the puropse of storing water; and the location of the intersection with all other canals, ditches, laterals or reservoirs which are crossed by this work or with which connections are made. All streams, and all intersecting ditches, canals and reservoirs not connected with the proposed work must be represented in ink of a different color from that used to represent the proposed work. These maps must show the name of the proposed work, and, where possible, the number of the permit. They must, in addition, show the name or names of the applicant or applicants, and bear a certificate of the surveyor giving the date of survey, his name and postoffice address.

It shall be the duty of the state engineer to examine these maps or plats, to ascertain if they agree with the description contained in the application, and when found to agree, or made to agree, to approve the same, file one copy in his office and return the other, approved, to the party filing them.

In case of ditches or canals carrying more than fifty (50) cubic feet of water per second, the engineer may require, in addition to the maps or plats above described, the following:

A longitudinal profile of the ditch showing the bottom and proposed water line, the horizontal scale of which shall not be less than one inch to 1,000 feet, and the vertical scale not less than one inch to 20 feet; a plan showing cross-sections at a sufficient number of points to show all the different forms which the ditch when completed will take, and showing what portion of the water is to be conveyed in excavation, and what portion is to be conveyed in embankment. These plans shall be drawn on a horizontal and vertical scale of not less than one inch to twenty feet.

Plans of any dams, cribs, embankments or other proposed works to obstruct any river, stream, lake or pond, or other source of water supply, shall be drawn on a longitudinal scale of not less than one inch to two hundred feet, and for cross-sections on a scale of not less than one inch to twenty feet; and shall show what material is intended to be used and placed in such work. Timber, brush, stone or other material except earth, used in such works shall be shown in detail on a plan, the scale of which shall not be less than one inch to four feet. The maps of all proposed reservoirs shall show the surface of the ground under water, and a sufficient number of lines of level shall be shown so that the contents of the reservoir or basin may be accurately determined. If the levels are shown by contour lines, they shall be on a scale sufficiently large to show vertical levels not exceeding five feet, and with all such reservoir plans there shall be furnished a plan, on a scale of not less than one inch to ten feet, showing the method of providing a wasteway for such reservoir and the method of drawing off the water from such reservoir or basin.

Certificate to appropriator.

Sec. 49. Upon it being made to appear to the satisfaction of the board of control that any application for a permit to appropriate water has been perfected in accordance with the provisions of this act, and the endorsement of the state engineer obtained thereon, it shall be the

duty of the board of control, by the hand of its president, attested under the seal of the secretary, to send to the County Clerk a certificate of the same character as that described in Section 37 of this act, which said certificate shall be recorded in the office of the County Clerk, as provided in Section 37.

Date of priority.

Sec. 50. The priority of such appropriations shall date from the filing of the application in the state engineer's office.

Legal Standard.

Sec. 51. A cubic foot of water per second of time shall be the legal standard for the measurement of water in this State, both for the purpose of determining the flow of water in natural streams, and for the purpose of distributing water therefrom.

County to pay Expenses of Printing.

Sec. 52. All bills for the printing of notices to claimants of water in the adjudications provided for in this act shall be paid for by the county in which the stream, the appropriation of whose waters shall have been so adjudicated, is situated, the said bills to be approved by the superintendent of the water division in which the adjudication is made.

WATER COMMISSIONERS.

Districts.

Sec. 53. The board of control shall divide the State into water districts, said water districts to be so constituted as to secure the best protection to the claimants for water, and the most economical supervision on the part of the State. Said water districts shall not be created until a necessity therefor shall arise, but shall be created from time to time as the appropriations and priorities thereof, from the streams of the State, shall be adjudicated.

Commissioners, how appointed.

Sec. 54. For each water district created under this act, there shall be appointed one commissioner, who shall be a resident of the district in which he is to serve and who shall be appointed by the Governor, to be selected by him from persons recommended to him by the superintendent of the water division in which such water district is situated. Each commissioner shall hold his office four years and until his successor is appointed and has qualified. The Governor shall, by like selection and appointment, fill all vacancies which may occur in the office of water commissioner, and may at any time remove any water commisisoner for failure to perform his duties as such water commissioner, upon complaint in that respect being made to him in writing.

Duties. Penalties for interference. Power to arrest.

Sec. 55. It shall be the duty of said water commissioner to divide the water in the natural stream or streams in his district among the several ditches taking water therefrom, according to the prior rights of each, respectively, in whole or in part, and to shut and to fasten, or cause to be shut and fastened, under the direction of the superintendent of his water division, the headgates of ditches heading in any of the natural streams of the district, when, in times of scarcity of water, it is necessary so to do by reason of priority of the rights of others taking water from the same stream, or its tributaries.

Every person who shall wilfully open, close, change or interfere with any headgate or water box without authority, shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined a sum not exceeding one hundred dollars, or be imprisoned in the county jail for a term not to exceed six months, or be punished by both such fine and imprisonment. The water commissioners or their assistants, within their districts, shall have the power to arrest any person or persons offending and turn them over to the sheriff of the proper county, and immediately upon delivering any such person so arrested into the custody of the sheriff, it shall be the duty of the water commissioner making such arrest to immediately, in writing and upon oath, make complaint before the

proper justice of the peace against the person so arrested.

Water Commissioners to prevent waste water.

Sec. 56. Said water commissioners shall divide, regulate and control the use of the water of all streams within their respective districts in such manner, as near as may be, as will prevent unnecessary waste of water; and, to that end, such commissioners shall shut and fasten the headgate or gates of all ditches, so that no more water will flow into said ditches than is actually required and used for the purposes for which water was appropriated. Any person who may be injured by the action of any water commissioner, or by his failure to act pursuant to this section, may resort to any court of competent jurisdiction for any relief to which he may be entitled.

Pay of commissioners.

Sec. 57. Water commissioners herein provided for shall each be entitled to pay at the rate of four dollars per day for each day he shall be actually employed in the duties of his office, to be paid by the county in which the work is performed. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and the time spent by him in the performance of his duties in each county respectively, into which his water district may extend, and he shall present a true copy thereof, verified by his oath, to the Board of County Commissioners of the county in which the work may have been done. The said Board of County Commissioners shall, upon approval thereof by the superintendent of the water division, allow the same.

Assistants.

Sec. 58. Said water commissioners shall have power, in case of emergency, to employ suitable assistants to aid him in the discharge of his duties. Such assistants shall take the same oaths as the water commissioner, and shall obey his instructions, and each shall be entitled to $2.50 per day for every day he is employed, not to exceed forty days in one year, to be paid upon certificates of the division superintendent, in the same manner as provided for the payment of the water commissioners.

When to begin work.

Sec. 59. Said water commissioners shall not begin their work until they have been called upon by two or more owners or managers of ditches, or persons controlling ditches in the several districts, by application in writing, stating that there is a necessity for the use of water; and they shall not continue performing services after the necessity therefor shall cease.

Headgates. Measuring flume. When not constructed.

Sec. 60. The appropriator of any of the public waters of the State shall maintain, to the satisfaction of the division superintendent of the district in which such appropriation is made, a substantial headgate at the point where the water is diverted, which shall be of such construction that it can be locked, and kept closed by the water commissioner; and such appropriator shall construct and maintain, when required by the division superintendent, a flume or measuring device, as near the head of such ditch as is practicable, for the purpose of assisting the water commissioner in determining the amount of water that may be diverted into said ditch from the stream. If any owner or appropriator of public waters that may have been adjudicated upon should neglect or refuse to put in such headgate, or measuring device, after thirty days' notice to do so by the division superintendent, the said superintendent may notify the County Commissioners of the county where such headgate, flume or measuring device should be situated, and it shall be the duty of said County Commissioners, when so notified by said division superintendent, to put in such headgate, flume or measuring device at the expense of the county where the expense is incurred, and present a bill of cost to the owner or owners of the ditch. If such owner or owners shall refuse or neglect, for three days after the presentation of such bill of costs, to pay the same, the said costs shall be made a charge upon the said ditch and shall be collected as delinquent taxes, and be subject to the same conditions and penalties as other delinquent taxes; and until the full and complete payment of such bill of costs, it shall be the duty of the water commissioner of the district in which such ditch is situated to close and

keep closed the headgate of such ditch, and to take such needful steps as will prevent any water from being diverted therein from the source of supply.

Pending cases, procedure in.

Sec. 61. All cases relating to the adjudication of priorities of rights to the use of water for beneficial purposes, in any of the water districts of this State, now pending in any of the District Courts of the State, excepting such cases which may have been, by any such courts by order, referred to the board of control, may remain in said courts, and said courts shall proceed with the adjudition thereof in accordance with the laws in force at the time of the inception of such cases; provided, that said court, or judge thereof in vacation, may, in its discretion, on the application of the parties interested, transfer any such case for adjudication to the board of control. All such cases which may be, in the manner aforesaid, referred by any District Court to the board of control, shall be transferred at once, on passage of this act, together with all the testimony heretofore taken in said cases, and with all the papers and pleadings relative thereto, and a copy of all journal entries made in the case by the clerk of such District Court, into the custody of the division superintendent of the division in which said adjudication may have been begun. Said division superintendent shall, as soon as possible, complete the taking of such testimony, and it shall be the duty of the board of control to first determine the rights of the parties on those streams where such determination has begun, and is unfinished at the time of the passage of this act.

Dams to be approved.

Sec. 62. Duplicate plans and specifications for any dam across the channel of a running stream, above five feet in height, or of any other dam intended to retain water, above ten feet in height, shall be submitted to the state engineer for his approval, and it shall be unlawful to construct such dam until the said plans and specifications have been approved.

The state engineer shall have authority to examine and inspect, during construction, any dam authorized

Should any person or persons residing on or owning land in the neighborhood of any irrigation works after completion, or in course of construction, apply to the state engineer in writing desiring an inspection of such works, the state engineer may order an inspection thereof. Before doing so, he may require the applicant for such inspection to make a deposit of a sum of money sufficient to pay the expenses of an inspection, and in case the application appears to him not to have been justified, he may cause the whole, or part, of such expense to be paid out of such deposit. In case the application appears to the state engineer to have been justified he may require the company to pay the whole, or any part, of the expense of the inspection, and the same may be collected in the same manner as is provided for the collection of the expenses of constructing headgates and measuring flumes.

Storage Reservoirs. Reclamation of mingled waters.

Sec. 63. Every water right filing for reservoir purposes shall state the purpose, give the capacity of the proposed reservoir, and designate the months of the year during which water will be impounded. Said appropriations for reservoir purposes shall be filed in the office of the state engineer, who shall keep a record of all such rights separate and apart from the record of rights to the direct use of water from the natural flow of streams. As between appropriations for storage, the first in time shall be the first in right; but stored rights shall be inferior to rights to water for direct application to beneficial uses, whether they be for irrigation, domestic, municipal, or mining purposes.

The first users of water from a storage reservoir shall have preference over others. In no case shall reservoir owners be allowed to sell water to new customers, when the supply is sufficient only for the old customers; in other words, the oldest customers shall have the first rights to the use of the water, provided they promptly pay the agreed rates charged for it. In case of disagreement between customers and reservoir owners as to said rates, the matter shall be submitted to three arbitrators, one to be chosen by the water users, another by the reservoir owners, and the third by the state engineer. The

rate charged for stored water shall be determined by the arbitrators on the basis of the cost of constructing and maintaining the reservoir and canals; in other words, the rate shall be so fixed as to insure to the reservoir owners a fair interest on the money invested in the works.

A dam may be constructed across the bed of any natural stream and the stored waters mingled with the natural flow of the stream, or the stored water may be turned into the channel of another stream or reservoir, and then be reclaimed; but, in reclaiming it, water already appropriated by another must not be diminished in quantity or deteriorated in quality. The owners of such reclaimed water shall construct and maintain, under the direction of the state engineer, accurate means of measuring the water, at both the point of turning in and the point of reclamation. Before the stored water is turned into a natural stream, the water commissioner shall be notified, and he shall measure the volume turned in and supervise distribution to those entitled to its use, giving them the amount turned in less the loss by seepage and evaporation in transit.

Fees to be charged by State Engineer.

Sec. 64. The state engineer shall receive the following fees, which he shall collect in advance and pay into the State Treasury, as by this act provided:

For filing and examining applications for permits to appropriate water, and maps of the same, two dollars.

For recording any water right instrument, not specified above, one dollar for the first one hundred words, and for each subsequent folio, fifteen cents.

For issuing certificates of appropriation, one dollar.

For making certified copies of any document recorded or filed in the engineer's office, per folio, fifteen cents, and for each certificate attached thereto, one dollar.

For examining and approving plans and specifications for any dam, ten dollars; and if necessary to inspect the site where the dam is to be built, an additional charge of ten dollars per day and expenses shall be made.

Fees to be turned into Treasury.

Sec. 65. All moneys received by the state engineer

in accordance with Section 64 of this act, shall be paid by him into the State Treasury on the first Monday of January, April, July and October, respectively. It shall be credited to the contingent fund of the state engineer's office and shall be available, and is hereby appropriated, for the payment of salaries for clerical assistance in said office. Such salaries shall shall be paid by the State Treasurer upon warrants drawn by the State Auditor and approved by the state engineer.

Fees of Board of Control.

Sec. 66. The secretary of the board of control shall collect the following fees, which shall be paid in advance and turned over to the State Treasurer and by him credited to the per diem fund of the board of control:

For making certified transcripts of the records of the board of control or of papers or documents filed with said board, one dollar for the first folio, and for each subsequent folio, fifteen cents.

For attaching certificate and seal of the board to each transcript, one dollar.

Repealing clause.

Sec. 67. Chapter 8, Title 63, Revised Statutes of Utah, 1898, and all acts and parts of acts in conflict with this act are hereby repealed.

APPENDIX B.

STATE ENGINEER'S OFFICE,
SALT LAKE CITY, UTAH.

CIPPOLETTI'S TRAPEZOIDAL WEIR TABLE.

Soon after the publication of the Special Instructions to Watermasters by this office, it was discovered that the table giving discharges of trapezoidal weirs was not only incomplete, but also incorrect, some serious errors having crept in through carelessness in proof reading and printing. It was therefore though best to calculate a new and complete table of discharges of trapezoidal weirs, and this has been done for lengths of weir from 1 to 20 ft., and for heads of water from 0.01 ft. to 3.0 ft.

The following table is computed by the formula $Q = 3.3\frac{3}{8} L H^{\frac{3}{2}}$, Q being the discharge in cubic feet per second, L the length of the weir in feet, and H the head on crest in feet, measured to still water. This table is to be used for obtaining the discharge over Cippoletti's trapezoidal weirs; for rectangular weirs without end contractions, it gives discharges about 1 per cent too great.

Example: What is the discharge over a weir $7\frac{1}{2}$ feet long under a head of $9\frac{3}{8}$ inches? Under column headed "$7\frac{1}{2}$ Feet Long," on page 63, find the discharge corresponding to the head, H, of $9\frac{3}{8}$ inches, which is 17.3942 cubic feet per second.

ROBERT C. GEMMELL,
State Engineer.

Salt Lake City, Utah, December, 1900.

DISCHARGE OVER CIPPOLETTI'S TRAPEZOIDAL WEIR OF VARIOUS LENGTHS AND WITH VARIOUS DEPTHS.

Formula: $D = 3.3\frac{2}{3}\ L\ H^{\frac{3}{2}}$

HEAD H, on crest. Measured to still water.		DISCHARGE IN CUBIC FEET PER SECOND.														HEAD H, on crest. Measured to still water.	
In Inches (Approx.)	In Feet.	1 Foot Long.	1½ Feet Long.	2 Feet Long.	2½ Feet Long.	3 Feet Long.	3½ Feet Long.	4 Feet Long.	5 Feet Long.	7½ Feet Long.	10 Feet Long.	12½ Ft. Long.	15 Feet Long.	18 Feet Long.	20 Feet Long.	In Feet.	In Inches (Approx.)
1-8	0.01	.0033	.0050	.0066	.0083	.0099	.0115	.0132	.0165	.0248	.0330	.0413	.0495	.0594	.0660	0.01	1-8
2-8	0.02	.0095	.0143	.0190	.0237	.0285	.0333	.0380	.0475	.0713	.0950	.1188	.1425	.1710	.1900	0.02	2-8
3-8	0.03	.0175	.0263	.0350	.0438	.0525	.0613	.0700	.0875	.1313	.1750	.2188	.2625	.3150	.3500	0.03	3-8
4-8	0.04	.0269	.0404	.0538	.0673	.0807	.0942	.1076	.1345	.2018	.2690	.3363	.4035	.4842	.5380	0.04	4-8
5-8	0.05	.0376	.0564	.0753	.0941	.1129	.1317	.1505	.1881	.2822	.3763	.4704	.5644	.6775	.7527	0.05	5-8
6-8	0.06	.0495	.0742	.0990	.1237	.1484	.1732	.1979	.2474	.3711	.4948	.6185	.7422	.8906	.9896	0.06	6-8
7-8	0.07	.0624	.0935	.1247	.1559	.1871	.2182	.2494	.3118	.4676	.6235	.7794	.9352	1.1223	1.2470	0.07	7-8
1 inch	0.08	.0762	.1143	.1524	.1905	.2285	.2666	.3047	.3809	.5713	.7618	.9523	1.1426	1.3712	1.5236	0.08	1 inch
1-8	0.09	.0909	.1364	.1818	.2273	.2727	.3182	.3636	.4545	.6818	.9090	1.1362	1.3635	1.6362	1.8180	0.09	1-8
2-8	0.10	.1065	.1597	.2129	.2662	.3194	.3726	.4258	.5323	.7985	1.0646	1.3307	1.5969	1.9163	2.1292	0.10	2-8
3-8	0.11	.1226	.1842	.2457	.3071	.3685	.4299	.4913	.6142	.9212	1.2283	1.5354	1.8424	2.2109	2.4566	0.11	3-8
4-8	0.12	.1400	.2099	.2799	.3499	.4199	.4898	.5598	.6998	1.0496	1.3995	1.7494	2.0992	2.5191	2.7990	0.12	4-8
4-8	0.13	.1578	.2367	.3156	.3945	.4734	.5523	.6312	.7890	1.1835	1.5780	1.9725	2.3670	2.8404	3.1560	0.13	4-8
5-8	0.14	.1764	.2645	.3527	.4409	.5291	.6172	.7054	.8818	1.3227	1.7635	2.2044	2.6452	3.1744	3.5270	0.14	5-8
6-8	0.15	.1956	.2934	.3912	.4890	.5867	.6845	.7823	.9779	1.4668	1.9558	2.4448	2.9337	3.5205	3.9117	0.15	6-8
7-8	0.16	.2155	.3232	.4309	.5387	.6464	.7541	.8618	1.0773	1.6160	2.1546	2.6933	3.2319	3.8784	4.3093	0.16	7-8
2 inches	0.17	.2360	.3539	.4719	.5899	.7079	.8259	.9438	1.1798	1.7697	2.3596	2.9495	3.5394	4.2473	4.7192	0.17	2 inches
1-8	0.18	.2571	.3856	.5141	.6426	.7711	.8997	1.0282	1.2853	1.9289	2.5705	3.2131	3.8578	4.6269	5.1410	0.18	1-8
2-8	0.19	.2788	.4182	.5576	.6971	.8365	.9759	1.1153	1.3941	2.0912	2.7882	3.4852	4.1823	5.0189	5.5765	0.19	2-8
3-8	0.20	.3011	.4517	.6022	.7528	.9034	1.0539	1.2045	1.5056	2.2584	3.0112	3.7640	4.5168	5.4202	6.0224	0.20	3-8
4-8	0.21	.3240	.4860	.6479	.8099	.9719	1.1339	1.2959	1.6199	2.4298	3.2397	4.0496	4.8596	5.8314	6.4794	0.21	4-8
5-8	0.22	.3474	.5211	.6948	.8685	1.0422	1.2159	1.3896	1.7370	2.6055	3.4740	4.3425	5.2110	6.2533	6.9481	0.22	5-8
6-8	0.23	.3714	.5570	.7427	.9284	1.1141	1.2997	1.4854	1.8568	2.7851	3.7135	4.6419	5.5702	6.6844	7.4271	0.23	6-8
7-8	0.24	.3958	.5937	.7917	.9896	1.1875	1.3854	1.5833	1.9792	2.9687	3.9583	4.9479	5.9374	7.1250	7.9166	0.24	7-8
3 inches	0.25	.4208	.6312	.8417	1.0521	1.2625	1.4729	1.6833	2.1042	3.1562	4.2083	5.2604	6.3124	7.5750	8.4167	0.25	3 inches
1-8	0.26	.4463	.6695	.8927	1.1158	1.3390	1.5622	1.7853	2.2317	3.3475	4.4633	5.5791	6.6950	8.0340	8.9267	0.26	1-8
2-8	0.27	.4723	.7085	.9447	1.1808	1.4170	1.6532	1.8893	2.3617	3.5425	4.7233	5.9041	7.0850	8.5019	9.4466	0.27	2-8
3-8	0.28	.4988	.7482	.9976	1.2470	1.4964	1.7458	1.9952	2.4941	3.7411	4.9881	6.2351	7.4822	8.9786	9.9762	0.28	3-8
4-8	0.29	.5258	.7887	1.0515	1.3144	1.5773	1.8402	2.1031	2.6289	3.9433	5.2577	6.5721	7.8866	9.4639	10.5154	0.29	4-8
5-8	0.30	.5532	.8298	1.1064	1.3830	1.6596	1.9362	2.2128	2.7660	4.1490	5.5320	6.9150	8.2980	9.9577	11.0641	0.30	5-8

Discharge over Cippoletti's Trapezoidal Weirs—continued.

HEAD, H. On Crest. Measured to still water.		DISCHARGE IN CUBIC FEET PER SECOND.													HEAD, H. On Crest. Measured to still water.	
In Inches. (Approx.)	In Feet.	1½ Feet Long.	2 Feet Long.	2½ Feet Long.	3 Feet Long.	3½ Feet Long.	4 Feet Long.	5 Feet Long	7½ Feet Long.	10 Feet Long.	12½ Feet Long.	15 Feet Long.	18 Feet Long.	20 Feet Long.	In Feet.	In Inches. (Approx.)
6-8	0.31	.8716	1.1622	1.4527	1.7433	2.0338	2.3244	2.9055	4.3582	5.8109	7.2636	8.7164	10.4600	11.6218	0.31	6-8
7-8	0.32	.9142	1.2189	1.5236	1.8283	2.1330	2.4378	3.0472	4.5708	6.0944	7.6180	9.1416	10.9699	12.1888	0.32	7-8
4 inches	0.33	.9573	1.2765	1.5956	1.9147	2.2338	2.5529	3.1912	4.7867	6.3823	7.9779	9.5734	11.4880	12.7647	0.33	4 inches
1-8	0.34	1.0012	1.3349	1.6687	2.0024	2.3361	2.6698	3.3373	5.0060	6.6746	8.3433	10.0119	12.0144	13.3493	0.34	1-8
2-8	0.35	1.0457	1.3942	1.7428	2.0913	2.4399	2.7884	3.4856	5.2283	6.9711	8.7139	10.4566	12.5480	13.9422	0.35	2-8
3-8	0.36	1.0908	1.4544	1.8180	2.1816	2.5452	2.9088	3.6360	5.4540	7.2720	9.0900	10.9080	13.0897	14.5441	0.36	3-8
4-8	0.37	1.1366	1.5154	1.8943	2.2731	2.6520	3.0308	3.7886	5.6828	7.5771	9.4714	11.3656	13.6388	15.1542	0.37	4-8
4-8	0.38	1.1829	1.5772	1.9715	2.3658	2.7601	3.1544	3.9431	5.9146	7.8861	9.8577	11.8292	14.1951	15.7723	0.38	4-8
5-8	0.39	1.2300	1.6399	2.0499	2.4599	2.8699	3.2799	4.0999	6.1498	8.1997	10.2496	12.2996	14.7595	16.3994	0.39	5-8
6-8	0.40	1.2776	1.7034	2.1293	2.5551	2.9810	3.4068	4.2586	6.3878	8.5171	10.6464	12.7756	15.3308	17.0342	0.40	6-8
7-8	0.41	1.3258	1.7677	2.2096	2.6515	3.0934	3.5354	4.4192	6.6288	8.8384	11.0480	13.2576	15.9092	17.6768	0.41	7-8
5 inches	0.42	1.3746	1.8328	2.2910	2.7492	3.2074	3.6656	4.5821	6.8731	9.1641	11.4551	13.7462	16.4955	18.3283	0.42	5 inches
1-8	0.43	1.4239	1.8986	2.3732	2.8479	3.3225	3.7972	4.7465	7.1197	9.4929	11.8661	14.2394	17.0874	18.9859	0.43	1-8
2-8	0.44	1.4739	1.9652	2.4565	2.9478	3.4391	3.9304	4.9130	7.3694	9.8259	12.2824	14.7388	17.6866	19.6519	0.44	2-8
3-8	0.45	1.5244	2.0326	2.5497	3.0489	3.5570	4.0652	5.0815	7.6221	10.1629	12.7036	15.2444	18.2932	20.3258	0.45	3-8
4-8	0.46	1.5755	2.1007	2.6259	3.1511	3.6763	4.2014	5.2518	7.8777	10.5036	13.1295	15.7554	18.9065	21.0072	0.46	4-8
5-8	0.47	1.6272	2.1696	2.7120	3.2544	3.7968	4.3392	5.4240	8.1359	10.8479	13.5599	16.2718	19.5263	21.6969	0.47	5-8
6-8	0.48	1.6794	2.2392	2.7990	3.3588	3.9186	4.4784	5.5980	8.3970	11.1960	13.9950	16.7940	20.1528	22.3920	0.48	6-7
7-8	0.49	1.7321	2.3095	2.8869	3.4643	4.0417	4.6190	5.7738	8.6607	11.5476	14.4345	17.3214	20.7858	23.0953	0 49	7-8
6 inches	0.50	1.7855	2.3806	2.9758	3.5709	4.1661	4.7612	5.9515	8.9272	11.9030	14.8787	17.8545	21.4254	23.8060	0.50	6 inches
1-8	0.51	1.8393	2.4524	3.0655	3.6785	4.2916	4.9047	6.1309	9.1963	12.2618	15.3273	18.3927	22.0713	24.5237	0.51	1-8
2-8	0 52	1.8937	2.5249	3.1561	3.7873	4.4185	5.0498	6.3122	9.4683	12.6244	15.7805	18.9366	22.7239	25.2488	0.52	2-8
3-8	0.53	1.9485	2.5980	3.2475	3.8970	4.5465	5.1960	6.4951	9.7426	12.9901	16.2376	19.4852	23.3823	25.9803	0.53	3-8
4-8	0.54	2.0039	2.6719	3.3399	4.0078	4.6758	5.3438	6.6797	10.0196	13.3594	16.6993	20.0391	24.0472	26.7190	0.54	4-8
5-8	0.55	2.0598	2.7465	3.4331	4.1197	4.8063	5.4929	6.8662	10.2992	13.7323	17.1654	20.5984	24.7182	27.4647	0.55	5-8
6-8	0.56	2.1163	2.8217	3.5271	4.2326	4.9380	5.6434	7.0543	10.5814	14.1085	17.6356	21.1628	25.3953	28.2170	0.56	6-8
7-8	0.57	2.1732	2.8976	3.6220	4.3464	5.0708	5.7952	7.2441	10.8661	14.4881	18.1101	21.7322	26.0787	28.9763	0.57	7-8
7 inches	0.58	2.2307	2.9742	3.7178	4.4613	5.2049	5.9484	7.4355	11.1532	14.8710	18.5888	22.3065	26.7679	29.7421	0.58	7 inches
1-8	0.59	2.2886	3.0515	3.8143	4.5772	5.3401	6.1029	7.6287	11.4430	15.2573	19.0717	22.8860	27.4632	30 5147	0.59	1-8
2-8	0.60	2.3470	3.1294	3.9117	4.6940	5.4764	6.258[illegible]	7.8234	11.7351	15.6468	19.5585	23.4702	28.1643	31.2937	0.60	2-8

Discharge over Cippoletti's Trapezoidal Weirs—continued.

HEAD, H, on Crest, Measured to Still Water.		DISCHARGE IN CUBIC FEET PER SECOND.												HEAD, H, on Crest, Measured to Still Water.	
In Inches. (Approx.)	In Feet.	2 Feet Long.	2½ Feet Long.	3 Feet Long.	3½ Feet Long.	4 Feet Long.	5 Feet Long.	7½ Feet Long.	10 Feet Long.	12½ Feet Long.	15 Feet Long.	18 Feet Long.	20 Feet Long.	In Feet.	In Inches. (Approx.)
3-8	0.61	3.2079	4.0099	4.8119	5.6138	6.4158	8.0198	12.0296	16.0395	20.0494	24.0592	28.8712	32.0791	0.61	3-8
4-8	0.62	3.2871	4.1089	4.9307	5.7525	6.5743	8.2179	12.3268	16.4357	20.5446	24.6536	29.5843	32.8714	0.62	4-8
4-8	0.63	3.3670	4.2087	5.0505	5.8922	6.7340	8.4175	12.6262	16.8349	21.0436	25.2524	30.3029	33.6699	0.63	4-8
5-7	0.64	3.4475	4.3093	5.1712	6.0331	6.8949	8.6187	12.9280	17.2373	21.5466	25.8560	31.0272	34.4747	0.64	5-8
6-8	0.65	3.5286	4.4107	5.2928	6.1750	7.0571	8.8214	13.2322	17.6428	22.0536	26.4642	31.7572	35.2858	0.65	6-8
7-8	0.66	3.6103	4.5129	5.4155	6.3181	7.2206	9.0258	13.5387	18.0516	22.5645	27.0774	32.4929	36.1032	0.66	7-8
8 inches	0.67	3.6927	4.6159	5.5390	6.4622	7.3854	9.2317	13.8476	18.4634	23.0793	27.6951	33.2342	36.9269	0.67	8 inches
1-8	0.68	3.7757	4.7196	5.6635	6.6074	7.5513	9.4392	14.1587	18.8783	23.5979	28.3174	33.9810	37.7566	0.68	1-8
2-8	0.69	3.8593	4.8241	5.7889	6.7537	7.7185	9.6482	14.4722	19.2963	24.1204	28.9444	34.7333	38.5926	0.69	2-8
3-8	0.70	3.9435	4.9293	5.9152	6.9011	7.8869	9.8587	14.7880	19.7173	24.6466	29.5760	35.4911	39.4346	0.70	3-8
4-8	0.71	4.0282	5.0353	6.0424	7.0494	8.0565	10.0706	15.1059	20.1412	25.1766	30.2118	36.2543	40.2825	0.71	4-8
5-8	0.72	4.1137	5.1421	6.1705	7.1989	8.2273	10.2842	15.4262	20.5683	25.7104	30.8524	37.0230	41.1367	0.72	5-8
6-8	0.73	4.1997	5.2496	6.2995	7.3494	8.3993	10.4992	15.7487	20.9983	26.2479	31.4974	37.7970	41.9967	0.73	6-8
7-8	0.74	4.2862	5.3578	6.4294	7.5009	8.5725	10.7156	16.0734	21.4312	26.7890	32.1468	38.5763	42.8625	0.74	7-8
9 inches	0.75	4.3734	5.4668	6.5601	7.6535	8.7468	10.9336	16.4003	21.8671	27.3339	32.8006	39.3608	43.7342	0.75	9 inches
1-8	0.76	4.4612	5.5765	6.6918	7.8071	8.9224	11.1530	16.7295	22.3060	27.8825	33.4590	40.1508	44.6120	0.76	1-8
2-8	0.77	4.5495	5.6869	6.8243	7.9617	9.0990	11.3738	17.0607	22.7476	28.4345	34.1214	40.9457	45.4952	0.77	2-8
3-8	0.78	4.6384	5.7981	6.9577	8.1173	9.2769	11.5961	17.3942	23.1922	28.9903	34.7883	41.7461	46.3845	0.78	3-8
4-8	0.79	4.7279	5.9099	7.0919	8.2739	9.4558	11.8198	17.7297	23.6396	29.5495	35.4594	42.5513	47.2792	0.79	4-8
5-8	0.80	4.8180	6.0225	7.2270	8.4315	9.6360	12.0450	18.0674	24.0899	30.1124	36.1348	43.3619	48.1799	0.80	5-8
6-8	0.81	4.9086	6.1358	7.3629	8.5901	9.8172	12.2716	18.4073	24.5431	30.6789	36.8146	44.1776	49.0862	0.81	6-8
7-8	0.82	4.9998	6.2497	7.4997	8.7496	9.9996	12.4995	18.7492	24.9989	31.2486	37.4984	44.9980	49.9978	0.82	7-8
10 inches	0.83	5.0915	6.3644	7.6373	8.9101	10.1830	12.7288	19.0931	25.4575	31.8219	38.1862	45.8236	50.9151	0.83	10 inches
1-8	0.84	5.1838	6.4798	7.7757	9.0717	10.3676	12.9595	19.4392	25.9190	32.3988	38.8785	46.6542	51.8380	0.84	1-8
2-8	0.85	5.2766	6.5958	7.9150	9.2341	10.5533	13.1916	19.7874	26.3832	32.9790	39.5748	47.4898	52.7664	0.85	2-8
3-8	0.86	5.3700	6.7126	8.0551	9.3975	10.7401	13.4251	20.1377	26.8502	33.5628	40.2753	48.3304	53.7004	0.86	3-8
4-8	0.87	5.4640	6.8300	8.1960	9.5620	10.9280	13.6600	20.4899	27.3199	34.1499	40.9708	49.1758	54.6398	0.87	4-8
4-8	0.88	5.5585	6.9481	8.3377	9.7273	11.1169	13.8962	20.8442	27.7923	34.7404	41.6884	50.0262	55.5846	0.88	4-8
5-8	0.89	5.6535	7.0669	8.4802	9.8936	11.3070	14.1337	21.2005	28.2674	35.3343	42.4011	50.8812	56.5348	0.89	5-8
6-8	0.90	5.7490	7.1863	8.6236	10.0608	11.4981	14.3726	21.5589	28.7452	35.9315	43.1178	51.7414	57.4904	0.90	6-8

Discharge over Cippoletti's Trapezoidal Weirs—continued.

HEAD, H, on crest, Measured to still water.		DISCHARGE IN CUBIC FEET PER SECOND.											HEAD, H, on crest, Measured to still water.	
In Inches. (Approx).	In Feet.	2½ Feet Long.	3 Feet Long.	3½ Feet Long.	4 Feet Long	5 Feet Long.	7½ Feet Long:	10 Feet Long.	12½ Feet Long.	15 Feet Long	18 Feet Long.	20 Feet Long.	In Feet.	In Inches. (Approx.)
7-8	0.91	7.3064	8.7677	10.2289	11.6902	14.6128	21.9191	29.2255	36.5319	43.8382	52.6059	58.4510	0.91	7-8
11 inches	0.92	7.4272	8.9126	10.3980	11.8834	14.8543	22.2815	29.7086	37.1358	44.5629	53 4756	59.4173	0.92	11 inches
1-8	0.93	7.5486	9.0583	10.5680	12.0777	15.0972	22.6457	30.1943	37.7429	45.2915	54.3497	60.3886	0.93	1-8
2-8	0.94	7.6707	9.2048	10.7389	12.2730	15.3413	23.0120	30.6826	38.3533	46.0239	55.2288	61 3653	0.94	2-8
3-8	0.95	7.7933	9.3520	10.9106	12.4693	15.5866	23.3799	31.1732	38.9665	46.7598	56.1118	62.3464	0.95	3-8
4-8	0.96	7.9168	9.5001	11.0835	12.6668	15.8335	23.7503	31.6670	39.5838	47.5005	57.0006	63.3340	0.96	4-8
5-8	0.97	8.0408	9.6489	11.2571	12.8652	16.0816	24.1223	32.1631	40.2039	48.2446	57.8936	64.3262	0.97	5-8
6-8	0.98	8.1654	9.7985	11.4316	13.0647	16.3309	24.4963	32.6617	40.8272	48.9926	58.7912	65.3235	0.98	6-8
7-8	0.99	8 2907	9.9488	11.6070	13.2651	16.5814	24.8722	33.1628	41.4536	49.7442	59.6932	66.3258	0.99	7-8
12 inches	1.00	8.4167	10.1000	11.7834	13.4667	16.8334	25.2500	33.6667	42.0833	50.5000	60.6000	67.3333	1.00	12 inches
1-8	1.01	8.5432	10.2519	11.9605	13.6692	17.0865	25.6297	34.1729	42.7161	51 2594	61.5112	68.3458	1.01	1-8
2-8	1.02	8.6704	10.4045	12.1386	13.8727	17.3409	26.0113	34.6817	43.3521	52.0226	62.4271	69.3634	1.02	2-8
3-8	1.03	8.7982	10.5579	12.3175	14.0772	17.5965	26.3947	35.1929	43.9911	52.7894	63.3474	70.3859	1.03	3-8
4-8	1.04	8.9267	10.7120	12.4974	14.2827	17.8534	26.7801	35.7068	44.6335	53.5602	64.2722	71.4136	1.04	4-8
5-8	1.05	9.0558	10.8669	12.6781	14.4892	18.1115	27.1673	36.2230	45.2788	54.3345	65.2013	72.4460	1.05	5-8
6-8	1.06	9.1854	11.0225	12.8596	14.6967	18.3708	27.5563	36.7417	45.9271	55.1126	66.1350	73.4834	1.06	6-8
7-8	1.07	9.3157	11.1789	13.0420	14.9052	18.6315	27.9472	37.2629	46.5786	55.8944	67.0732	74.5258	1.07	7-8
13 inches	1.08	9.4466	11.3359	13.2252	15.1146	18.8932	28.3398	37.7864	47.2330	56.6796	68.0155	75.5728	1.08	13 inches
1-8	1.09	9.5781	11.4937	13.4093	15.3250	19.1562	28.7343	38.3124	47.8905	57.4686	68.9624	76.6248	1.09	1-8
2-8	1.10	9.7102	11.6523	13.5943	15.5364	19.4205	29.1307	38.8409	48.5511	58.2614	69.9138	77.6819	1.10	2-8
3-8	1.11	9.8430	11.8115	13.7801	15.7487	19.6859	29.5288	39.3718	49.2148	59.0577	70.8692	78 7436	1.11	3-8
4-8	1.12	9.9762	11.9715	13.9667	15.9620	19.9525	29.9287	39.9049	49.8811	59.8574	71.8290	79.8099	1.12	4-8
4-8	1.13	10.1102	12.1322	14.1542	16.1762	20.2203	30.3305	40.4406	50.5508	60.6609	72.7931	80.8812	1.13	4-8
5-8	1.14	10.2447	12.2936	14.3425	16.3914	20.4893	30.7339	40.9786	51.2233	61.4679	73.7616	81.9572	1.14	5-8
6-8	1.15	10.3798	12.4557	14.5317	16.6076	20.7595	31.1392	41.5190	51.8988	62.2785	74.7343	83.0380	1.15	6-8
7-8	1.16	10.5155	12.6186	14.7217	16.8248	21.0310	31.5464	42.0619	52.5774	63.0928	75.7113	84.1238	1.16	7-8
14 inches	1.17	10.6517	12.7820	14.9124	17.0427	21.3034	31.9551	42.6068	53.2585	63.9102	76.6923	85.2136	1.17	14 inches
1-8	1.18	10.7886	12.9463	15.1040	17.2617	21.5771	32.3656	43.1542	53.9428	64.7313	77.6776	86.3084	1.18	1-8
2-8	1.19	10.9260	13.1112	15.2964	17.4816	21.8520	32.7780	43.7040	54.6300	65.5560	78.6672	87.4080	1.19	2-8
3-8	1.20	11.0640	13.2768	15.4896	17.7024	22.1280	33.1920	44.2560	55.3200	66.3840	79.6607	88.5120	1.20	3-8

Discharge over Cippoletti's Trapezoidal Weirs—continued.

HEAD, H, on crest, Measured to still water.		DISCHARGE IN CUBIC FEET PER SECOND.										HEAD, H, on crest, Measured to still water.	
In Inches. (Approx.)	In Feet.	3 Feet Long.	3½ Feet Long.	4 Feet Long.	5 Feet Long.	7½ Feet Long.	10 Feet Long.	12½ Feet Long.	15 Feet Long.	18 Feet Long.	20 Feet Long.	In Feet.	In Inches. (Approx.)
4-8	1.21	13.4431	15.6836	17.9241	22.4052	33.6077	44.8103	56.0129	67.2154	80.6586	89.6206	1.21	4-8
5-8	1.22	13.6101	15.8785	18.1468	22.6835	34.0253	45.3670	56.7088	68.0505	81.6607	90.7341	1.22	5-8
6-8	1.23	13.7778	16.0741	18.3704	22.9630	34.4445	45.9259	57.4074	68.8889	82.6668	91.8519	1.23	6-8
7-8	1.24	13.9462	16.2705	18.5949	23.2436	34.8654	46.4872	58.1090	69.7308	83.6769	92.9744	1.24	7-8
15 inches	1.25	14.1152	16.4677	18.8202	23.5253	35.2879	47.0506	58.8133	70.5759	84.6912	94.1012	1.25	15 inches
1-8	1.26	14.2849	16.6657	19.0466	23.8082	35.7123	47.6164	59.5205	71.4246	85.7097	95.2329	1.26	1-8
2-8	1.27	14.4553	16.8645	19.2738	24.0922	36.1383	48.1844	60.2305	72.2766	86.7360	96.3689	1.27	2-8
3-8	1.28	14.6264	17.0641	19.5018	24.3773	36.5660	48.7546	60.9433	73.1319	87.7584	97.5093	1.28	3-8
4-8	1.29	14.7981	17.2645	19.7308	24.6635	36.9953	49.3271	61.6589	73.9906	88.7888	98.6542	1.29	4-8
5-8	1.30	14.9705	17.4656	19.9606	24.9508	37.4262	49.9016	62.3770	74.8524	89.8230	99.8032	1.30	5-8
6-8	1.31	15.1436	17.6675	20.1914	25.2393	37.8589	50.4785	63.0981	75.7178	90.8614	100.9571	1.31	6-8
7-8	1.32	15.3173	17.8702	20.4231	25.5289	38.2933	51.0577	63.8221	76.5866	91.9039	102.1154	1.32	7-8
16 inches	1.33	15.4917	18.0737	20.6556	25.8196	38.7293	51.6391	64.5489	77.4586	92.9505	103.2783	1.23	16 inches
1-8	1.34	15.6668	18.2779	20.8890	26.1113	39.1669	52.2225	65.2781	78.3338	94.0005	104.4451	1.34	1-8
2-8	1.35	15.8425	18.4829	21.1233	26.4041	39.6061	52.8082	66.0102	79.2123	95.0548	105.6163	1.35	2-8
3-8	1.36	16.0188	18.6886	21.3584	26.6980	40.0469	53.3959	66.7449	80.0938	96.1128	106.7918	1.36	3-8
4-8	1.37	16.1958	18.8951	21.5944	26.9931	40.4896	53.9861	67.4826	80.9792	97.1750	107.9722	1.37	4-8
4-8	1.38	16.3735	19.1024	21.8314	27.2892	40.9338	54.5784	68.2230	81.8676	98.2480	109.1567	1.38	4-8
5-8	1.39	16.5518	19.3104	22.0690	27.5863	41.3794	55.1725	68.9656	82.7588	99.3104	110.3450	1.39	5-8
6-8	1.40	16.7307	19.5191	22.3076	27.8845	41.8267	55.7689	69.7111	83.6534	100.3840	111.5378	1.40	6-8
7-8	1.41	16.9103	19.7287	22.5470	28.1838	42.2757	56.3676	70.4595	84.5514	101.4615	112.7351	1.41	7-8
17 inches	1.42	17.0905	19.9389	22.7873	28.4842	42.7262	56.9683	71.2104	85.4524	102.5428	113.9366	1.42	17 inches
1-8	1.43	17.2713	20.1499	23.0284	28.7856	43.1783	57.5711	71.9639	86.3566	103.6279	115.1421	1.43	1-8
2-8	1.44	17.4528	20 3616	23.2704	29.0880	43.6320	58.1760	72.7200	87.2640	104.7168	116.3520	1.44	2-8
3-8	1.45	17.6349	20.5741	23.5132	29.3916	44.0873	58.7831	73.4789	88.1746	105.8095	117.5661	1.45	3-8
4-8	1.46	17.8177	20.7873	23.7569	29.6961	44.5441	59.3922	74.2402	89.0883	106.9060	118.7844	1.46	4-8
5-8	1.47	18.0011	21.0012	24.0014	30.0018	45.0026	60.0035	75.0044	90.0052	108.0062	120.0069	1.47	5-8
6-8	1.48	18.1850	21.2159	24.2467	30.3084	45.4625	60.6167	75.7709	90.9250	109.1101	121.2335	1.48	6 8
7-8	1.49	18.3697	21.4313	24.4929	30.6161	45.9241	61.2322	76.5102	91.8483	110.2179	122.4643	1.49	7-8
18 inches	1.50	18.5549	21.6474	24.7398	30.9248	46.3872	61.8496	77.3120	92.7744	111.3293	123.6993	1.50	18 inches

Discharge over Cippoletti's Trapezoidal Weirs.—(Continued.)

HEAD H, on crest. Measured to still water.		DISCHARGE IN CUBIC FEET PER SECOND.									HEAD H, on crest. Measured to still water.	
In Inches. (Approx.)	In Feet.	3½ Feet Long.	4 Feet Long.	5 Feet Long.	7½ Feet Long.	10 Feet Long.	12½ Feet Long.	15 Feet Long.	18 Feet Long.	20 Feet Long.	In Feet.	In Inches. (Approx.)
1-8	1.51	21.8642	24.9876	31.2346	46.8518	62.4691	78.0864	93.7036	112.4444	124.9382	1.51	1-8
2-8	1.52	22.0818	25.2363	31.5454	47.3181	63.0908	78.8635	94.6362	113.5633	126.1815	1.52	2-8
3-8	1.53	22.3000	25.4857	31.8572	47.7857	63.7143	79.6429	95.5714	114.6858	127.4266	1.53	3-8
4-8	1.54	22.5190	25.7360	32.1700	48.2550	64.3400	80.4250	96.5100	115.8120	128.6800	1.54	4-8
5-8	1.55	22.7387	25.9871	32.4839	48.7258	64.9677	81.2096	97.4516	116.9419	129.9354	1.55	5-8
6-8	1.56	22.9591	26.2390	32.7987	49.1981	65.5974	81.9968	98.3961	118.0754	131.1949	1.56	6-8
7-8	1.57	23.1802	26.4917	33.1146	49.6719	66.2292	82.7865	99.3438	119.2126	132.4584	1 57	7-8
19 inches	1.58	23.4021	26.7452	33.4315	50.1472	66.8630	83.5788	100.2945	120.3534	133.7260	1.58	19 inches
1-8	1.59	23.6246	26.9995	33.7494	50.6241	67.4988	84.3735	101.2482	121.4978	134.9975	1.59	1-8
2-8	1.60	23.8478	27.2546	34.0683	51.1024	68.1366	85.1707	102.2049	122.6458	136.2731	1.60	2-8
3-8	1.61	24.0717	27.5105	34.3882	51.5822	68.7763	85.9704	103.1644	123.7974	137.5526	1.61	3-8
4-8	1.62	24.2963	27.7672	34.7090	52.0635	69.4180	86.7725	104.1270	124.9526	138.8361	1.62	4-8
4-8	1.63	24.5217	28.0248	35.0310	52.5464	70.0619	87.5773	105.0928	126.1113	140.1237	1.63	4-8
5-8	1.64	24.7477	28.2830	35.3538	53.0307	70.7076	88.3845	106.0614	127.2736	141.4151	1.64	5-8
6-8	1.65	24.9744	28.5421	35.6777	53.5165	71.3553	89.1941	107.0330	128.4394	142.7105	1.65	6-8
7-8	1.66	25.2017	28.8020	36.0025	54.0037	72.0049	90.0061	108.0074	129.6089	144.0099	1.66	7-8
20 inches	1.67	25.4298	29.0626	36.3283	54.4924	72.6566	90.8207	108.9849	130.7818	145.3131	1.67	20 inches
1-8	1.68	25.6585	29.3240	36.6551	54.9826	73.3101	91.6376	109.9652	131.9582	146.6202	1.68	1-8
2-8	1.69	25.8880	29.5863	36.9829	55.4743	73.9657	92.4571	110.9486	133.1382	147.9313	1.69	2-8
3-8	1.70	26.1181	29.8493	37.3116	55.9674	74.6232	93.2790	111.9348	134.3216	149.2463	1.70	3-8
4-8	1.71	26.3489	30.1130	37.6413	56.4619	75.2825	94.1031	112.9238	135.5085	150.5650	1.71	4-8
5-8	1.72	26.5804	30.3776	37.9720	56.9579	75.9439	94.9299	113.9158	136.6989	151.8877	1.72	5-8
6-8	1.73	26.8125	30.6429	38.3036	57.4554	76.6072	95.7590	114.9108	137.8929	153.2143	1.73	6-8
7-8	1.74	27.0453	30.9089	38.6362	57.9542	77.2723	96.5904	115.9084	139.0902	154.5446	1.74	7-8
21 inches	1.75	27.2788	31.1758	38.9697	58.4545	77.9394	97.4243	116.9091	140.2909	155.8788	1.75	21 inches
1-8	1.76	27.5129	31.4434	39.3042	58.9563	78.6084	98.2605	117.9126	141.4952	157.2168	1.76	1-8
2-8	1.77	27.7478	31.7118	39.6397	59.4595	79.2794	99.0993	118.9191	142.7028	158.5587	1.77	2-8
3-8	1.78	27.9833	31.9809	39.9761	59.9641	79.9522	99.9402	119.9283	143.9138	159.9043	1.78	3-8
4-8	1.79	28.2194	32.2508	40.3135	60.4702	80.6269	100.7836	120.9404	145.1283	161.2541	1.79	4-8
5-8	1.80	28.4562	32.5214	40.6518	60.9776	81.3035	101.6294	121.9552	146.3462	162.6069	1.80	5-8

Discharge over Cippoletti's Trapezoidal Weirs—continued.

HEAD H, on crest. Measured to still water.		DISCHARGE IN CUBIC FEET PER SECOND.								HEAD H, on crest. Measured to still water.	
In Inches. (Approx.)	In Feet.	4 Feet Long.	5 Feet Long.	7½ Feet Long.	10 Feet Long.	12½ Feet Long.	15 Feet Long.	18 Feet Long.	20 Feet Long.	In Feet.	In Inches. (Approx.)
6-8	1.81	32.7928	40.9910	61.4864	81.9819	102.4774	122.9728	147.5674	163.9638	1.81	6-8
7-8	1.82	33.0649	41.3312	61.9967	82.6623	103.3279	123.9934	148.7921	165.3245	1.82	7-8
22 inches	1.83	33.3378	41.6723	62.5083	83.3445	104.1806	125.0167	150.0200	166.6889	1.83	22 inches
1-8	1.84	33.6114	42.0143	63.0214	84.0286	105.0357	126.0429	151.2514	168.0571	1.84	1-8
2-8	1.85	33.8858	42.3573	63.5359	84.7145	105.8931	127.0718	152.4860	169.4290	1.85	2-8
3-8	1.86	34.1609	42.7012	64.0517	85.4023	106.7529	128.1034	153.7241	170.8045	1.86	3-8
4-8	1.87	34.4368	43.0460	64.5689	86.0919	107.6149	129.1378	154.9655	172.1839	1.87	4-8
4-8	1.88	34.7134	43.3918	65.0876	86.7835	108.4794	130.1752	156.2102	173.5669	1.88	4-8
5-8	1.89	34.9907	43.7384	65.6076	87.4768	109.3460	131.2152	157.4582	174.9536	1.89	5-8
6-8	1.90	35.2688	44.0860	66.1290	88.1720	110.2150	132.2580	158.7095	176.3440	1.90	6-8
7-8	1.91	35.5476	44.4345	66.6517	88.8690	111.0862	133.3035	159.9642	177.7379	1.91	7-8
23 inches	1.92	35.8271	44.7839	67.1758	89.5678	111.9598	134.3517	161.2220	179.1356	1.92	23 inches
1-8	1.93	36.1074	45.1343	67.7013	90.2685	112.8356	135.4027	162.4832	180.5369	1.93	1-8
2-8	1.94	36.3884	45.4855	68.2282	90.9710	113.7138	136.4565	163.7477	181.9420	1.94	2-8
3-8	1.95	36.6701	45.8377	68.7564	91.6753	114.5941	137.5129	165.0154	183.3505	1.95	3-8
4-8	1.96	36.9526	46.1907	69.2860	92.3814	115.4768	138.5721	166.2864	184.7627	1.96	4-8
5-8	1.97	37.2357	46.5447	69.8169	93.0893	116.3616	139.6339	167.5606	186.1785	1.97	5-8
6-8	1.98	37.5196	46.8995	70.3492	93.7989	117.2486	140.6984	168.8381	187.5979	1.98	6-8
7-8	1.99	37.8042	47.2552	70.8828	94.5104	118.1380	141.7656	170.1188	189.0209	1.99	7-8
24 inches	2.00	38.0895	47.6119	71.4178	95.2237	119.0296	142.8356	171.4027	190.4474	2.00	24 inches
1-8	2.01	38.3755	47.9694	71.9541	95.9388	119.9235	143.9082	172.6899	191.8776	2.01	1-8
2-8	2.02	38.6622	48.3278	72.4917	96.6556	120.8196	144.9834	173.9802	193.3113	2.02	2-8
3-8	2.03	38.9497	48.6871	73.0307	97.3742	121.7178	146.0614	175.2736	194.7485	2.03	3-8
4-8	2.04	39.2378	49.0473	73.5710	98.0946	122.6183	147.1419	176.5704	196.1893	2.04	4-8
5-8	2.05	39.5267	49.4084	74.1126	98.8168	123.5210	148.2252	177.8703	197.6337	2.05	5-8
6-8	2.06	39.8163	49.7704	74.6555	99.5407	124.4259	149.3110	179.1734	199.0815	2.06	6-8
7-8	2.07	40.1066	50.1333	75.1999	100.2665	125.3331	150.3998	180.4798	200.5331	2.07	7-8
25 inches	2.08	40.3976	50.4970	75.7454	100.9939	126.2424	151.4908	181.7888	201.9877	2.08	25 inches
1-8	2.09	40.6892	50.8616	76.2923	101.7231	127.1539	152.5846	183.1016	203.4462	2.09	3-8
2-8	2.10	40.9816	51.2270	76.8405	102.4540	128.0675	153.6810	184.4173	204.9080	2.10	4-8

Discharge over Cippoletti's Trapezoidal Weirs—continued.

HEAD, H, on crest, Measured to still-water.		DISCHARGE IN CUBIC FEET PER SECOND.							HEAD, H, on crest, Measured to still water.	
In Inches. (Approx.)	In Feet.	5 Feet Long.	7½ Feet Long.	10 Feet Long.	12½ Feet Long.	15 Feet Long.	18 Feet Long.	20 Feet Long.	In Feet.	In Inches. (Approx.)
3-8	2.11	51.5934	77.3901	103.1868	128.9835	154.7802	185.7361	206.3735	2.11	3-8
4-8	2.12	51.9606	77.9408	103.9211	129.9014	155.8816	187.0581	207.8423	2.12	4-8
4-8	2.13	52.3287	78.4929	104.6573	130.8216	156.9859	188.3831	209.3146	2.13	4-8
5-8	2.14	52.6976	79.0464	105.3952	131.7440	158.0928	189.7114	210.7904	2.14	5-8
6-8	2.15	53.0674	79.6011	106.1348	132.6685	159.2022	191.0427	212.2697	2.15	6-8
7-8	2.16	53.4381	80.1571	106.8761	133.5951	160.3142	192.3771	213.7523	2.16	7-8
26 inches	2.17	53.8096	80.7143	107.6191	134.5239	161.4286	193.7145	215.2383	2.17	26 inches
1-8	2.18	54.1820	81.2729	108.3639	135.4549	162.5458	195.0551	216.7279	2.18	1-8
2-8	2.19	54.5552	81.8328	109.1104	136.3880	163.6656	196.3988	218.2208	2.19	2-8
3-8	2.20	54.9293	82.3940	109.8586	137.3233	164.7879	197.7455	219.7173	2.20	3-8
4-8	2.21	55.3043	82.9563	110.6085	138.2606	165.9127	199.0953	221.2169	2.21	4-8
5-8	2.22	55.6801	83.5201	111.3601	139.2001	167.0402	200.4482	222.7202	2.22	5-8
6-8	2.23	56.0567	84.0850	112.1134	140.1418	168.1701	201.8041	224.2268	2.23	6-8
7-8	2.24	56.4342	84.6513	112.8684	141.0855	169.3026	203.1630	225.7367	2.24	7-8
27 inches	2.25	56.8125	85.2188	113.6250	142.0313	170.4375	204.5250	227.2500	2.25	27 inches
1-8	2.26	57.1917	85.7875	114.3833	142.9791	171.5750	205.8900	228.7666	2.26	1-8
2-8	2.27	57.5717	86.3575	115.1433	143.9291	172.7150	207.2581	230.2867	2.27	2-8
3-8	2.28	57.9525	86.9288	115.9050	144.8813	173.8575	208.6290	231.8101	2.28	3-8
4-8	2.29	58.3343	87.5013	116.6685	145.8356	175.0028	210.0032	233.3369	2.29	4-8
5-8	2.30	58.7168	88.0751	117.4335	146.7919	176.1502	211.3802	234.8669	2.30	5-8
6-8	2.31	59.1001	88.6501	118.2002	147.7502	177.3003	212.7603	236.4003	2.31	6-8
7-8	2.32	59.4843	89.2264	118.9685	148.7106	178.4528	214.1433	237.9370	2.32	7-8
28 inches	2.33	59.8693	89.8039	119.7386	149.6733	179.6079	215.5294	239.4772	2.33	28 inches
1-8	2.34	60.2551	90.3827	120.5102	150.6378	180.7653	216.9184	241.0205	2.34	1-8
2-8	2.35	60.6418	90.9627	121.2836	151.6045	181.9254	218.3104	242.5671	2.35	2-8
3-8	2.36	61.0293	91.5439	122.0585	152.5731	183.0878	219.7053	244.1170	2.36	3-8
4-8	2.37	61.4176	92.1263	122.8351	153.5439	184.2526	221.1032	245.6703	2.37	4.8
4-8	2.38	61.8067	92.7100	123.6134	154.5168	185.4201	222.5042	247.2268	2.38	4-8
5-8	2.39	62.1967	93.2950	124.3933	155.4916	186.5900	223.9079	248.7866	2.39	5-8
6-8	2.40	62.5874	93.8811	125.1748	156.4685	187.7622	225.3146	250.3496	2.40	6-8

Discharge over Cippoletti's Trapezoidal Weirs—continued.

HEAD, H. on crest. Measured to still water.		DISCHARGE IN CUBIC FEET PER SECOND.					
In Inches. (Approx.)	In Feet.	7½ Feet Long.	10 Feet Long.	12½ Feet Long.	15 Feet Long.	18 Feet Long.	20 Feet Long.
7-8	2.41	94.4685	125.9579	157.4474	188.9370	226.7243	251.9159
29 inches	2.42	95.0570	126.7427	158.4284	190.1140	228.1370	253.4855
1-8	2.43	95.6469	127.5292	159.4115	191.2938	229.5525	255.0584
2-8	2.44	96.2379	128.3172	160.3965	192.4758	230.9709	256.6344
3-8	2.45	96.8301	129.1068	161.3835	193.6602	232.3923	258.2136
4-8	2.46	97.4236	129.8981	162.3726	194.8472	233.8165	259.7962
5-8	2.47	98.0182	130.6909	163.3636	196.0364	235.2438	261.3819
6-8	2.48	98.6141	131.4854	164 3568	197.2281	236.6738	262.9709
7-8	2.49	99.2111	132.2815	165.3519	198.4222	238.1067	264.5630
30 inches	2.50	99.8093	133.0791	166.3489	199.6186	239.5426	266.1583
1-8	2.51	100.4088	133.8784	167.3480	200.8176	240.9812	267.7569
2-8	2.52	101.0095	134.6793	168.3491	202.0190	242.4228	269.3586
3-8	2.53	101.6113	135.4817	169.3521	203.2226	243.8672	270.9635
4-8	2.54	102.2144	136.2858	170.3573	204.4287	245.3144	272.5716
5-8	2.55	102.8186	137.0914	171.3643	205.6371	246.7646	274.1829
6-8	2.56	103.4240	137.8986	172.3733	206.8479	248.2176	275.7973
7-8	2.57	104.0306	138.7074	173.3843	208.0611	249.6734	277.4149
31 inches	2.58	104.6384	139.5178	174.3973	209.2767	251.1321	279.0356
1-8	2.59	105.2473	140.3297	175.4121	210.4946	252.5936	280.6595
2-8	2.60	105.8574	141.1432	176.4290	211.7148	254.0578	282.2865
3-8	2.61	106.4687	141.9583	177.4479	212.9374	255.5250	283.9166
4-8	2.62	107.0812	142.7749	178.4686	214.1624	256.9949	285.5499
4-8	2.63	107.6948	143.5931	179.4914	215.3896	258.4677	287.1863
5-8	2.64	108.3097	144.4129	180.5161	216.6194	259.9432	288.8258
6-8	2.65	108.9257	145.2342	181.5428	217.8513	261.4216	290.4684
7-8	2.66	109.5427	146.0570	182.5712	219.0854	262.9027	292.1141
32 inches	2.67	110.1611	146.8814	183.6018	220.3221	264.3867	293.7629
1-8	2.68	110.7806	147.7074	184.6343	221.5611	265.9734	295.4148
2-8	2.69	111.4012	148.5349	185.6686	222.8024	267.3629	297.0698
3-8	2.70	112.0229	149.3639	186.7049	224.0459	268.8551	298.7279
4-8	2.71	112.6459	150.1943	187.7431	225.2917	270.3501	300.3890
5-8	2.72	113.2700	151.0266	188.7833	226.5399	271.8479	302.0532
6-8	2.73	113.8952	151.8602	189.8253	227.7903	273.3484	303.7204
7-8	2.74	114.5216	152.6954	190.8693	229.0431	274.8518	305.3909
33 inches	2.75	115.1491	153.5321	191.9151	230.2982	276.3578	307.0643
1-8	2.76	115.7777	154.3703	192.9629	231.5555	277.8665	308.7406
2-8	2.77	116.4075	155.2100	194.0125	232.8150	279.3781	310.4201
3-8	2.78	117.0384	156.0512	195.0640	234.0768	280.8922	312.1025
4-8	2.79	117.6705	156.8940	196.1175	235.3410	282.4092	313.7880
5-8	2.80	118.3037	157.7383	197.1729	236.6075	283.9289	315.4766
6-8	2.81	118.9380	158.5840	198.2300	237.8760	285.4513	317 1681
7-8	2.82	119.5735	159.4313	199.2891	239.1470	286.9765	318.8627
34 inches	2.83	120.2101	160.2801	200.3501	240.4202	288.5042	320.5603
1-8	2.84	120.8478	161.1304	201.4130	241.6956	290.0348	322.2608
2-8	2.85	121.4867	161.9822	202.4778	242.9733	291.5681	323.9645
3-8	2.86	122.1266	162.8355	203.5444	244.2533	293.1039	325.6710
4-8	2.87	122.7677	163.6903	204.6129	245.5354	294.6426	327.3806
4-8	2.88	123.4099	164.5465	205.6831	246.8198	296.1838	329.0931
5-8	2.89	124.0532	165.4043	206.7554	248.1064	297.7277	330.8086
6-8	2.90	124.6977	166.2636	207.8295	249.3954	299.2744	332.5272
7-8	2.91	125.3432	167.1243	208.9054	250.6864	300.8238	334.2486
35 inches	2.92	125.9899	167.9865	209.9831	251.9796	302.3757	335.9731
1-8	2.93	126.6376	168.8501	211.0626	253.2752	303.9303	337.7003
2-8	2.94	127.2865	169.7153	212.1441	254.5730	305.4876	339.4307
3-8	2.95	127.9364	170.5819	213.2274	255.8728	307.0475	341.1630
4-8	2.96	128.5875	171.4500	214.3125	257.1750	308.6101	342.9001
5-8	2.97	129.2397	172.3196	215.3995	258.4794	310.1753	344.6303
6-8	2.98	129.8930	173.1907	216.4884	259.7860	311.7432	346.3814
7-8	2.99	130.5473	174.0631	217.5789	261.0946	313.3137	348.1203
36 inches	3.00	131.2028	174.9371	218.6714	262.4056	314.8868	349.8743