STATE OF COLORADO

DEPARTMENT OF STATE ENGINEER

REPORT

ON

THE WATER RESOURCES

OF

THE SOUTH PLATTE RIVER BASIN

IN

COLORADO

AND

PRESENT UTILIZATION OF SAME

TOGETHER WITH

PRESENT AND FUTURE TRANSMOUNTAIN DIVERSIONS

PREPARED UNDER THE DIRECTION

OF

M. C. HINDERLIDER, State Engineer

IN COOPERATION WITH

THE PLATTE VALLEY WATER CONSERVATION LEAGUE

AND

THE U. S. ARMY ENGINEERS

DENVER, COLORADO

1931

C O N T E N T S

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ARTICLE I

FOREWORD

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Colorado ranks second among the states of the Union as regards irrigation enterprises and developments, and still presents great opportunities for further advancement in the art and practice of irrigation.

The public water supplies of Colorado are the state's most valuable asset, and hence the conservation and efficient use of the same are not only of vital concern to her present citizens but will be of even greater interest to their posterity.

One of the recognized characteristics of stream flow in an arid region is the erratic nature of the same, not only as regards the amount of water produced from year to year, but also as regards the rate of runoff or stream flow from month to month, and from day to day. The efficient use of the water supplies of this state, is therefore dependent upon careful regulation, mainly thru storage. While the normal flow of all the streams originating on the easterly slope of the Rocky Mountains in Colorado, is appropriated several times over, considerable quantities of water pass out of the state each year, in addition to the amounts placed to a beneficial use in the states adjacent to Colorado, which condition results in a serious loss to the irrigation interests of this state. Such remaining unused water supplies on the easterly slope of the Rocky Mountains are now required to supplement existing shortages under the various canal systems taking water from these streams, and for stabilizing values under such systems, and not for the reclamation of new areas.

Preliminary, however, to further attempts to provide increased storage capacity for conserving unused water which now escapes across the borders of the state, a determination of the justification for the necessary expenditures in any particular locality, requires full consideration of all phases of this very complicated subject.

For many years it has been the desire of this office to make a complete inventory of the water resources of this state for the purposes above mentioned, but lack of finances precluded the carrying out of such a program.

The Twenty-seventh General Assembly of the State of Colorado appropriated the nominal sum of $10,000 for the use of this office in initiating such investigations. While this appropriation was wholly inadequate to finance the cost of a comprehensive investigation which the importance of the work justified, the Act of the legislature provided that such appropriation should be expended in cooperation with local agencies which would contribute at least an equivalent sum of money, to meet the state appropriation, and thereby made it possible for this office to largely supplement the financial assistance provided by the legislature. The act appropriating the above mentioned sum provided that such appropriation should be allocated among the major river systems of the state, in the proportion that the irrigated area in any river system bore to the total irrigated area in the state, and also provided that any part of such allocation not taken advantage of by the local water users in any major stream system by November 30, 1929, might be transferred to any other major stream system, where the same would be met by an equal sum of money contributed by local agencies in such stream basin.

For the purpose of distributing the cost as equitably as possible among the beneficiaries, it was suggested that the local contributions be made by the Boards of County Commissioners of the Counties in which the irrigated lands are located, such contributions by the counties being predicated upon the irrigated area in those counties. The sums thus raised were handled thru a treasurer designated by the local Water Users Association, and were paid out on vouchers approved by this office.

Under the provisions of a recent Act of the United States Congress, five million dollars were appropriated for the purpose of making a comprehensive study of the Upper Mississippi River and its principal tributaries in the interest of flood control, navigation, irrigation, power, domestic and other uses of the waters of such streams. The Corps of U. S. Army Engineers, with headquarters at Kansas City, Missouri, was charged with the duty of making an intensive study of the South Platte River Basin. Since such investigation was necessarily of the same nature as that contemplated under the provisions of the Act of the Twenty-seventh General Assembly of this state, cooperative agreements were entered into between this office and the United States Army Engineers whereby the latter department agreed to contribute substantial financial and engineering assistance in cooperation with this department, in the prosecution of such investigations. This latter cooperation by the Army Engineers consisted principally in the establishment and maintenance of eight stream-gaging stations on the tributaries of the South Platte River, field surveys of eight reservoir and dam sites with necessary inlet canals, and the financing of the services of the engineer directly in charge of the investigation in this office, together with a portion of the salaries of other assistants.

This Report embodies the results of studies in the South Platte Basin only, as contemplated by the Act of the Twenty-seventh General Assembly.

This office herein desires to recognize and extend due credit for the very valuable assistance provided by the U. S. Army Engineers in carrying out this comprehensive investigation, without which the scope of the same would have been materially limited and made of lesser value.

We also desire to express our appreciation for the valuable assistance rendered by members of the Boards of County Commissioners, who contributed the cooperative funds, and for the support and cooperation extended by the members and executive committee of the Platte Valley Water Conservation League, which sponsored this investigation, and who have loyally supported our endeavors to make the investigation a success. Also to the Great Western Sugar Company, which made a substantial contribution in money.

Special credit is due Mr. Thomas Hawthorne, engineer, who under the supervision of this office, made the studies of water supply and utilization, and the compilation of maps, dam designs and other data composing the body of this report. Mr. Hawthorne was specially qualified for this undertaking as a result of previous years spent by him on studies of water supply and utilization on the Poudre River in this state, and in the state of Washington, for the U. S. Bureau of Reclamation.

The scope of this report was designed to include a consideration of the following factors:

1. A determination of the available daily water supply of each major drainage basin, resulting from all sources.

2. A determination of the daily demand upon this water supply, as a result of presently constructed works.

3. A determination of the daily shortages under each major canal system, and the period when such shortages occur.

4. A determination of the amount of storage needful to regulate stream flow to take care of existing shortages.

5. A determination of the periods and extent of surplus runoff and the location of the same in the stream basin.

6. A determination of additional reservoir capacity needful to further regulate stream flow to provide the most efficient use of all water supplies, and the proper location of same.

7. A study of type and cost of dams needful to provide such reservoir capacity.

8. A determination of the benefits to be derived by certain canals thru direct application, or river exchange as a result of further reservoir development.

9. A field cruise to determine the present acreage under irrigation, and the area of seeped lands.

10. A determination of the feasibility and probable cost of transmountain diversions.

11. Preparation of maps of reservoir sites, tentative designs for dams, and a comprehensive wall map showing the essential features of the South Platte River Basin in Colorado.

12. Compilation of the results of such studies in the form of reports for the use of the public.

These studies to date, as was to be expected, disclose that the remaining water supplies of the South Platte River in Colorado, when further regulated and conserved, will be required very largely to supplement existing shortages under most of the canal systems. Such conservation will not result in any immediate material increase in the acreage now under irrigation.

Denver, Colorado, M. C. HINDERLIDER,

June 1, 1931. State Engineer of Colorado.

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ARTICLE II

SOUTH PLATTE RIVER INVESTIGATIONS

SUMMARY OF WATER SUPPLY COMPUTATIONS

AND STORAGE POSSIBILITIES

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1. Representative Period for Water Supply Computations

A fairly representative period of water supply records for the various streams supplying the irrigated lands in the South Platte area, was required as a basis for predicting future run-off.

The period of years used should extend as far back as reliable stream-flow records would allow, with an average near the long time average and should show typical stream behavior.

Construction of reservoirs along the lower South Platte River was completed, and reservoirs were in operation by 1915, since which date conditions affecting the flow at Julesburg have been about the same. Julesburg river flow records are practically continuous from 1917 to 1928, inclusive, and incomplete prior to that period. Therefore, the representative period for Julesburg is confined to the years 1917-1928.

The longest stream flow record is that for the Cache la Poudre River at the mouth of the canyon, which covers a period of 45 years from 1884 to 1928, inclusive.

Practically continuous 20 year records, or from 1909 to 1928, inclusive are available for St. Vrain Creek at Lyons and for Clear Creek in the vicinity of Golden.

The following table shows the long time run-off averages as compared to the 1917-1928 and 1918-1928 periods:

TABLE NO. 1

Stream	Location	Years of Record	Av. Ann. Runoff A. Ft.	Avg. for Period 1917-1928	PerCent of Normal	Avg. 1918-1928	PerCent of Normal
Cache la Poudre	Canon	45	319,600	335,000	104.8	318,360	99.6
" " "	"	20	318,700	335,000	105.1	318,360	99.6
St. Vrain Creek	Lyons	20	102,980	104,950	101.9	102,720	99.8
Clear Creek	Golden	20	185,620	182,360	98.2	183,040	98.6

Surplus flows for the Cache la Poudre R. at the canyon for May, June and July were computed for the 20 year period 1909 to 1928, incl. The averages of the totals for the 20 year period and for 1917-1928 and 1918-1928 are as follows:

TABLE NO. 2

Summary Surplus on Poudre R. at Canon, Platte River Sh'tges. Supplied.
Acre-feet.

Avg. Ann. Surplus 1909-1928	Avg. Ann Surplus 1917-1928	% Normal	Avg. Ann. Surplus 1918-1928	% Normal
48,760	57,060	117.0	46,000	94.4

The period 1917 to 1928, inclusive, evidently gives an average above the normal for stream run-off and for surplus flows.

If the high run-off year of 1917 is excluded, the period 1918-1928 yields averages slightly below the long time average and appears to be the best available representative period for water supply studies.

For Julesburg, it contains the highest year's run-off of record (1924) and the low year of 1925 which is the lowest recorded, under present conditions on the river.

For the Cache la Poudre River at the canon, the period contains the lowest recorded run-off since 1884 (1919) and the high year of 1923 with a discharge amounting to 88% of the highest since 1885 and an average period run-off of 99.6% of the 45 years average.

Gaging station records were found for the tributaries at points above irrigation diversions for each year from 1918 to 1928 except for District 9, where 1918 and 1919 were missing. These years were supplied from the estimates of the water commissioners in their weekly reports, so that the computations of surplus flows on all tributaries would cover the same period of years.

ARTICLE III

Average Annual Mountain Water Supply for South Platte Basin.

The average annual run-off of the principal streams entering the South Platte Basin from the mountain areas from 1918 to 1928, incl., is given below in Table No. 3.

Some additional water accrues to the streams in the plains area from intermittent discharge of creeks during summer rains but, in general, this water is not a reliable source of supply for irrigation.

In District No. 3, the only district for which there is data available for run-off from plains tributaries, it is estimated that the annual average supply from this source is about 15,000 acre-feet or only 04% of the mountain supply.

In the cases of Districts 3, 5, 6 and 7, canals divert above the canon gaging stations and their average diversions have been added to the gaging station records as shown in the table.

TABLE NO. 3

Average Annual Mountain Water Supply, South Platte Basin, Period 1918-1928

Dist.	Stream Entering District	(Climatic Years*) Avg. Ann. Run-off Acre-Feet.		Remarks
3	Poudre R. at Canon	318,400		
	No. Poudre Canal	26,000		Diverts above river gage
	Poudre Val. Canal	6,300		" " " "
	Fort Collins, W. W.	2,000		" " " "
	Total Dist. No. 3		352,700	
4	Big Thompson in Canon	155,700		
	Little Thompson Creek	22,100		
	Buckhorn Creek	17,800		
	Total Dist. No. 4		195,600	
5	St. Vrain at Lyons	102,700		
	So. Ledge Ditch	400		Diverts above gage.
	Supply Canal	6,600		" " "
	Left Hand Creek	5,000		
	Total Dist. No. 5		114,700	
6	Main Boulder, Orodall	78,300		
	So. Boulder, Eldorado	57,000		
	Community and So. Boulder & Coal Creek Ditches	6,000		Diverts above gage.
	Coal Creek	6,600		
	Total Dist. No. 6		147,900	
7	Clear Cr. at Golden	183,000		
	Golden (Welch) Ditch	4,000		Diverts above gage.
	Ralston Creek	6,900		
	Total Dist. No. 7		193,900	
8	South Platte R. at So. Platte	321,700		
	Plum Creek	17,400		
	Deer Creek	8,500		
	Total Dist. No. 8		347,600	
9	Bear Creek at Starbuck	52,800		Mean 1920-28
	Turkey Creek	9,600		
	Total Dist. No. 9		62,400	
	Total Avg. Ann. Mtn. Water Supply		1,414,800	

* Years ending Sept. 30th.

TABLE NO. 4

Annual Variation of Total Mountain Water Supply

Year Ending Sept. 30	Total Mountain Water Supply Acre-Feet		Year Ending Sept. 30	Total Mountain Water Supply Acre-Feet	
1918	1,367,000		1924	1,770,000	
1919	1,114,000		1925	917,000	Minimum
1920	1,450,000		1926	1,725,000	
1921	1,986,000	Max.	1927	1,150,000	
1922	1,070,000		1928	1,307,000	
1923	1,707,000		Mean	1,414,800	

The year 1921 had a runoff which was 140% of the mean.
" " 1925 " " " " " 65% " " "

A R T I C L E IV

Average Annual Seepage Return for Streams of South Platte Basin.

All available data on return flow were taken up in detail for each district, and are given in the individual district studies, together with conclusions as to present return flow.

The following summary table is considered to represent, fairly conservatively, the seepage return for recent years.

It varies from 0.7 of a second foot per mile of stream for Boulder Creek to 8.8 second-feet per mile in the case of the South Platte River in District No. 1.

Evidently a large part of the return flow in Districts 4, 5, 6, 7 and 9 returns directly to the South Platte River instead of to the streams supplying those mountain districts.

TABLE NO. 5

Summary Average Seepage Return
South Platte Basin

Dist. No.	Stream	Average Ann. Return Flow Sec. Ft.	Average Ann. Return Flow Acre-Ft.	Sec. Ft. per Mile of stream
1	So. Platte River, Kersey to Balsac - 66 mi.	580	420,000	8.8
2	South Platte River, Denver to Kersey - 63 mi.	350	253,400	5.5
3	Cache la Poudre River, Canon to Mouth - 47 mi.	152	110,000	3.2
4	Big Thompson River, Canon to Mouth - 24 mi.	50	36,200	2.1
	Little Thompson Creek, Eagle D. to Mouth - 16 mi.	20	14,400	1.25
5	St. Vrain Creek, Lyons to Mouth - 28 mi.	45	32,600	1.6
6	Boulder Creek, Canon to Mouth - 25 mi.	18	13,000	0.7
7	Clear Creek, Canon to Mouth - 18 mi.	22	15,900	1.2
8	South Platte River, Canon to Denver - 20 mi.	90	65,200	4.5
9	Bear Creek, Ward Ditch to mouth - 9 mi.	16	11,600	1.8
64	South Platte River, Balzac to Julesburg - 83 mi.	400	290,000	4.8
	Total Avg. Annual Seepage Return	1,743	1,262,300	= 47% total supply.
	Total Avg. Annual Run-off (Table 3)		1,414,800	= 53% total supply.
	Total Avg. Annual Supply		2,677,100	

ARTICLE V

Duty of Water in South Platte Basin.

The gross amounts of water diverted by canals for irrigation, both from natural flow and from storage, was compiled for all districts in Division No. 1, for the period 1921 to 1928, incl., except District No. 23, for which records are lacking.

The total acre-feet diverted for irrigation, and the number of acres irrigated, as reported by Water Commissioners, and acre-feet, gross diversions, per acre irrigated, are shown in the following 3 Tables.

TABLE NO. 6

Total Acre-Feet diverted by Canals for Irrigation

Year Ending Sept.30	Total A.Ft. Diverted by Canals in District No.:										Total A.Ft. Diverted.
	1	2	3	4	5	6	7	8	9	64	
1921	463514	511002	371000	188608	91529	121586	159650	188922	54565	309960	2,460,336
1922	361727	346372	218000	129113	77445	112162	131000	111262	50592	258927	1,796,600
1923	527421	410971	383000	172826	104776	188836	145700	156430	54888	264576	2,409,424
1924	453801	420188	319000	181153	109714	203487	161200	147424	51751	300918	2,348,636
1925	338907	302854	264000	113422	55841	116410	124700	73401	28223	308432	1,726,190
1926	553019	461686	430000	210952	115124	170820	172900	137272	53032	388082	2,692,887
1927	470514	371016	345000	146346	100537	154511	150000	115038	38948	301902	2,193,812
1928	503767	401904	348000	181515	113352	159202	136000	140078	45901	411216	2,440,935
Avg.	459084	403249	334750	165491	96040	153380	147644	133728	47240	318000	2,258,600

TABLE NO. 7

Acres Irrigated in South Platte Basin

Year Ending Sept.30	Acres Irrigated in District No.: 1	2	3	4	5	6	7	8	9	64	Total Acres Irrigated
1921	121105	165396	264340	129480	85755	95681	102590	58755	17085	129968	1,170,155
1922	140261	180594	265940	140060	68825	86875	102620	55544	20348	125758	1,186,825
1923	143149	209984	266940	140775	90526	168505	104460	48377	19870	146265	1,338,851
1924	160877	209532	266940	141276	87505	170433	104595	50076	16773	148479	1,356,476
1925	157098	202754	267630	127940	48220	170407	104843	46711	16158	151133	1,292,894
1926	162676	206064	267640	141070	91406	172503	104813	49077	19265	154038	1,368,552
1927	157468	205591	268140	141420	81019	170834	104773	47621	22497	157063	1,366,426
1928	164131	213457	268540	141430	89264	173223	104913	47760	18345	160037	1,381,100
Avg.	150846	199170	267014	137931	81565	151060*	104201	50490	18793	146593	1,307,660

TABLE NO. 8

Acre-Ft. Diverted per Acre Irrigated in South Platte Basin

Year Ending Sept.30	Gross Duty, Acre-Ft. per Acre in District No.: 1	2	3	4	5	6	7	8	9	64	Average A.Ft. per A.
1921	3.83	3.09	1.40	1.46	1.07	1.27	1.56	3.22	3.19	2.39	2.25
1922	2.56	1.92	0.82	0.92	1.13	1.29	1.28	2.00	2.48	2.06	1.65
1923	3.68	1.96	1.43	1.23	1.16	1.12	1.39	3.23	2.76	1.81	1.98
1924	2.82	2.01	1.20	1.28	1.25	1.19	1.54	2.94	3.09	2.03	1.94
1925	2.16	1.49	0.99	0.89	1.16	0.68	1.19	1.57	1.75	2.04	1.39
1926	3.39	2.24	1.61	1.49	1.26	0.99	1.65	2.80	2.75	2.52	2.07
1927	2.99	1.80	1.29	1.04	1.10	0.91	1.43	2.42	1.73	1.92	1.66
1928	3.07	1.88	1.30	1.28	1.27	0.92	1.30	2.95	2.50	2.57	1.90
Avg.	3.06	2.04	1.25	1.20	1.18	1.05	1.42	2.64	2.53	2.17	1.85

The above gross duties are based on Water Commissioners' reports of canal diversions and areas irrigated and are exclusive of precipitation. It is probable that the areas irrigated are reported too large and that the duties, as given above, are somewhat high.

Mr. Ralph L. Parshall, in Agricultural Bulletin No. 279, reports the average gross canal duties in Districts 1 and 64 for 1920 as 3.20 acre-feet per acre and 2.15 acre-feet per acre. These determinations were based on independent canal and area measurements but check fairly closely with the averages shown in Table 17 above obtained from the reports of the Water Commissioners.

The consumptive use of water for District No. 3 was estimated by R. G. Hemphill during 1916 and 1917 from his records of inflow and outflow. He concluded that the consumptive use for this district is "not to exceed 1.25 acre-feet per acre irrigated." The river flow in 1916 was 86% of the normal and 162% in 1917. In years of shortage, the water actually consumed by crops is somewhat less than 1.25 acre-feet per acre but this figure probably represents the crop requirement.

The consumptive use for District No. 7 was computed for the year 1927, when Clear Creek run-off was 88% of normal, from state gaging records and reports of the Water Commissioner, and found to be 1.19 acre-feet per acre irrigated.

ARTICLE VI

Surplus Available for Additional Storage on Mountain Tributaries.

Detail computations, by daily flows, were made to determine the amounts of surplus waters available for additional storage on the Cache la Poudre River, Big Thompson River, St. Vrain Creek, Boulder Creek, Clear Creek and Bear Creek, corresponding to Districts Nos. 3, 4, 5, 6, 7 and 9 respectively. The surplus in District 23 has heretofore been determined by engineers for the Denver Board of Water Commissioners.

The system used in determining surplus flows, was to take from the daily mean flows at the point of record on the stream supplying the district in question with irrigation water, increased by available return flow, the probable daily aggregate diversion requirements of all canals diverting below the point of record. The remainder was considered available for storage at the point of record on the stream and at any other point above, to the extent that it was flowing at such point at the time it became surplus.

It was recognized that, while the daily surplus flows in a mountain district, determined as explained above, were in excess of the district's requirements, some of the surplus might be needed for irrigation in lower districts along the South Platte River. Accordingly, whenever shortages were reported in the South Platte River districts on the same dates that surplus waters occurred on mountain tributaries, the reported shortages were deducted from the surplus flows.

Considerable time was spent in investigating what quantities to use for canal diversion requirements for the present irrigated areas. The average diversions over a period of years were found to be too low as they included years of serious shortages when the canals diverted much less than they would have, if more water had been available. The use of water in a short year is not a fair representation of the demand for irrigation.

The combined maximum daily diversions of canals for the past 5 years were computed for several of the districts and found to give values considerably in excess of that which the canals diverted in good years when there was no apparent water shortage. This is due to the fact that the canals seldom divert their maxima on the same day; but that while several may be taking water to their full capacities, others will be diverting much less than their maxima.

It was decided that the fairest demand to assume in estimating surpluses, would be the use of water during a season of recent date when water was plentiful in general each day, and no shortages were experienced during the season.

The water supply for the year 1926 comes the nearest to meeting all irrigation requirements in all of the districts of the South Platte Valley, of any of the past 10 years prior to 1928.

The amount of water diverted in this year was above the average for good years, the flow was ordinarily well sustained throughout the season with few and small flood periods, there was little precipitation to interrupt irrigation and the average temperature was above normal. It appears that if the mountain districts could divert water each year as they did in 1926, their irrigation requirements would be well take care of.

Therefore, the daily canal diversions for 1926 were tabulated for each district and whenever the daily supply was greater than the aggregate daily diversions of 1926, the excess was considered surplus, subject to shortage demands in lower districts.

The months, April to August, inclusive, were found to contain all of the practical possibilities for additional storage in the mountain districts. The winter flow is small and there are more than enough decreed reservoirs in the districts to absorb all of it if they keep their inlet canals open all winter and do not depend on filling during the early summer floods.

In the computations for Table No. 9 below, it was assumed that the present reservoirs would take all of the available winter flow and that the excess over irrigation requirements during the irrigation season would be available for additional storage.

In case the present reservoirs continued to let winter water pass when ice conditions became troublesome, and divert for storage during the irrigation season, new channel reservoirs would store the winter water thus released, and the net result would be the same.

Channel reservoirs, having no inlet canals to become blocked with ice, could store the winter run-off more easily than the present reservoirs to which such winter flow is decreed, and it is probable there would be considerable cooperation and exchange of water between old and new reservoirs which would result in economy and increased conservation of the storable excess.

Table No. 9 below gives in acre-feet, the surpluses with reported Platte shortages deducted, for Districts Nos. 3, 4, 5, 6, 7 and 9 for the representative period 1918 to 1928, inclusive.

TABLE NO. 9

Surplus Water Available for Additional Storage on Mountain Tributaries.
Acre-Feet by Monthly Summaries

Year	Water Dist.	April	May	June	July	Aug.	Total
1918	3		1840	54150	3070		59060
	4		0	8640	0		8640
	5		840	11700	320		12860
	6		864	7710	0		8574
	7		0	17650	1325		18975
	9		982	2400	4530		7912
Total			4526	102250	9245		116021
1919	3		1950	0	0		1950
	4		0	0	0		0
	5		2220	0	0		2220
	6		4135	0	0		4135
	7		662	0	0		662
	9		9130	0	0		9130
Total			18097	0	0		18097
1920	3		3960	49060	130		53150
	4		0	3720	0		3720
	5		17900	2080	125		20105
	6		17990	0	0		17990
	7		11410	3097	0		14507
	9		15780	0	0		15780
Total			67040	57957	255		125252
1921	3		2600	72800	0	0	75400
	4		5000	53900	488	0	59388
	5		14000	39000	880	1840	55720
	6		21070	43100	130	686	64986
	7		25600	78200	4360	0	108160
	9		15980	12850	313	0	29143
Total			84250	299850	6171	2526	392797
1922	3		1780	6270	0		8050
	4		0	0	0		0
	5		1575	0	0		1575
	6		1158	0	0		1158
	7		0	0	0		0
	9		1470	0	0		1470
Total			5983	6270	0		12253

TABLE NO. 9 (cont'd)

Year	Water Dist.	April	May	June	July	August	Total
1923	3		2520	110800	14560	0	127880
	4		38	66300	22000	5730	94068
	5		5140	23000	9720	3360	41220
	6		3913	15800	1130	2175	23018
	7		1540	14650	3060	0	19250
	9		256	5840	1245	0	7341
Total			13407	236390	51715	11265	312777
1924	3		4380	106300	0		110680
	4		7010	64200	0		71210
	5		11200	22800	0		34000
	6		13440	8790	0		22230
	7		8130	30700	0		38830
	9		10995	6248	0		17243
Total			55155	239038	0		294193
1925	3		1560	7920	0		9480
	4		0	0	0		0
	5		0	0	0		0
	6		0	0	0		0
	7		0	0	0		0
	9		0	0	0		0
Total			1560	7920	0		9480
1926	3	0	6390	24050	0	0	30440
	4	5250	22750	27800	1500	0	57300
	5	0	15300	12850	1320	0	29470
	6	0	24830	6182	107	0	31119
	7	0	31900	36800	5260	0	73960
	9	0	22750	4440	625	0	27815
Total		5250	123920	112122	8812	0	250104
1927	3		2410	13700	0	0	16110
	4		0	7200	0	0	7220
	5		4420	2260	0	646	7326
	6		3190	0	0	14	3204
	7		408	2010	0	0	2418
	9		1770	0	0	0	1770
Total			12198	25190	0	660	38048
1928	3		4440	9260	147	0	13847
	4		5190	8450	1080	0	14720
	5		9640	4840	590	516	15586
	6		7363	1273	127	175	8938
	7		13050	10700	0	0	23750
	9		4963	343	0	0	5306
Total			44646	34866	1944	691	82147
Avg.	1918-28	477	39162	101987	7104	1377	150106
% Total		0.3%	26.%	68.%	4.7%	01.%	100%

TABLE NO. 10

Summary of Surplus Water Available for Additional Storage on Mountain Tributaries - Acre-Feet by Years.

Year	Water District Number						Total
	3	4	5	6	7	9	
1918	59,060	8,640	12,860	8,574	18,975	7,912	116,021
1919	1,950	0	2,220	4,135	662	9,130	18,097
1920	53,150	3,720	20,105	17,990	14,507	15,780	125,252
1921	75,400	59,388	55,720	64,986	108,160	29,143	392,797
1922	8,050	0	1,575	1,158	0	1,470	12,253
1923	127,880	94,068	41,220	23,018	19,250	7,341	312,777
1924	110,680	71,210	34,000	22,230	38,830	17,243	294,193
1925	9,480	0	0	0	0	0	9,480
1926	30,440	57,300	29,470	31,119	73,960	27,815	250,104
1927	16,110	7,220	7,326	3,204	2,418	1,770	38,048
1928	13,847	14,720	15,586	8,938	23,750	5,306	82,147
Avg.	46,000	28,800	20,000	16,900	27,300	11,200	150,106
Approx. Avg. Ann. Shortage in District	34,400	25,000	14,800	38,000	12,000	None	124,200
Approx. Avg. Ann. Surplus that it is practical to store	32,000	26,000	20,000	13,000	25,000	11,000	127,000

The above storable surpluses are available at the canon gaging stations on the several streams or at points above these stations, to the extent of the stream flow at such points. Such surpluses could also be stored downstream but this would result in a less efficient use in the districts in which they occur.

Future storage works should preferably be on stream channels so as to catch the early summer flood flows that pass present reservoir inlet canals. They should be on mountain tributaries in preference to the plains area and thus be available to mountain districts where the shortages are usually greater than along the South Platte River.

There are great variations from year to year, in the storable surpluses. Usually every third year is a dry one, and ordinarily reservoirs should be constructed about twice the capacity as indicated by the annual average surplus, to yield a little less than this annual average, or all that it is practical to store.

Surplus for Storage in District No. 23.

All of the present and future storage possibilities of material size in South Park or Dist. No. 23, are controlled by the City of Denver for municipal water supply.

Mr. Geo. M. Bull, Engineer for the Denver Board of Water Commissioners, has estimated that the total average annual surplus for storage on the South Platte River at South Platte, under natural flow conditions is 106,500 acre-feet. He also estimates that present reservoirs above South Platte, are storing on the average about 63,500 acre-feet per year of this surplus, which leaves a storable balance in District No. 23 of 43,000 acre-feet, uncontrolled by present reservoirs under present methods of operation. The quantity available for storage after present decrees are fully in operation would be much less.

Denver's principal storage reservoir, Lake Cheesman, has a total capacity of 79,000 acre-feet, but 50,000 acre-feet of this capacity is held as a reserve to protect the City water supply. If additional reservoir capacity were provided to hold this reserve, it is estimated that the present annual yield of Lake Cheesman would be increased about 30,000 acre-feet.

The storable annual surplus in South Park not now covered by decrees in favor of the City of Denver, is less than 20,000 acre-feet.

A R T I C L E VII

Surplus for Storage in South Platte Basin based upon Flow at Colo.-Nebraska State Line.

The record of the discharge of the South Platte River at the State Line affords an opportunity for arriving at the total surplus, from all sources, in the South Platte Basin.

The river flow at Julesburg is subject to an allowance for the demands of the Western Irrigation Canal in Nebraska, during the irrigation season, and for the proposed Perkins County Canal, to divert opposite Ovid, during the storage season, in compliance with the South Platte River Compact ratified by Congress and effective in 1926.

After these demands are met, all of the remaining run-off at Julesburg, that is divertable, is surplus for Colorado above the point of minimum flow in the river.

Allowance for Western Irrigation Canal. According to the South Platte Compact, the Western Irrigation Canal is entitled to divert between April 1st and October 15th, as great a part of 120 second-feet as can be put to beneficial use, with priority as of June 14, 1897. This demand is to be met, when necessary, at the expense of junior priorities in Dist. 64, of which there are 9 with decrees totaling 1856.5 sec. ft. These later priorities in turn may call upon junior decrees in the upper districts, to replace reductions made in favor of the Western Canal.

Therefore, it appears that the Western Canal will have a prior right over subsequent diversions on the South Platte River for additional storage.

The Western Irrigation District is estimated to embrace 14,992 acres of land, of which 14,792 acres were reported as irrigated in 1926. This probably is about all that can be irrigated. For this purpose 33,887 acre-feet were diverted in 1926, being equivalent to 2.29 acre-feet per acre irrigated.

TABLE NO. 11

IRRIGATION FROM SOUTH PLATTE RIVER

BY WESTERN IRRIGATION CANAL

(Copied from Records of Nebraska Bureau of Irrigation at Bridgeport, Nebraska.

Year	Use of Water by Western Irrigation District (Acre Feet)								
	Apr.	May	June	July	Aug.	Sept.	Oct.	Total	Acres Irrigated
1920	-----	2,166	4,306	4,610	3,453	3,042	12,734	30,311	14,311
1921	-----	3,908	5,314	2,773	4,466	5,091	5,080	36,707	11,567
1922	6,089	2,164	2,463	1,654	1,406	1,777	1,896	17,449	14,458
1923	-----	2,541	3,134	4,449	1,015	1,414	646	13,199	14,311
1924	-----	3,671	2,001	2,410	1,523	2,338	0	11,943	13,570
1925	3,445	2,975	541	307	0	426	2,769	12,545	14,440
1926	5,286	5,760	8,878	5,543	1,428	6,992	0	33,887	14,792
1927	-----	1,350	3,367	2,265	3,578	3,034	3,163	16,757	14,792
1928	2,055	4,374	3,645	2,499	3,239	2,485	6,530	24,827	13,006
Averages	1,875	3,212	3,739	2,946	2,234	2,956	3,646	21,958	13,916

Average acre-feet per acre diverted = 1.60

The average seasonal diversions for District 64 amount to 2.09 acre-feet per acre irrigated for the period 1921-1928 and 2.52 acre-feet per acre for the good water year of 1926.

The 1926 diversions in District 64 were distributed throughout the irrigation season as follows:

TABLE NO. 12

Month (1926)	% Total diversions for irrigation
April	9
May	17
June	18
July	19
Aug.	18
Sept.	14
Oct.	5
	100

The use of 36,000 acre-feet per year under the Western Canal, which occurred in 1926 when 14,792 acres were irrigated, when the distribution by months, if made in accordance with that in Water District 64 during 1926, is considered a liberal allowance for the Nebraska Canal.

TABLE NO. 13

Proposed Allowance for Western Irrigation Canal

Month	%Total Gross Diversions	Diversions Acre-Feet	Equivalent Daily Diversions. Sec. Ft.
April	9	3240	54
May	17	6120	100
June	18	6480	109
July	19	6840	111
Aug.	18	6480	105
Sept.	14	5040	85
Oct.	5	1800	61
Total	100	36000	

Allowance for Perkins County Canal. The compact allows this canal to divert up to the rate of 500 second-feet between Oct. 15th and April 1st of the succeeding year, for storage, as of priority date Dec. 17, 1921, provided however that Colorado's preferred right to divert an additional 35,000 acre-feet in District 64 is not interfered with.

The most feasible location for the diversion and use of District 64's preferred right to 35,000 acre-feet is either through enlargement of the Julesburg Reservoir, or the construction of the South Side or Sedgwick system. Either of these projects would divert from the river between Iliff and Crook. The average return flow from such diversion point to Julesburg is about 130 second-feet, which represents unusable flow in District #64 during the storage season.

In the present computations, it is assumed that District 64 will divert, between Iliff and Crook, all of the Julesburg flow, less 130 sec. ft., at a rate up to 350 second-feet, starting October 15th and continuing until April 1st or until 35,000 acre-feet have been stored, and the Perkins County Canal will take all of the remaining flow at Julesburg up to 500 second-feet during the same period.

Undivertable Flow at Julesburg. The excess of the seepage return to the river, below the point of minimum flow, over the average canal diversions below this point, represents flow that cannot be diverted above, as it originates too far down-stream and becomes undivertable in Colorado.

The difference between the run-off at Julesburg and the undivertable flow is surplus, that may be diverted upstream, after the compact obligations have been met.

A study of 16 series of seepage measurements made by R. G. Hosea in 1916, 1917 and 1918, showing the river flows at frequent intervals, and later measurements made by the State Engineer, indicate that the average point of minimum flow on the river is at Sedgwick for the period May 1st to Oct. 15th, and at Balzac from Oct. 16th to April 30th, of the succeeding year.

Average aggregate canal diversions below the points of minimum flow, were compiled for the period 1924 to 1928, incl., and deducted, day by day, from the average daily seepage return below the points of minimum flow, the remainder being undivertable flow at Julesburg.

Additional diversions up to 350 s.f. were allowed, until 35,000 A. Ft. had been stored during the period Oct. 16 to Apr. 1.

A summary of the undivertable flow, in acre-feet, is given below:

TABLE NO. 14

Summary Undivertable Flow at Julesburg, in Acre-feet

Month	Return Flow Below Pt. of Minimum Flow	Avg. Divers. Below Pt. of Minimum Flow	Average Undivert. Flow at Julesburg	Pt. of Min. Flow is at:-
Jan.	24,000	2,010	21,960	Balzac
Feb.	21,650	1,215	20,435	"
Mar.	24,000	6,725	17,275	"
Apr.	23,200	16,400	7,460	"
May	1,965	1,430	535	Sedgwick
June	1,900	1,875	159	"
July	1,965	1,618	357	"
Aug.	1,965	1,315	658	"
Sept.	1,900	984	920	"
Oct.	13,320	12,300	1,150	Balzac & Sedgwick
Nov.	23,200	18,810	4,380	Balzac
Dec.	24,000	12,440	11,520	"
Total	163,065	77,122	86,809	

The following table gives a summary, in acre-feet of the estimated surplus flows at Julesburg that can be diverted in Colorado, above the points of minimum flow:

(The results are exclusive of allowances for additional diversions during the storage season in District No. 64)

TABLE NO. 15

Summary of Surplus for Colo. (above min. flow pts.) from South Platte R. at Julesburg, Acre-Feet.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
1918	13,530	0	365	1,250	5,560	4,700	4,270	2,110	5,740	16,070	11,180	7,460	72,235
1919	12,550	0	369	0	2,220	11,330	22,520	12,730	0	0	0	3,590	65,309
1920	11,160	0	0	0	0	0	33,800	82,800	13,470	1,760	1,080	16,500	160,570
1921	7,810	0	0	0	0	0	7,560	11,260	625,000	15,300	0	2,170	669,100
1922	10,100	0	590	1,230	11,800	15,850	6,820	8,380	0	0	0	0	54,770
1923	0	0	0	0	0	0	4,630	13,100	360,000	20,550	15,150	13,960	427,390
1924	43,100	88,200	65,000	52,300	67,200	57,800	114,700	85,200	300,000	440	0	5,260	879,200
1925	5,230	0	0	0	4,450	0	50	0	0	0	0	0	9,730
1926	520	0	0	2,090	1,350	0	18,180	70,600	107,250	34,600	2,360	1,170	238,120
1927	11,650	0	0	100	430	12,400	69,900	15,360	4,840	0	7,780	1,230	123,690
1928	10,350	0	0	80	40	860	0	10,090	83,800	43,600	11,900	0	160,720
Avg.	11,455	8,018	6,030	5,186	8,459	9,358	25,672	28,330	136,373	12,029	4,495	4,667	260,075
% Total	4.4	3.1	2.3	2.0	3.3	3.6	9.9	10.9	52.4	4.6	1.7	1.8	100

206,901 acre-feet or 80% of the average surplus occurs during the months April to August, inclusive.

TABLE NO. 16

Annual Summary - Distribution of Flow at Julesburg, Acre-Feet

Year Ending Sept. 30	Run-off So. Platte at Julesburg	Western Canal could have diverted	Dist. 64 could have diverted additional	Perkins Canal could have diverted	Upstream surplus for Colo.	Surplus not divertable
1918	253,640	28,942	35,000	116,380	72,235	1,083
1919	238,060	21,680	35,000	111,160	65,309	4,911
1920	310,830	28,678	35,000	81,190	160,570	5,392
1921	787,590	32,110	35,000	46,870	669,100	4,510
1922	237,280	14,012	35,000	129,490	54,770	4,008
1923	537,340	34,672	33,830	36,130	427,390	5,318
1924	1,111,770	25,960	35,000	166,460	879,200	5,150
1925	153,280	14,840	35,000	90,260	9,730	3,450
1926	394,960	33,780	35,000	84,280	238,120	3,780
1927	293,320	26,830	35,000	102,760	123,690	5,040
1928	316,260	29,570	35,000	90,130	160,720	840
Avg.	421,303	*26,460	34,894	95,919	260,075	*3,954

* The maximum diversion of the Western Canal in 1920 was reported as 290 Sec. Ft. in June and in October. All of the undivertable surplus occurred early in April each year and could have been diverted by the Western Canal above their normal irrigation requirements. This addition would bring the annual average diversions of the Western Canal up to 30,414 acre-feet.

ARTICLE VIII

General Summary of Surplus Flows in South Platte Basin

Table No. 10 above gives the annual average surplus flows available for additional storage in mountain districts 3, 4, 5, 6, 7 and

9, and on page 21 it is stated that the present surplus in District 23, under present operating conditions, is 43,000 acre-feet, annual average.

Table No. 15 gives the average annual storable surplus above minimum flow points in the entire South Platte Basin, under terms of the Compact with Nebraska.

If the above data are combined, the following annual summary is obtained for the total surplus flows that could be stored and made available for irrigation, in addition to present facilities as now operated.

TABLE NO. 17

General Summary - Surplus for Storage - South Platte Basin

Dist. No.	Avg. Annual Storable surplus	Period for Average
3	46,000 A. Ft.	1918-1928
4	28,800 "	" "
5	20,000 "	" "
6	16,900 "	" "
7	27,300 "	" "
9	11,200 "	" "
23	43,000 "	1902-1919
64	34,900 "	1918-1928
So.Platte Valley	66,900 "	" "
Total	295,000 A. Ft.	

Practically 150,000 acre-feet additional may be stored annually on the average, in mountain districts 3 to 9 incl., 43,000 acre-feet for city water supply in district 23, 35,000 acre-feet, to be diverted between Iliff and Crook in District 64, and about 67,000 acre-feet on the South Platte River between Districts 23 and 64.

In case channel storage on any of the mountain tributaries proves impractical, the surplus on such tributary can be added to that available on the South Platte River.

Water available for storage on some of the mountain tributaries will be increased, eventually by construction of transmountain projects.

A R T I C L E   IX

Reservoir Sites in South Platte Basin for Additional Storage

Storage possibilities on the Cache la Poudre River in District No. 3 have been covered in a report of the Bureau of Reclamation dated May, 1928.

The following table summarizes the channel reservoir possibilities for additional storage in District No. 3.

TABLE NO.18

Proposed Channel Reservoirs, District No. 3

Reservoir	Available Capacity, Acre-Ft.	Avg. Ann. Yield Acre-Ft.	Estimated Cost $	Cost per A. Ft. Capacity	Cost per A. Ft. Yield	Type of Dam
Bellvue	52,000	22,000	$3,747,000	$72	$170	Earth fill, Ambursen spillway
Elkhorn	50,000	20,000	3,790,000	76	190	Concrete arch.
" (1)	37,000	17,000	1,832,000	50	108	Earth & rock fill
Halligan	21,680 (2)	8,000	588,000	27	74	Concrete Arch (3)

(1) Reservoir proposed by M. C. Hinderlider.
(2) Added capacity to 6,320 acre-feet, present capacity.
(3) Upstream enlargement of present dam (max. practical development)

Eight reservoir and dam sites in other water districts were surveyed by engineers of the War Department during the summer of 1930. Preliminary geological examinations were made by Professor C. H. Wentworth at each site but no drilling has been done to determine foundation conditions. Preliminary estimates of quantities, costs and drawings are given in detail in another chapter of this report.

Following, is a summary of new reservoir possibilities in other water districts of the South Platte than District No. 3:

TABLE NO. 19

Reservoir Site	Located on:	Available Capacity Acre-Ft.	Estimated Cost	Cost per Acre-Ft. Capacity	Type of Dam
Sedgwick System	So. Platte River	35,000	$1,971,000	$56.	Earth Dykes-Concrete Face.
Arkins	Big Thompson R.	32,700	2,006,000	61.	Earth and Gravel Fill
Mt. Olympus	" " "	28,400	1,480,000	52.	Concrete Arch
No. St. Vrain	No. St. Vrain Cr.	30,000	2,186,000	73.	Earth & Gravel Fill
So. St. Vrain	So. St. Vrain Cr.	20,000	2,027,000	101.	Earth & Gravel Fill
Floyd Hill	Clear Creek	33,000	5,794,000	175.	Concrete Arch
Empire Sta.	Clear Creek	60,000	5,922,000	99.	Rock-Fill, Concr. Face
Kittredge	Bear Creek	21,000	3,340,000	159.	Concrete Gravity

Note: All of the above sites are located in stream channels with the exception of the Sedgwick System, which would be supplied by a feeder canal from the South Platte River and a diversion dam in the vicinity of Iliff.

ARTICLE X

REPORT ON CRUISE OF IRRIGATED AREA
IN SOUTH PLATTE BASIN IN COLORADO
1930

A cruise of the area of lands irrigated by the South Platte River and its tributaries in Colorado, was carried on during the summer of 1930.

The cruise started with one party with automobile, driver and cruiser, sketching irrigated areas on township plats, and was concluded with four such parties in the field. The scale of the township plats used was 1 mile = 2 inches. Ditches, reservoirs and roads were located on the plats in the office according to existing maps, and checked and corrected in the field at the time the areas irrigated, were measured. Usually distances were determined by speedometer reading, although pacing was used in some instances. In cases where there was doubt as to whether a tract was irrigated or not it was the practice to inquire of the owner or a neighbor.

The areas cruised show what was irrigated, sub-irrigated and seeped at the time the examination was made, or for the season of 1930. Areas which had been irrigated at some previous time but were receiving no water in 1930, were excluded.

The principal irrigated portions of Water Districts 1, 2, 3, 4, 5, 6, 7, 8, 9 and 64 were thus cruised.

There were scattered areas on intermittent streams in several of the districts which were not cruised on account of the difficulty involved in determining them, and lack of time.

These non-cruised areas were given in the water commissioners' reports for 1930 as follows:

District No.	Area Irrigated in 1930 but not cruised.
1	17,912 acres
4	1,790 "
5	11,600 "
8	5,841 "
64	5,001 "
Total	42,144 "

No cruise was made for District No. 23, comprising South Park. The irrigated area of this district as estimated by Engineer Geo. M. Bull is 48,000 acres. This acreage was confirmed by H. C. Bishop, Assessor for Park County.

The total area actually cruised in 1930 is as follows:

SOUTH PLATTE BASIN

AREAS CRUISED, 1930.

Acres irrigated 1930 - - - - - - - - - -	974,268
" sub- " 1930 - - - - - - - - - -	36,739
Total irrigated & sub-irrigated - -	1,011,007
Total seeped area, 1930 - - - - - -	26,512
Total acres actually cruised, 1930 -	1,037,519

The cruised areas were segregated by water districts and non-cruised areas added to district totals where these occurred, for comparison with areas as reported by the various water commissioners as follows:

COMPARISON IRRIGATED AREAS IN SOUTH PLATTE BASIN IN 1930 - BY CRUISE & BY WATER COMM'RS. REPORTS

District No.	Acres Irr. in 1930 By Area Cruise*	Acres Irr. in 1930 Reported by Water Commiss's.	PerCent Diff.	Acres Irrig. As Reported in 1922
1	124,731	145,683	- 14%	140,261
2	158,044	216,082	- 27%	180,594
3	244,920	266,540	- 08%	265,940
4	89,915	142,130	- 37%	140,060
5	87,524	85,115	+ 03%	68,825
6	72,142	169,168	- 57%	86,875
7	75,907	104,893	- 28%	102,620
8	46,434	47,840	- 03%	55,544
9	17,765	13,812	+ 22%	20,348
64	135,772	162,682	- 17%	125,758
23	48,000	48,000	- - -	48,000
TOTAL	1,101,151	1,401,975	- 21½%	1,234,825

* Includes acreage irrigated from streams of intermittent flow.

Hemphill's cruise of 1917, part of which was used for our 1930 areas, showed the area irrigated in District No. 3 to be about 11% less than that reported by the Water Commissioner, and Hemphill explained the difference as mainly due to duplicated areas. Our difference for 1930 is only 08% less than that reported for that year. The area cruise also shows close conformity to the areas reported by the Water Commissioners for Districts 5 and 8. District 9 would have checked closely but for the incompleteness of the Water Commissioner's report which left out areas which used water.

Areas reported by Water Commissioners for Districts 1 and 64, do not vary greatly from the results shown by the cruise.

The Water Commissioners for Districts 2, 4, 6 and 7 (especially 6) appear to be reporting much more land as irrigated, than can be accounted for.

In District 6, the Water Commissioner reports more land as irrigated in 1930 than was covered by all the ditches originating in the district.

The following table is a summary of the cruised areas as taken from the township plats on which the cruised areas were platted in the field:

SUMMARY CRUISED AREA BY WATER DISTRICTS
SOUTH PLATTE BASIN - 1930

Water District	Irrigated Acres, 1930	Sub-Irrigated Acres, 1930	Total Acres Irrigated and sub-irrigated	Seeped Acres, 1930	Total Acres Cruised includ. Seeped Areas
1	102,532	4,287	106,819	3,145	
2	148,003	10,041	158,044	3,909	
3	242,199	2,721	244,920	1,323	
4	86,444	1,681	88,125	1,144	
5	71,618	4,306	75,924	1,061	
6	68,472	3,670	72,142	756	
7	75,652	252	75,904	547	
8	38,795	1,798	40,593	545	
9	17,765	-----	17,765	83	
64	122,788	7,983	130,771	13,999	
TOTALS	974,268	36,739	1,011,007	26,512	1,037,519

ARTICLE XI

REPORT ON

SOUTH PLATTE RIVER INVESTIGATIONS

Contents

REPORT ON

SOUTH PLATTE RIVER INVESTIGATIONS

Contents (Cont'd)

REPORT ON

SOUTH PLATTE RIVER INVESTIGATIONS

Contents (Cont'd)

CHAPTER I.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1
WATER DISTRICT NO. 1 - WATER SUPPLY

Contents

CHAPTER I.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

WATER DISTRICT No. 1 - WATER SUPPLY

I. Water Supply Records.

The main water supply of District No. 1 is that which enters it from Districts 2 and 3. These combined amounts of water are measured at the Kersey gaging station on the South Platte River, below the mouth of the Cache La Poudre River, which station was established by the State in 1901. Records are incomplete prior to 1910, and 1913 is missing. Return flow is an important part of the available supply, and some water is obtained from several creeks of intermittent flow, of which records are not kept.

TABLE NO. 1

RUN-OFF SOUTH PLATTE RIVER AT KERSEY - MEAN DAILY IN SEC. FEET

Dist. No. 1

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Feet
1910	1200	976	(1000)	(1031)	860	984	386	232	97	96	96	105	426,060
1911	376	422	335	456	371	301	122	84	149	195	123	102	182,960 Min.
1912	291	432	363	357	340	430	335	619	1507	2504	986	523	527,210
1913	620	802	-	-	-	-	-	-	-	-	-	-	(No record)
1914	(698)	(766)	(677)	1350	1860	1440	3040	8010	5480	796	1730	561	1,590,600 Max.
1915	836	852	(750)	618	704	672	1980	3460	2700	408	445	395	834,600
1916	1240	973	788	(630)	(921)	648	517	450	234	122	321	(213)	426,360
1917	(964)	791	737	619	599	638	539	3930	6230	1310	180	265	1,014,800
1918	634	622	655	571	620	485	532	297	2312	1695	275	628	516,900
1919	795	798	865	918	796	539	595	426	114	137	404	249	399,700
1920	474	679	(600)	521	539	383	837	2440	1030	324	488	323	523,200
1921	635	791	674	512	533	349	1090	1680	12000	851	771	335	1,211,600
1922	511	628	822	603	553	597	532	151	106	114	129	115	292,880
1923	146	337	445	480	617	640	430	441	6000	1450	1250	625	772,680
1924	1520	2280	1200	1230	1230	1230	3240	3020	6710	237	173	367	1,350,300
1925	498	488	514	508	594	420	179	73	209	157	283	162	245,470
1926	578	716	620	514	583	450	2550	2950	3340	1090	197	210	831,500
1927	561	688	562	587	482	496	796	455	460	418	676	273	389,700
1928	678	504	571	610	548	527	324	2210	2260	923	273	229	584,700
Average	698	766	677	673	708	624	1001	1718	2830	713	489	316	675,900
Average 1918-28	639	776	684	641	645	556	1010	1286	3140	672	447	320	651,240

Note: Figures enclosed thus ( ) have been estimated.

2. Temperature and Precipitation at Fort Morgan.

Fort Morgan is centrally located in District No. 1. The local U. S. Weather Bureau Station has recorded temperatures here since 1899 and rainfall since 1888.

Tables Nos. 2 and 3, below, give the monthly and annual mean temperature and monthly and annual inches of precipitation for the period 1921 to 1928 and normals for the whole periods of record.

TABLE NO. 2

MONTHLY AVERAGE TEMPERATURES, DEGREES FAHRENHEIT, AT FORT MORGAN

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual
1921	25.0	29.6	40.6	43.8	55.6	66.8	75.2	73.2	64.4	55.8	41.6	28.6	50.0
1922	15.4	23.0	33.2	40.1	53.8	63.7	-	-	61.2	44.4	31.4	25.7	-
1923	29.3	20.2	27.2	42.6	50.7	62.3	69.0	64.8	56.4	40.6	35.2	20.6	43.2
1924	17.4	29.5	23.3	42.0	47.5	62.8	67.0	67.8	54.8	47.8	35.6	13.9	42.4
1925	15.2	32.8	37.3	47.0	55.0	64.6	71.8	68.4	61.8	42.6	36.2	27.0	46.6
1926	24.6	36.4	38.6	48.3	58.4	67.4	70.7	69.9	58.0	49.4	37.4	19.4	48.2
1927	27.6	32.5	33.0	47.0	58.6	62.4	68.4	65.0	60.3	50.8	39.4	18.8	47.0
1928	29.2	27.8	38.6	44.3	56.8	59.4	69.0	66.3	58.6	49.2	35.3	20.8	46.3
Average 30 years	24.1	27.8	35.7	46.7	56.4	66.6	73.1	71.0	62.0	49.2	36.6	25.3	47.9

TABLE NO. 3

INCHES OF PRECIPITATION AT FORT MORGAN

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual
1921	2.03	0.03	0.70	1.10	1.23	1.55	2.00	1.71	0.48	0.67	T	0.11	11.61
1922	0.00	-	0.10	2.80	2.59	1.46	0.77	1.07	0.00	0.14	2.31	0.25	-
1923	T	0.07	0.56	1.51	2.90	2.06	2.17	1.94	1.58	1.41	T	0.34	14.54
1924	0.10	0.36	0.91	0.32	3.56	0.48	0.25	0.62	3.14	0.87	T	0.17	10.78
1925	0.04	0	0.23	0.75	0.98	2.46	1.58	2.61	0.66	1.27	0.82	0.78	12.18
1926	0.34	0.09	0.39	0.41	2.54	2.03	3.76	0.78	0.58	0.51	0.15	0.40	11.98
1927	0.01	0.46	0.91	2.06	0.58	4.81	2.49	1.50	1.57	0.19	0.44	0.18	15.20
1928	0.00	0.08	0.38	0.42	2.32	4.00	3.80	0.43	T	2.13	0.56	0.00	14.12
Average 41 years	0.28	0.41	0.69	1.77	2.36	1.83	2.49	1.65	0.92	0.85	0.35	0.38	13.98

3. Seepage and Return Flow in District No. 1

The Colorado Agricultural College Experiment Station bulletin No. 279 by Ralph L. Parshall, gives the results of continuous seepage records in Districts 1 and 64 during the latter half of 1919 and for the whole year of 1920, with the exceptions of the last 20 days in November and the month of December.

Mr. Parshall regarded a number of drainage streams, which carry both seepage water and surface run-off, as inflow. In the spot seepage measurements made by R. G. Hosea and the State Engineer, these drains were taken as seepage return.

For purposes of comparison, Mr. Parshall's determinations have been changed to include the drainage water as return flow, and are so shown in the following table.

TABLE NO. 4

SUMMARY OF RETURN FLOW - DIST. NO. 1. KERSEY TO BALZAC
FROM PARSHALL'S BULLETIN NO. 279 - MEAN SEC. FT.

1919 Month	From Parshall's Table 12 (Sec. Ft.)	Parshall's Results Adjusted to Include Drainage Streams	
July	389	454	
Aug.	420	482	
Sept.	493	547	
Oct.	463	506	
1920			
Jan.	398	441	
Feb.	418	461	
Mar.	421	467	
Apr.	417	470	
May	335	407	(High Water)
June	466	549	
July	451	530	
Aug.	431	509	
Sept.	591	667	
Oct.	520	590	
Mean	444 sec. ft.	506	
Av'g. Apr.-Sept.	444	513	
Av'g. Winter Mos.	444	493	

TABLE NO. 5

R. G. HOSEA'S SERIES OF MEASUREMENTS
KERSEY TO BALZAC - SECOND FEET

Year	Mean in s.f. for Storage Season	Mean in s.f. for Irrigation Season	Mean in s.f. for Year
1916	615	505	560
1917	629	530	580
1918	638	550	594
Av'g.	627	528	578

TABLE NO. 6

SEEPAGE MEASUREMENTS FROM STATE ENGINEER'S REPORTS
KERSEY TO BALZAC - (66 Miles)

Year	Month	Return Flow Second-Feet	
1907	Oct. - Nov.	285.90	River rose at Kersey during measurement
1908	" "	409.19	
1916	-	660.00	
1925	Nov.	498.50	
1926	Nov.	558.00	
1927	Oct.	608.40	
Av'g.		503.33	
Av'g.			
Without 1907		546.82	
Without 1907 & 1908		581.22	Av'g. 1916-1927

A later measurement made by State Engineer in Apr., 1930, gave 589.7 sec. ft.

TABLE NO. 7

SEEPAGE RETURN IN DIST. NO. 1 AS REPORTED
BY WATER COMMISSIONER IN 1928

1928 Month	Av'g. Reported Return Flow (s.f.)	1928 Month	Av'g. Reported Return flow (s.f.)
Jan.	650	July	612
Feb.	600	Aug.	626
March	555	Sept.	658
April	500	Oct.	700
May	552	Nov.	700
June	612	Dec.	697

Annual Average - 622 sec. ft.

The return flow as reported by Water Commissioner Cutler is the difference between the sum of the water diverted in the district and passing out of the district, and the amount entering the district. For the months of Oct., November and December, it included from 50 to 175 sec. ft. diverted for stock and factory use, most of which water is wasted back into the river. Therefore, the return as reported for these months averages about 100 second feet too much and the annual average should be about 600 second feet.

Mr. Parshall in his bulletin No. 279 shows that the October return for 1919-1920, "does not show good agreement with the mean return for the 14 months' period when taken for the individual or intermediate sections: however, when the entire distance, Kersey to Julesburg, is considered, the October return shows almost an exact agreement."

Referring to Table No. 4 above, Parshall's results adjusted, shows the mean return for October 1919 and 1920 is 548 second feet, and the mean for the 14 months of 1919 and 1920 is 506 second feet, or about 8% less than the October mean for the river section between Kersey and Balzac.

Parshall's average return for the irrigation season, is a little greater than that for the storage season, while Hosea shows less for the irrigation season.

If the latest available seepage determinations from all sources are averaged, results are as given in the following table:

TABLE NO. 8

MEAN ANNUAL SEEPAGE RETURN, DISTRICT No. 1, IN RECENT YEARS

Date of Measurement	Authority	Return Flow Second Feet	Remarks
Annual, 1918	R. G. Hosea	594	See Table No. 5
14 mos. 1919-20	Ralph L. Parshall	506	Adjusted for Comparison, (Table No. 4)
Oct. 1927	State Engineer	608	See Table No. 6
Annual, 1928	Water Commis'r.	600	Oct., Nov. & Dec. adjusted, (Table No. 7)
Apr., 1930	State Engineer	590	
Average	Ann. Return 1918-30 -	580	

According to the data at hand, the mean annual return flow for the period 1918-1928, appears to be about 580 second feet or 420,000 acre-feet per year. For the 66 miles of river in this district, the average return amounts to 8.8 second feet per mile which is the largest rate recorded anywhere in the South Platte Basin.

4. Use of Water for Irrigation in District No. 1

The Main water supply entering this district is given below:

TABLE NO. 9
AVERAGE ANNUAL WATER SUPPLY ENTERING DIST. NO. 1

Origin of Supply	Av'g. Annual Run-Off, Ac.-Ft.	Remarks
So. Platte R. at Kersey	651,200	Av'g. 1918 to 1928, incl.
From Seepage Return	420,000	580 S.F. Ann. Av'g. 1918-1930
Total Average Supply	1,071,200	A. ft. per year.

For the 197,486 acres irrigable and 164,138 acres irrigated in 1928, the above supply amounts to 5.42 acre-feet per acre and 6.52 acre feet per acre, respectively. It is needless to add that a large part of the water entering this district passes downstream for use in District No. 64.

TABLE NO. 10
GROSS USE OF WATER BY CANALS FOR IRRIGATION DIST. NO. 1
Acre-Feet

Year Ending Sept.30	Run-Off So. Platte at Kersey	Diverted by Ditches from Natural Flow	Diverted From Storage	Total Diverted For Irrig.	Total Acres Irrigated in Dist. No. 1	Ac.-Ft. Div.per Acre Irr.
1921	1,211,600	402,086	61,428	463,514	121,105	3.83
1922	292,880	228,749	*132,978	361,727	140,261	2.56
1923	772,680	326,221	*201,200	527,421	143,149	3.68
1924	1,350,300	237,336	*216,465	453,801	160,877	2.82
1925	245,470	213,156	125,751	338,907	157,098	2.16
1926	831,500	359,699	193,320	553,019	162,676	3.39
1927	389,700	296,664	173,850	470,514	157,468	2.99
1928	584,700	315,134	188,633	503,767	164,131	3.07
Av'g.	709,850	297,381	161,703	459,084	150,846	3.06

*Estimated from Water Commissioner's Weekly reports.

While the average diversions for all ditches indicated no shortage of water for this district, the Water Commissioner usually reports considerable shortage for junior rights. This seems to be due to the practice of allowing senior appropriators to take an excessive amount of water at times, leaving to the junior appropriators what is left.

5. Canal Diversions in District No. 1

TABLE NO. 11

LIST OF CANALS DIVERTING FROM THE SO. PLATTE RIVER IN DISTRICT NO. 1, IN THE ORDER OF GEOGRAPHICAL LOCATION ON THE RIVER

Ident. No.	Name of Ditch	Years of Priority	Am't. of Decree (s.f.)	Maximum Capacity	Area Under	Area Irr. in 1928
1.	Hoover	1884	23.00	23	1280	1251
2.	Empire	1906	575.00	550	Under	Bijou
2a.	Riverside Inlet	1902-07	(1240.00)	(1000)	To Riverside Reserv.	
3.	Riverside Irr. Dist.	1876-07	308.00	295	31,500	23,946
4.	Hardin	1873-84	13.00	25	800	800
5.	Bijou	1871-1900	596.32	500	40,000	29,920
6.	Corona Ranch	1875-86	56.00	15	1,200	1,200
7.	Schultz	1871-88	28.00	25	800	800
8.	Putnam (under Bijou)	1880-82	40.00	40	2,800	2,742
9.	Weldon Valley	1881	165.00	165	12,000	8,710
10.	Ft. Morgan	1882	323.00	350	15,000	14,850
11.	Upper Platte & Beaver	1868-88	234.17	250	14,000	12,870
12.	Deuel & Snyder	1871-88	84.00	70	3,200	2,915
13.	Lower Platte & Beaver	1882-88	322.00	340	18,000	16,825
14.	Tremont	1901	150.00	125	2,500	2,137
15.	Gill and Stevens	1889	23.00	10	1,000	1,000
16.	Snyder	1902	175.00	50	3,500	2,046
17.	Trowell	1900	90.00	25	2,500	2,000
18.	A. A. Smith	1887	20.00	30	1,500	1,475
19.	Union	1901	46.87	20	2,000	1,888
20.	Tetsel	1874-82	37.00	40	1,300	1,284
21.	Johnson & Edwards	1872-86	63.00	50	4,500	3,962
	Totals -		3,332.36	2998	159,380	132,621

TABLE NO. 12

LIST OF DITCHES NOT DIVERTING FROM SO. PLATTE RIVER

DISTRICT NO. 1

Name of Ditch	Years of Priority	Amount Decreed	Maximum Capacity	Area Under	Area Irrig. 1928
From Box Elder Creek					
Klug	1891-06	580.00	500	3,000	1,595
Lone Tree Creek					
H. W. BacKing	1904	4.10	68	140	140
J. B. Cooke	1887	Not stated	35	1,920	1,920
Dover Reservoir	1911	" "	22	600	600
Henry Johnson	1908	2.22	97	320	320
Munson & Mimmac	1881-88	4.50	37	345	345
Roberts Lateral	1900	5.00	54	350	350
Ward	1885-95	7.00	19	155	155
Big Crow Creek					
Hereford	1910	Not stated	no record	1,500	1,200
Porter Creek	1907	4.00		1,200	780
O. T. Perry	1902	5.00		240	240
Camfield	1884-85	83.00		640	640
Seven Cross	1884	26.23		800	800
Big Beaver Creek					
Beaver Farmers	1889	308.00	308	7,680	3,800
Beaver Creek Ditch	1889	16.00	20	500	345
Beaver Creek School Land	1898	50.00	30	Upper Platte & Beaver	
Bushman	1898	152.00	150	750	750
Wylie, Light & Follman	1895	27.50	30	1,000	1,000
Big Beaver	1882	44.00	44	807	807
Hunt		no decree	no record	680	680
Comanche Creek					
Comanche	1889	4.00	10	160	160
*Living Springs #1 & #2	1903	79.20	80	600	600
Washita	1907	17.82	no record	500	350
Kiowa Creek					
Desert Ditches	1895	140.00	140	1,500	1,200
Gleason	1908	5.16	6	250	250
Eglehoff-Grove	1893	46.00	46	300	300
Geo. A. Wood	1883	3.00	5	150	150
D. C. Bailey	1888	5.50	6	200	200
Aux.	1875-87	3.50	5	160	160
Oaks 1 & 4	1866-68	5.00	5	160	160
Deitrich #1 & #2	1878-79	4.00	6	320	320
Wendling	1868	5.00	5	120	120
Fred Bachman	1881-82	6.50	10	300	300
McGuire	1896-11	15.00	20	750	750
TOTALS		1,657.73	1758	28,097	21,487

* Reported by W. C. as Comanche #1 and #2

The Aggregate daily diversions of all canals diverting from the South Platte River in District No. 1 during the good water year of 1926 is given below in Table No. 13:

TABLE NO. 13

TOTAL DAILY DIVERSIONS FROM SOUTH PLATTE RIVER IN DISTRICT NO. 1
SEASON OF 1926 - IN DAILY MEAN SECOND-FEET

Day	April	May	June	July	Aug.	Sept.	Oct.
1	150	1652	1329	576	761	646	767
2	150	1652	1329	576	761	646	747
3	150	1669	1313	799	761	646	695
4	150	1669	1313	794	686	735	795
5	181	1669	1463	843	686	777	740
6	221	1669	1445	632	661	745	740
7	258	1519	1490	632	650	766	749
8	258	1282	1500	614	600	766	762
9	253	1262	1473	427	558	766	667
10	253	1262	1398	462	543	766	657
11	539	1045	1231	557	660	921	654
12	777	1025	1201	569	697	906	674
13	752	1043	1083	737	724	855	674
14	836	979	1099	949	713	855	663
15	1061	979	1018	949	627	855	663
16	1221	969	930	945	730	760	636
17	1241	1074	535	1054	723	613	626
18	1172	764	475	1126	723	620	706
19	1274	764	459	1401	721	641	696
20	1330	808	514	1404	721	646	696
21	1370	873	576	1200	726	651	682
22	1430	893	588	1178	701	775	682
23	1438	893	783	1050	701	785	666
24	1418	997	992	752	638	805	636
25	1450	1429	1147	734	623	745	906
26	1490	1675	982	739	623	810	806
27	1432	1405	955	757	601	825	806
28	1432	1437	824	757	601	825	806
29	1432	1474	714	739	596	825	786
30	1432	1474	714	739	614	825	786
31	----	1309	---	739	614	---	786
Total	26551	38614	30873	25430	20744	22802	22355 Total
A.-Ft.	52700	76600	61200	50450	41150	45200	44330 for Season 371,630
% Total	14	21	16	14	11	12	12 Ac.Ft.

6. Principal Reservoirs in District No. 1 Filled From Diversions in District No. 1.

TABLE NO. 14

Name of Reservoir	Acre-Feet Amount Decreed	Acre-Feet Maximum Capacity
Empire	37,710	37,700
Riverside	57,507	57,500
Bijou No. 2	9,183	9,183
Jackson Lake	35,629	35,445
Adams **	11,050	9,525
Bootleg *	6,190	6,190
Totals	157,269	155,543

** Not in use
* Not reported by W. C.

Total Number of reservoirs in District No. 1 - 25

Total capacity of reservoirs in District No. 1 - 168,500 acre-ft.

TABLE NO. 15

MAXIMUM STORAGE EACH YEAR 1921-28 IN RESERVOIRS - DISTRICT NO. 1

Year	Date	Amount in Storage A.-Ft.	Remarks		
1921	May 1	127,672	4	reservoirs	reported
1922	"	121,308	15	"	"
1923	"	114,925	19	"	"
1924	"	124,247	24	"	"
1925	April 1	119,959	4	"	"
1926	June 1	136,044	12	"	"
1927	May 1	125,294	12	"	"
1928	June 1	135,820	10	"	"

7. Reservoir Sites for Additional Storage in District No. 1

There are several proposed schemes for providing additional storage in this district, by enlargement of present reservoirs, and by construction of new reservoirs in the South Platte River channel. They are summarized as follows:

TABLE NO. 16

Name Reservoir or Enlargement	Filing No. & Year	Height Dam	Capacity Acre-Feet	Remarks
1. Empire Res.Enl'rgm't	7,217-1910	31 ft.to 44 ft.	14,500	Enl'rgmt. Sup. Statement filed
2. Riverside Res. "	8,442-1911	29 ft.to 41 ft.	25,000	" "
3. Riverside No. 2 or Wildcat Res.	7,830-1910	80 ft.	42,500	Lapsed
4. Old Fort Res.	7,071-1910	55 ft. to H. W.	69,000	Sup.Stm't.filed
5. Narrows Res.	6,820-1910	100' to H.W.L.	660,000	Lapsed

Empire Reservoir Enlargement

The present Empire Reservoir has a decreed capacity of 37,710 acre-feet. It fills practically every year through the Empire Canal, with 550 sec. ft. capacity. It delivers all of its stored water to the Bijou Canal (500 s.f.) which has 40,000 acres under it, with 29,920 acres irrigated in 1928. This reservoir is owned by the Bijou Irrig. District. There are 8 dikes around this reservoir with a total length of nearly 5 miles.

The filing for enlargement by the district, contemplates raising the present dams or dikes from 31 feet, maximum height, to 44 feet and storing an additional 14,500 acre-feet of water to be used on lands in the irrigation district. The estimated cost of enlargement is given as $155,000, "approximate". There is no spillway for this reservoir. It is not intended to enlarge the feeder canal or outlet.

A supplemental statement was filed in 1920, in which it was stated that considerable work had been done in widening the bases of the fills and in placing rip rap in preparation for raising the dikes. It was estimated that the enlargement would be completed in 5 years (following 1920). The dikes have not yet been raised, however.

Riverside Reservoir Enlargement

The Riverside Reservoir of the Riverside Irrigation District has a decreed capacity of 57,500 acre-feet and uses the greater part of this capacity every year. The Riverside inlet canal carries up to 1,000 second feet. The greater part of the stored water goes to the Riverside Outlet Canal for the Riverside Irrigation District lands. The irrigable area of the district is given as 31,500 acres, with 23,946 acres irrigated, in 1928. The reservoir also feeds other canals in District No. 1, directly via the river or thru exchange. These canals are the Bijou, Hoover, Upper, and Lower Platte and Beaver.

In the enlargement filing No. 8442 filed by the irrigation district in 1911, it is intended to raise the water surface 6 ft., thereby storing an additional 25,000 acre-feet of water for use in District No. 1. The estimated cost of the enlargement is given as $400,000.

A supplemental statement declaring the intention of the irrigation district to carry out the proposed work was filed in 1919. The dikes are still at their original elevations.

Riverside No. 2 or Wildcat Reservoir

This is a site on Wildcat Creek under the Riverside Outlet canal of the Riverside Irrigation District.

The original filing No. 4890, entitled the Wildcat Reservoir, made in 1908, contemplated a dam 70 ft. high, capacity 28,500 acre-feet and estimated cost of $175,000.

In 1910, the Riverside Irrigation District filed an amended map and statement (No. 7830), designated Riverside Reservoir No. 2, covering the same site. The map has a scale of 1" = 600'.

In this filing the dam is 80 ft. high, capacity 42,500 acre-feet and the estimated cost of enlargement over filing No. 4890, $148,000. This would make the total estimated cost of the reservoir, as enlarged, amount to $323,000.

The water supply was to be obtained from Wildcat and Spring Creeks and from the South Platte River via the Riverside inlet Canal, through Riverside Reservoir and via the Riverside outlet canal.

No supplementary statement covering this filing is on file in the State Engineer's office and it is assumed to have lapsed.

Old Fort Reservoir Site

Filing No. 7071 was made by Messrs. Jackson and Ridenour in 1910. The damsite is about 1½ miles above Fort Morgan, and below the mouth of Bijou Creek, in a rather wide part of the South Platte River channel. The reservoir would extend upstream from this point about 8 miles. The maximum depth of storage was to be 55 feet and the reservoir capacity, 69,000 acre-feet. The cost was not given. The filing map is of a preliminary nature made on a scale of 1" = 1000' and shows the topography and the river only. It is probable that about 8 miles of the main line of the Union Pacific Railroad would be submerged as well as the intake of the Upper Platte and Beaver Ditch and the station of Narrows. The Fort Morgan Canal and the Riverside Outlet appear to skirt opposite sides of the reservoir at high water line, and might be adversely affected.

The stored water was to be used for the irrigation of new lands lying in a narrow strip along the south side of the South Platte River in Logan, Sedgwick and Phillips counties, in connection with a proposed Old Fort and Haxtun Canal, (filing No. 7904). This canal was to be an extension of the Lower Platte and Beaver Ditch, leaving this ditch on the upper side at a point about opposite Hillrose and extending around and above the Prewitt Reservoir and present irrigated lands, for about 98 miles to the Haxtun reservoir site in District 65, with an estimated capacity of 20,000 acre-feet.

The Old Fort Reservoir site might be feasible, to supplement the water supply of present ditches, if the cost of acquiring the site doesn't prove prohibitive, but the contemplated 98 miles of outlet canal for new lands seems hardly a practical proposition.

Messrs. Jackson and Ridenour filed supplementary statements in 1920 in which they indicated their intentions of going farther with this scheme, when the market for irrigation securities improved.

<u>The Narrows Reservoir Site</u>

Filing No. 6820 for this site was made in 1910 by the Colorado Engineering and Construction Company of Greeley, Colorado. The filing map is on a scale of 1" = 2000'. It does not show existing improvements.

The proposed dam is at the station of Narrows, about 6 miles upstream from Fort Morgan. The reservoir site extends for a distance of about 14 miles above Narrows.

The height of dam is given as 100 feet to spillway crest, reservoir capacity as 660,000 acre-feet and estimated cost as $5,600,000. The area to be submerged at high water is about 16,000 acres, a great part of which is evidently irrigated farm land.

The map shows a fair dam and reservoir site that could be developed to store a large quantity of water at a reasonable cost, if it were not for existing improvements, such as the Union Pacific Railroad, highways, canals, 4 towns and cultivated farm lands.

The reservoir was intended to supply the Upper and Lower Platte and Beaver Ditches, the north Sterling Irrigation District and other ditches in the vicinity. It is considerably larger than would be justified by the present available storable excess. The canals, which were to have been supplied, have secured other supplemental water supplies.

A dam to provide a maximum storage depth of 60 feet, would store about 200,000 acre-feet at this site, and a depth of 80 ft. would store about 390,000 acre-feet.

No supplemental statement is on record for this filing, and it is considered to have lapsed.

CHAPTER II

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

WATER DISTRICT NO. 2 - WATER SUPPLY

Contents

CHAPTER II

SOUTH PLATTE RIVER SYSTEM - DIVISION NO. 1

WATER DISTRICT NO. 2 - WATER SUPPLY

1. Water Supply Records

The water used in District No. 2 is derived from the South Platte River inflow at the Denver gaging station, from Clear Creek, Dry Creek, St. Vrain Creek, Big Thompson River, seepage return and from several small creeks of intermittent flow.

The South Platte River gaging station at Denver, which provides a record of the main supply of the district, has been in operation since May 7, 1895. Lake Cheesman storage releases have affected flows at this station since 1901 and from Antero Reservoir, since 1909.

Records are available at the mouth of Clear Creek from April 1, 1914 to Nov. 30, 1914 and from Feb. 25, 1927 to date; at the mouth of the Big Thompson River from April 1 to Nov. 30, 1914 and from March 1, 1927 to date. Flows for other periods have been estimated by the district Water Commissioner.

The following table gives the recorded run-off of the South Platte River at Denver since 1909, the period during which conditions have been similar as regards upstream reservoir operations:

TABLE NO. 1

RUN-OFF SOUTH PLATTE RIVER AT DENVER IN MEAN DAILY SECOND-FEET
DRAINAGE AREA - 3840 SQ. MI. - ALTITUDE - 5240 FT.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Feet
1909	(125)	(110)	(120)	(80)	(75)	(100)	(140)	(325)	(830)	(750)	(775)	1787	320,710
1910	564	324	194	268	190	501	372	492	304	187	374	120	235,790
1911	110	90	90	123	96	81	123	207	343	595	270	132	137,050
1912	104	89	98	70	63	89	79	379	874	971	756	274	233,560
1913	222	256	(180)	(120)	(90)	(95)	(400)	457	690	407	274	235	207,010
1914	(251)	(225)	(244)	342	358	510	1920	2880	1960	1500	2305	434	784,120
1915	370	330	252	(188)	189	247	1480	1170	1210	353	427	383	398,000
1916	400	255	229	183	177	182	145	430	509	397	445	228	217,330
1917	205	162	148	138	119	132	176	1070	1770	603	470	248	316,650
1918	162	123	138	106	120	112	319	529	1000	818	356	320	248,030
1919	251	231	189	164	133	161	597	1200	876	683	841	393	346,590
1920	149	144	156	146	116	98	234	1340	523	740	606	314	277,870
1921	162	149	147	101	115	135	717	1270	3850	1120	1130	406	561,170
1922	197	220	196	169	166	160	362	514	556	376	451	211	216,360
1923	165	147	189	144	151	143	145	321	800	1060	1600	636	333,810
1924	836	673	379	324	414	293	848	1320	1530	532	246	187	458,000
1925	194	149	171	185	150	80	65	167	206	221	322	263	131,410
1926	151	165	122	94	119	182	989	1470	1220	783	379	208	355,810
1927	101	164	112	116	118	150	183	353	395	472	390	247	169,560
1928	124	122	121	103	97	120	130	787	733	379	284	150	191,070
Av'g.	242	206	174	158	153	179	471	834	1009	647	635	359	307,000
Av'g. 1919-1928	233	216	178	155	158	152	427	874	1069	637	625	302	304,170
Av'g. A.Ft. 1919-28	14,300	12850	10940	9530	8770	9340	25400	53700	63600	39100	38400	17950	
Av'g. 1918-28	227	208	174	151	155	148	417	843	1063	654	600	304	299,060

Note: Figures enclosed thus ( ) have been estimated by comparison with record at South Platte.
79% of the average flow for the period 1918-28, incl., occurred during the irrigation season or from April 1 to September 30.

TABLE NO. 2

RUN-OFF CLEAR CREEK AT MOUTH IN MEAN DAILY SECOND-FEET
From Estimates by Water Commissioner

Year Ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-Off Acre Ft.
1918	2	14	25	13	10	11	37	45	660	191	5	9	61,341
1919	10	20	14	11	49	55	62	68	8	20	61	4	23,007
1920	5	72	27	15	15	23	99	436	128	26	23	3	52,940
1921	2	99	62	27	10	10	91	266	1107	49	2	2	103,635
1922	2	24	24	16	25	15	25	25	86	73	14	2	19,950
1923	2	6	35	35	40	52	23	46	1104	151	109	15	96,972
1924	46	132	38	28	25	65	51	195	566	31	3	3	71,193
1925	14	20	15	10	10	10	5	4	7	7	5	5	6,752
1926	17	21	21	7	26	18	164	504	831	353	11	7	119,523
* 1927	5	27	11	(20)	(16)	53.4	23.5	54.6	240	78.2	157	15.6	42,440
**1928	22.1	17.5	37.4	34.3	26.1	23.2	11.8	425	543	90.5	25.5	8.4	76,472
Av'g. 1918-28	12	41	28	20	23	30	54	188	480	97	38	7	
Av'g. A.Ft.	738	2440	1720	1230	1276	1845	3210	11560	28550	5960	2336	416	61,300

* Mar.-Sept. from State gaging sta. record. Jan.-Feb., estimated.

** All from State gaging sta. record.

TABLE NO. 3

RUN-OFF ST. VRAIN CREEK AT MOUTH IN MEAN DAILY SEC. FEET

From Water Commissioner's Estimates and State Gaging Station

(Left-hand, Dry, Boulder and Idaho Creeks Empty into the St. Vrain Above its Mouth)

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1918	29	30	29	30	30	58	70	76	716	244	96	98	90,600
1919	116	92	82	83	81	81	64	44	49	60	69	23	51,000
1920	52	52	58	46	60	60	142	381	108	81	51	50	69,200
1921	37	41	41	41	40	40	179	414	1256	101	41	44	136,700
1922	50	45	42	40	40	40	45	61	44	49	62	48	34,200
1923	33	39	40	40	40	44	55	247	1182	305	42	42	127,000
1924	132	178	109	88	59	74	263	355	572	73	107	64	125,100
1925	54	44	42	40	40	40	35	35	37	67	46	33	31,000
1926	66	60	62	62	60	63	385	250	147	66	74	43	80,700
1927	52	50	45	(100)	(80)	104	219	204	248	207	269	156	104,700
1928	149	117	114	127	88	118	101	1150	646	271	159	101	190,880
Av'g.	70.0	68.0	60.4	63.4	56.2	65.6	141.6	292.5	445.0	138.5	92.4	63.8	
A.-Ft.	4304	4050	3714	3898	3120	4034	8430	17985	27080	8520	5682	3795	94,600

TABLE NO. 4

RUN-OFF BIG THOMPSON RIVER AT MOUTH IN MEAN DAILY SEC. FEET

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1918	30	30	29	33	39	45	43	78	582	121	6	15	63,000
1919	43	46	40	37	36	37	34	½	0	0	0	11	17,100
1920	34	38	35	35	35	35	38	217	17	25	28	23	34,200
1921	43	50	44	42	40	40	42	409	1375	33	24	25	130,600
1922	42	48	46	37	34	35	38	1	40	21	12	10	21,900
1923	25	42	45	50	50	50	50	31	2910	326	26	34	217,300
1924	66	193	163	114	91	106	296	774	914	71	18	21	170,700
1925	50	50	50	50	50	50	34	4	5	6	6	8	21,800
1926	30	53	49	46	45	44	233	221	215	62	15	28	62,700
1927	53	50	47	(45)	(45)	55	43	11	36	21	24	18	27,100
1928	90	69	55	45	32	47	16	72	106	93	32	30	41,670
Av'g.	46.0	60.9	54.8	48.5	45.2	49.4	78.8	165.3	563.6	70.8	17.4	20.3	
A-Ft.	2828	3620	3370	2982	2510	3038	4690	10170	33530	4353	1070	1210	73,400

Note: 4 ditches divert from the So. Platte River in Dist. 2, below the mouth of the Big Thompson, with aggregate decrees totaling 356 s.f., capacities of 411 s.f. and irrigate a total of 15,345 acres.

The Cache la Poudre River enters the South Platte just above the lower limit of District 2 but below all diversions in this district.

2. Temperature and Precipitation at Fort Lupton.

Fort Lupton is situated in about the middle of the irrigated lands of District No. 2 and the climatic records there probably represent the average for the whole area.

Weather Bureau records of precipitation have been kept at Fort Lupton since 1911, and temperature records since 1919.

Mean monthly and annual temperatures and monthly and annual rainfall in inches for the period 1921 to 1928 and normals for the periods of record are given below in Tables 5 and 6.

TABLE NO. 5

MONTHLY AVERAGE TEMPERATURES, DEGREES FAHRENHEIT, FORT LUPTON

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	29.7	32.6	43.8	44.8	56.8	67.7	72.5	70.1	62.2	54.1	40.0	31.6	50.5
1922	20.9	28.0	38.2	45.0	58.6	70.6	72.0	73.6	64.6	50.9	34.5	29.6	48.9
1923	34.3	25.2	31.7	47.2	56.0	65.8	73.0	68.4	59.8	44.3	39.2	26.4	47.6
1924	22.2	34.4	27.2	45.4	53.4	68.4	71.7	71.8	59.6	52.7	40.2	18.8	47.2
1925	24.2	37.4	42.0	52.1	60.4	68.3	73.8	69.4	62.6	42.8	36.4	26.8	49.7
1926	23.1	34.4	37.0	47.5	58.8	67.1	70.6	71.9	60.1	52.0	40.0	22.2	48.7
1927	30.5	33.2	34.3	47.3	60.1	65.4	71.7	66.5	60.0	52.0	41.6	20.6	48.6
1928	30.2	31.2	40.0	44.5	58.2	60.8	70.2	68.6	60.3	48.5	36.1	22.0	47.6
Av'g. 10 yrs.	27.3	32.0	36.8	45.6	57.9	67.0	72.3	70.1	60.5	49.3	37.3	25.1	48.4

TABLE NO. 6

INCHES OF RAINFALL AT FORT LUPTON

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	0.40	0.13	0.27	2.50	1.80	3.75	1.88	1.79	0.69	0.50	0.37	0.70	14.78
1922	0.37	0.30	0.15	1.87	0.47	0.39	1.40	2.59	0.06	0.07	1.10	0.37	9.14
1923	0.16	0.52	0.85	0.79	2.72	5.54	2.13	3.01	0.84	2.61	0.04	0.28	19.49
1924	0.34	0.27	0.93	0.48	2.83	0.78	0.44	0.15	1.52	0.90	0.07	0.86	9.57
1925	0.04	0.02	0.29	0.12	1.21	1.90	2.54	1.54	0.71	2.33	0.40	0.65	11.75
1926	0.27	0.23	0.57	1.23	2.47	1.08	2.33	0.74	0.28	1.10	0.18	0.65	11.13
1927	0.03	0.27	0.91	1.12	0.99	2.71	1.45	1.84	1.27	0.28	0.67	0.21	11.75
1928	0.06	0.22	0.79	0.70	2.50	4.13	2.39	0.72	0.39	1.57	0.78	0.03	14.28
Av'g. 18 yrs.	0.19	0.40	0.46	1.72	2.23	1.02	1.82	1.53	1.16	1.13	0.50	0.61	12.77

3. Seepage and Return Flow in District No. 2

TABLE NO. 7

SOUTH PLATTE RIVER SEEPAGE - DENVER TO MOUTH CACHE LA POUDRE R.

From Prof. Carpenter's Bulletin No. 180

Year	Month	Seepage Return Second-Feet	Year	Month	Seepage Return Second-Feet
1890	Oct.	194.59	1900	Oct.-Nov.	351.91
1891	Oct.-Nov.	229.76	1902	" "	295.91
1893	" "	237.51	1903	" "	282.07
1894	" "	281.12	1904	" "	315.09
1895	" "	252.48	1905	" "	253.10
1896	" "	235.59	1907	" "	328.90
1898	" "	377.03	1908	" "	340.01
Av'g.	1890-98	258.30	Av'g.	1900-08	309.57

Note: Return from Cache la Poudre River to Kersey not included in above table.

TABLE NO. 8

SOUTH PLATTE RIVER SEEPAGE - DENVER TO KERSEY (63 miles)

From State Engineer's Report

Year	Month	Seepage Return Second-Feet	
1907	Oct.-Nov.	454.90	River rose at Kersey during Measurem't.
1908	Oct.-Nov.	385.01	
1916	-	310.00	
1921	March	353.60	Meas. made for Denver to La Salle
1922	April	310.00	38.4 s.f. was added for return
1926	March	338.70	La Salle-Kersey.
1926	Nov.-Dec.	419.40	
1927	Oct.-Nov.	339.20	
Average - 1908-1927		350.84	

TABLE NO. 9

SOUTH PLATTE RIVER SEEPAGE - DENVER TO KERSEY

From Water Commissioner's Reports

1928

Month	Av'g. Reported Return Flow		Month	Av'g. Reported Return Flow
Jan.	348		July	350
Feb.	340		Aug.	350
Mar.	347		Sept.	350
Apr.	348	(1927 Report)	Oct.	350
May	387		Nov.	350
June	400		Dec.	350

Annual Average - 356 s.f.

The return flow in District No. 2 probably fluctuates between 310 and 400 second-feet according to river stage seasonal conditions, and temperature, but the yearly average is about 350 sec. ft. or 5.6 sec. ft. per mile of river for the 63 miles in the district.

Using 350 second feet as the average annual daily return flow to the stretch of the South Platte River included in District No. 2, the annual return flow amounts to 253,400 acre feet or 1.19 acre-feet per acre irrigated in the district, (213,500 acres in 1928).

This rate is greatly in excess of that for the mountain slope districts, 4, 5, 6 and 7 which lie to the west of District 2, as shown below:

District	Acre-Ft. Annual Return Flow	Acres Irrigated in Dist.(1930	Return-flow A. Ft. per Acre Irrigated
2	253,400	158,044	1.60 - 1 sec.ft.per 610
4	50,600	91,705	0.55 A. Irr.in Dist.2.
5	29,000	99,124	0.30
6	13,040	72,142	0.18
7	14,700	75,907	0.19
Sum. Dists. 4 to 7	107,340	338,878	0.36
5 Dists.	360,740	496,922	0.57

The average rate of return flow per acre irrigated in District 2 is almost three times that for Districts No. 4 to 7, inclusive.

Evidently, a large part of the seepage return from the lands irrigated in the tributary districts lying west of District No. 2, returns directly to the South Platte River instead of to the streams supplying the tributary districts.

4. Use of Water for Irrigation in District No. 2

The principal average annual water supply for this district is as follows:

TABLE NO. 10
AVERAGE ANNUAL WATER SUPPLY FOR DISTRICT NO. 2

Origin of Supply	Av'g. Annual Run-off A.-Ft.	Remarks
So. Platte R. at Denver	307,000	Av'g. 1909-1928 (20 yrs.)
From Clear Creek	61,300)	Av'g. 1918-1928 (9 yrs. W. Com.
From St. Vrain Creek	94,600)	est., 2 yrs. by gage)
From Big Thompson R.	73,400)	
From Seepage Return	253,400	Av'g. 350 s.f.
Total Av'g. Supply	789,700	

The water commissioner reported in 1928 238,103 acres irrigable and 213,457 acres irrigated. The land cruise in 1930 showed 158,044 acres as irrigated.

Therefore, the total average water supply entering this district amounts to 3.32 acre-feet per irrigable acre and 3.70 acre-feet per acre irrigated, based upon 213,457 acres irrigated and 5.00 acre-feet per acre based upon 158,044 acres in 1930. Part of the supply passes from the district for use in Districts 1 and 64.

The following table of gross use of water by canals from natural flow and from storage, in District No. 2 was compiled from data given in the reports of the Division Engineer of Div. No. 1.

TABLE NO. 11

GROSS USE OF WATER BY CANALS FOR IRRIGATION IN DIST. 2

Year Ending Sept.30	Run-off So. Platte at Denver	Diverted by Ditches from Natural Flow	Diverted From Storage	Total Diverted For Irrig.	Total Acres Irrig. in Dist. No.2	Acre-ft. per Acre Irrigated
1921	561,170	441,409	69,593	511,002	165,396	3.09
1922	216,360	278,986	*67,386	346,372	180,594	1.92
1923	333,810	369,241	*41,730	410,971	209,984	1.96
1924	458,000	308,995	*111,193	420,188	209,522	2.01
1925	131,410	224,550	78,304	302,854	202,754	1.49
1926	355,810	359,686	102,000	461,686	206,064	2.24
1927	169,560	273,466	97,550	371,016	205,591	1.80
1928	191,070	297,590	104,314	401,904	213,457	1.88
Average	302,150	319,240	84,009	403,249	199,170	2.04

* Estimated from Water Commissioner's weekly reports.

Although the average use of water by all the canals doesn't fall below what is considered a good supply in the tributary districts, the Water Commissioner reports considerable shortage for junior ditches every year throughout most of the irrigation season.

As a large part of the water supply of this district comes from return flow from Districts 4, 5, 6 and 7, which cannot be measured directly, it is not feasible to approximate the consumptive use of water for the district as a whole.

5. Canal Diversions in District No. 2.

The following table gives a list of canals which divert from the South Platte River. They are given in the order in which they head on the river:

TABLE NO. 12

Identi. No.	Name of Canal	Years of Priority	Total Decreed Rights s.f.	Canal Capacity Sec. Ft.	Acres Under 1928	Acres Irrig. 1928
1.	Farmers & Gardeners	(a) 1863-74	24.00	25	299	299
2.	Burlington) Same	1862-85	380.40	350	14,000	10,891
	Denver-Hudson) System	1907	300.00	350	34,000	32,440
	O'Brian)	1908	600.00	600	32,000	32,000
3.	Gardeners'	1861	4.00	6	150	150
4.	Fulton	1865-82	448.80	300	17,000	16,700
5.	Brantner	1860-81	111.18	111	5,500	5,500
6.	Brighton	1863-71	44.80	50	4,895	3,763
7.	Lupton Short Line	1892	72.00	30	845	845
8.	Lupton Bottom	1863-73	150.57	140	6,000	5,405
9.	Platteville	1862-73	147.38	137	6,000	5,020
10.	Side Hill	1866-82	116.80	40	1,194	1,194
11.	Evans No. 2	1871-75	404.05	225	6,000	5,660
	Platte Valley	1909	215.95		14,000	13,101
12.	Beeman)Mutual	1866-77	134.34	50	2,000	1,989
	Meadow Isl.No.2)Ditch	1866-76	58.82	40	1,030	1,030
13.	Bucker's	1879	121.87	60	7,000	6,960
14.	Farmers' Independent	1865-79	520.00	300	11,000	10,990
15.	Hewes & Cook (Western)	1866-94	185.00	130	8,700	8,700
16.	Jay Thomas	1865	18.00	12	520	520
17.	Big Bend	1873	16.88	6	180	180
18.	Union	1874-81	188.03	150	5,512	5,512
19.	Section No. 3	1870-73	57.71	45	1,700	1,700
20.	Lower Latham	1869-81	287.73	350	13,000	13,000
21.	Patterson	1871	19.92	30	1,355	1,355
22.	Wyatt	1878	23.63	6	270	270
23.	Plumb (or Highland)	1871	24.40	25	720	720
	Totals		4,676.26	3,568	194,870	185,894

(a) Diverts in Dist. No. 8, decreed in Dist. No. 2.

TABLE NO. 13

DECREED DITCHES IN DISTRICT NO. 2 WHICH DO NOT DIVERT FROM SOUTH PLATTE RIVER

Identi. No.	Name of Canal	Years of Priority	Total Decreed Rts.s.f.	Canal Capacity sec.Ft.	Acres Under Canal 1928	Acres Irrig. 1928
	From Graffin Slough					
1.	Abbett	1873	11.80	3	100	85
2.	Hodgson	1869	12.82	6	350	350
	From Seepage					
1.	McCanne Seepage	1892	4.00	6	450	450
	From Big Dry Creek					
1.	Calkins	1883	13.00	4	210	210
2.	German	1855	85.00	40	1,200	915
3.	Jones	1883-88	13.09	6	270	270
4.	Thompson	1889	36.66	37	1,000	586
5.	Whipple (or Bull)*	1884	5.00	300	No record	
6.	Yoxall	1896	16.80	3	80	79
	From Little Dry Creek					
1.	Slate	1893	6.00	6	600	400
	From First Creek					
1.	Brereton and Maul	1895	12.30	6	400	260
Totals (without Whipple Ditch Areas) -			225.47	417	4,660	3,605

* Main Supply is from Standley Lake Res. Area under Whipple Ditch is reported as 35,000 acres with area irrigated included in that under Standley Lake (21,535 acres).

As in the case of the mountain tributaries, the canal diversions for 1926 are considered to be the fair demand on the South Platte River during the irrigation season. These diversions are given below in Table No. 14:

TABLE NO. 14

TOTAL DAILY DIVERSIONS FROM SOUTH PLATTE RIVER IN DISTRICT NO. 2 FOR SEASON OF 1926, IN MEAN DAILY SECOND-FEET

Day	April	May	June	July	Aug.	Sept.	Oct.
1	0	672	1,681	1,121	1,090	654	619
2	0	672	1,768	1,132	1,032	715	570
3	0	793	1,937	1,218	805	727	604
4	0	836	1,964	1,203	828	751	607
5	0	905	1,872	921	841	858	402
6	0	1,201	1,802	952	914	786	350
7	16	1,230	1,454	1,013	1,095	854	323
8	16	1,193	1,636	1,032	1,267	786	344
9	16	1,089	1,588	1,026	1,139	659	346
10	16	1,140	1,512	1,031	1,238	644	316
11	12	1,049	1,503	533	1,235	626	321
12	12	1,075	1,524	517	1,269	601	309
13	14	1,104	1,448	585	1,083	667	306
14	14	885	1,108	687	947	642	288
15	14	877	1,228	826	877	652	283
16	65	894	1,137	963	845	614	276
17	65	1,033	1,196	1,303	893	603	282
18	54	1,025	1,246	1,171	922	601	260
19	114	1,084	1,320	1,191	911	608	290
20	136	1,214	1,299	1,199	850	581	290
21	145	1,362	1,424	1,086	828	592	337
22	148	1,367	1,499	974	787	572	289
23	158	1,421	1,716	1,075	728	589	269
24	158	1,749	1,824	1,185	810	587	228
25	158	1,768	1,784	1,155	784	567	210
26	350	1,731	1,519	1,102	732	561	200
27	353	1,632	1,465	1,076	685	611	200
28	381	1,543	1,549	1,150	646	599	200
29	368	1,634	1,354	1,142	644	600	200
30	398	1,602	1,217	1,153	644	545	200
31	xxx	1,689	xxxx	1,110	628	xxx	200
Total	3,181	37,469	45,574	31,832	27,997	19,452	9,919
A. Ft.	6,310	74,300	90,400	63,100	55,500	38,600	19,600 Total A.Ft. 347,810
Av'g. s.f.	106	1,208	1,519	1,026	903	649	320
% Total	2	21	26	18	16	11	6

Note: The above table includes diversions of all ditches from the South Platte River in District No. 2 from April 1st to Oct. 31st, whether for direct irrigation or storage or both.

6. Principal Reservoirs in District No. 2.

TABLE NO. 15

Name of RESERVOIR		Dates of Priorities	Acre-Feet Decreed	Acre-Feet Maximum Capacity (W.C. Est.)
Barr & Oasis				
	Barr	11/20/82 - (1990 A.F.)		
	Oasis	11/20/85 - (9090 A.F.)		
	Enlargem't.	1/14/09 - (21,930 A.F.)	33,010	32,143
Bowles -	No. 1	1/30/07 - (700 A. F.)		
	No. 2	4/14/08 - (475 A. F.)	1,175	1,175
(A) Horsecreek		3/17/11	16,965	20,650
Olds		1/28/18 - (534 A. F.)		
		6/15/22 - (548 A. F.)	1,082	900 (Not now in use)
Prospect		11/20/10 - (5970 A.F.)		
		7/20/22 - (1690 A.F.)	7,660	5,970
Milton		5/29/09 - (26,733 A.F.)		
		5/29/09 - (16,374 (B) A.F.)	43,107	24,392
Lower Latham		6/23/98 - (4,325 A.F.)		
		6/24/00 - (1,430 A.F.)	5,755	6,212
Standley (C)		Not decreed		18,500
Sand Creek		3/17/11	1,804	Not reported by W. C.
Totals			110,558	109,942

(A) Enlargement from storage depth of 48' to 51'. (7/20/22). Acre-feet not given. Outlet is 22 ft. above bottom of reservoir, hence there is 22 ft. of dead water.

(B) Conditional decree that has never been made absolute.

(C) Standley Lake has no decree but File No. 125½, dated 1902, asks for 101,200 A. ft. It was never built that large, but has now a safe capacity of 18,500 A. ft. It fills from Clear and Ralston Creeks, Leyden and Coal Creeks and Woman or Big Dry Creek. It is also served thru the Church ditch and Croke Canal out of Clear Creek.

Total Number of reservoirs in District No. 2 = 45.

Total Capacity of reservoirs in " " 2 = 132,600 A. Ft.

TABLE NO. 16

DISTRICT NO. 2 RESERVOIRS
MAXIMUM STORAGE EACH YEAR - 1921-28, Inclusive

Year	Date	Amount in Reservoirs	Number of Reservoirs Reported
1921	May 1	80,184	29
1922	May 1	84,969	38
1923	May 1	53,470	50 (A)
1924	May 1	99,470	43
(B)1925	Apr. 1	63,824	5
1926	May 1	96,266	7
1927	May 1	97,622	7
1928	June 1	96,670	7

(A) In 1923 the W. C. reported the German reservoirs No. 1 to No. 15 separately. They are small reservoirs having a total capacity of only 61 A. Ft., and in other years are reported as four reservoirs.

(B) Only those reservoirs of more than 1,000 A. Ft. are reported in years 1925-28, incl.

7. Reservoir Sites in District No. 2

District No. 2 is fairly well supplied with storage reservoirs at present but could use some additional capacity to catch the summer flood flows, equalize the stream run-off and make it available for irrigation later in the season, in the lower part of the district and in Districts 1 and 64.

There are two large reservoir sites in this district, viz: the MacCarthy on the South Platte River below the mouth of St. Vrain Creek and the Farmers No. 2 site in Beebe Draw, just below Milton Lake. Both sites have been filed on, but in both cases, the filings have lapsed.

MacCarthy Reservoir Site

A map of this site on a scale of 1" = 2,000' is shown in filing No. 4787 of 1908. The height of dam is given as 90 ft., the maximum capacity as 350,000 acre-feet and the area at high water line as 11,500 acres. The estimated cost is $2,000,000, which undoubtedly is far below what the present day cost would be for the dam and reservoir site. Practically all of the land to be flooded is improved and irrigated. The Western Canal and the Farmers' Independent Ditch head in the reservoir site and a branch of the Union Pacific R. R. and the main line of the Denver, Laramie and Northwestern R. R. traverse its full length. (Last mentioned R. R. probably defunct).

The estimated average annual surplus for storage at this site is about as follows (if it is built in advance of additional storage on Boulder and St. Vrain Creeks):

From Boulder Creek	- 17,000	acre-feet
From St. Vrain "	- 20,000	" "
From So. Platte R.	- 67,000	" "
Total	- 104,000	" "

To realize an average annual yield of 100,000 acre-feet, storage capacity for about 200,000 acre-feet should be provided, and a reservoir of this size would be justified at the MacCarthy site if it could be built at a reasonable cost and without too much interference with existing improvements.

A spillway of large capacity would be required at this site to care for excessive floods in the South Platte River. The maximum flood passing this point is about the same as that recorded at Kersey, minus the inflow from the Cache La Poudre River. On June 7, 1921, 31,000 second-feet was estimated as passing Kersey and the day before the Water Com. of District 3 reported 5,000 second feet as leaving the Cache La Poudre. It is probable that about 25,000 second feet is the maximum for the MacCarthy site since records have been kept on the river, and a safe spillway capacity would be from 40,000 to 50,000 second feet. For an 8 ft. depth of water a spillway crest 500 feet long would be required for 40,000 second-feet. A crest 550 ft. long would pass 46,000 sec. ft. with 8 ft. depth, or the crest could be shortened by the use of 18' high radial gates to about 200 feet.

Canals aggregating 576 sec. ft. in capacity divert below the site in District 2, and District 1 has canals with decrees totaling 3,000 sec. ft. The average daily flow at Kersey for June, the month of maximum run-off, for the period 1918-1928, incl., is 3,140 sec. ft.

An outlet capacity of around 4,000 sec. feet would be required.

Farmers' No. 2 Reservoir Site

The filing for this site, No. 7028, made in 1910, includes a map on a scale of 1" = 800'. The dam was to be 78 feet high and about 2 miles long, the reservoir to cover 3,800 acres of land, and impound 109,000 acre feet of water at maximum water surface elevation of 4770. The estimated cost in the filing is $395,000.

The water supply for the reservoir was to come from waste waters in Beebe Draw; from the South Platte River through an enlargement of The Platte Valley Canal, from its present capacity of 225 sec. ft. to 2400 sec. ft.; and from the Cache La Poudre River, Big Thompson River, Little Thompson River and St. Vrain Creek through a canal of 1,200 sec. ft. capacity heading on the Cache La Poudre near the intake of the new Mercer canal, above Fort Collins and extending to the South Platte River above the heading of the Platte Valley canal, picking up the surplus from the other streams mentioned, on the way.

The scheme for bringing Cache La Poudre, Big Thompson, Little Thompson and St. Vrain, waters to Beebe Draw appears entirely impractical.

Considerable water could be delivered to the site from the South Platte River through the enlargement of the Platte Valley canal to 2,400 sec. ft. Between 3 and 4 million cu. yds. of excavation and a number of structures would be required which would cost approximately $400,000, or as much as the estimate in the filing for this reservoir.

The outlet for this reservoir is at about elevation 4700 or 20 feet lower than that for the MacCarthy site.

Milton Lake, just south of the Farmers' No. 2 site, has a decreed capacity of 43,000 acre-feet but usually fills only to about 20,000 acre-feet.

The MacCarthy site, being on the river channel, would have a much better chance to fill than the Farmers' No. 2 site, and if the MacCarthy were constructed, there wouldn't be much surplus water left for any more off-channel reservoirs on the South Platte River.

On account of interference with existing improvements and the more favorable locations of reservoir sites at higher altitudes, the two sites mentioned above are not considered feasible.

CHAPTER III

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

CACHE LA POUDRE RIVER - WATER DISTRICT NO. 3 - WATER SUPPLY

Contents

CHAPTER III

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

CACHE LA POUDRE RIVER - WATER DISTRICT NO. 3 - WATER SUPPLY

1. Water Supply

In the following report on water supply conditions in the Cache La Poudre valley, use has been made of data contained in two reports of the U. S. Bureau of Reclamation, entitled "Progress Report on Additional Storage in Cache La Poudre Basin", of July, 1927, and "Surplus Water Supply Cache La Poudre River" of May, 1928, and in Bulletin No. 1026 of the U. S. Department of Agriculture. The two reports of the Bureau of Reclamation were based on stream flow records up to and including the year 1926. Bulletin No. 1026 deals with records prior to 1918 and more particularly for the years 1916 and 1917.

The present report includes the year 1928.

2. Discharge Records

A gaging station has been maintained by the State, on the Cache La Poudre River near the mouth of the canon since 1884. The station is just above the diversion dam of the Greeley water works and above all canal diversions with the exception of those for the North Poudre Canal, The Poudre Valley Canal, and the Fort Collins Water Works. The drainage area above the station is 1,071 square miles, as measured on U. S. G. S. topographic maps. Transmountain waters from water districts 47, 48 and 51, pass this station and are measured with the supply from the natural flow of the river.

The records at this point are, in general, continuous for the months of April to October, inclusive, fragmentary for other months on account of ice conditions from 1884 to 1919, and complete for all months from 1920 to 1928.

In the following table of discharge of the Cache La Poudre River at the mouth of the canon, the records for the period 1884 to 1917, inclusive, with period averages are as given in U. S. Dept. of Agriculture Bulletin No. 1026. On page 7 of the Bulletin, it is stated, "Estimates of the flow from November to March, inclusive, were furnished by John Armstrong, water commissioner for District No. 3, who has handled the division of the winter flow for over 25 years. To arrive at the annual discharge, Mr. Armstrong's estimates for the winter months were combined with available figures for other months, and then, if April or October records were partly missing, they were interpolated in the proportion of the percentages shown in the table. **** Data included in the table are from the original records of the Colorado Experiment Station and from the reports of the State Engineer."

TABLE NO. 1

DISCHARGE OF THE CACHE LA POUDRE RIVER AT THE MOUTH OF THE CANYON - DAILY MEAN SEC. FT.

Drainage Area = 1,071 sq. mi. - Elev. = 5,070.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Run-off Acre-ft.
					Mean Second Feet								
1884	-	-	-	219	2,536	4,812	2,143	792	305	-	-	-	689,000
1885	-	-	-	-	1,419	2,910	1,860	657	272	-	-	-	478,000
1886	-	-	-	-	1,309	1,872	717	306	185	-	-	-	302,000
1887	-	-	-	-	-	1,802	737	310	174	-	-	-	-
1888	-	-	-	-	489	1,117	421	201	105	-	-	-	169,000
1889	-	-	-	113	770	1,339	511	184	69	70	-	-	203,000
1890	-	-	-	200	1,046	1,281	647	290	103	81	-	-	271,000
1891	-	-	-	144	1,250	1,833	541	228	138	118	-	-	275,000
1892	-	-	-	-	408	1,512	735	209	-	-	-	-	-
1893	-	-	-	-	570	1,802	614	237	-	-	-	-	-
1894	-	-	-	-	1,406	2,063	735	339	164	104	-	-	321,000
1895	-	-	-	-	1,191	2,346	1,222	499	220	175	-	-	374,000
1896	-	-	-	-	912	1,062	452	274	294	199	-	-	219,000
1897	-	-	-	-	1,960	1,728	511	379	166	123	-	-	303,000
1898	-	-	-	146	656	1,317	485	154	70	61	-	-	192,000
1899	-	-	-	-	1,206	2,609	1,452	563	216	156	-	-	408,000
1900	-	-	-	742	3,095	3,281	674	231	134	108	-	-	518,000
1901	-	-	-	-	1,802	2,049	774	-	135	99	-	-	-
1902	-	-	-	106	1,069	1,291	379	176	166	136	-	-	219,000
1903	-	-	-	-	801	2,715	964	282	164	156	-	-	337,000
1904	-	-	-	161	-	-	1,043	328	176	-	-	-	-
1905	-	-	-	317	1,031	2,707	908	340	158	-	-	-	356,000
1906	-	-	-	-	1,083	1,652	935	-	-	-	-	-	-
1907	-	-	-	119	646	2,777	1,757	473	186	-	-	-	388,000

TABLE NO. 1 (cont'd.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Run-off Acre-feet
1908	-	-	-	135	-	1,493	792	766	229	-	-	-	-
1909	-	-	-	239	703	3,703	1,852	452	331	140	-	-	466,000
1910	-	-	-	179	780	947	269	128	152	154	-	-	176,000
1911	-	-	-	69	819	1,707	764	218	173	126	-	-	252,000
1912	-	-	-	63	785	2,186	1,230	429	212	163	-	-	325,000
1913	-	-	-	-	920	1,230	538	265	204	184	-	-	229,000
1914	-	-	-	215	2,147	2,500	818	335	195	91	-	-	400,000
1915	-	-	-	-	591	1,521	700	274	208	116	-	-	232,000
1916	-	-	-	151	847	1,703	754	397	263	114	-	-	274,000
1917	-	-	-	134	1,295	3,996	2,050	392	292	111	-	-	518,000
Avg.	(50)	(55)	(55)	192	1,147	2,087	911	347	189	127	(83)	(60)	320,000

TABLE NO. 1 (cont'd)

Year	Jan.	Feb.	Mar.	Apr.	May	Mean Second-Feet June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Run-off Acre-Feet
1918	(40)	(39)	65	129	782	2,530	960	275	175	88	70	(50)	314,350
1919	(35)	(40)	(48)	115	700	725	366	316	132	70	61	53	161,100
1920	41	46	35	103	1,110	2,670	1,180	422	237	91	69	47	365,810
1921	32	31	44	204	1,330	3,060	1,050	392	211	68	61	55	394,790
1922	32	28	36	101	672	1,570	374	319	90	54	46	47	203,120
1923	26	24	44	136	897	3,640	1,650	502	325	172	84	40	455,160
1924	30	25	100	429	1,380	3,680	974	351	145	112	72	45	442,800
1925	41	42	66	163	776	1,200	522	344	292	146	101	77	228,120
1926	65	64	60	302	1,600	2,210	1,090	380	195	66	63	61	373,210
1927	45	44	34	122	851	1,710	788	309	258	86	52	50	263,200
1928	46	47	67	96	1,130	1,790	1,100	316	197	71	53	(36)	300,300
Avg. 1918-1928 incl.	39	39	54	173	1,021	2,253	914	357	205	93	67	51	318,360
Coefficient of Variation 1918-28 = .306, Prob. Error = 6%													
Avg. 1884-1928 incl.	47	51	55	187	1,116	2,128	912	349	193	119	79	58	319,600
Avg. A-Ft.	2890	2830	3380	11,100	68,600	126,500	56,000	21,500	11,500	7,320	4,700	3,570	

Figures enclosed thus ( ) are partly estimated.

The maximum possible flood flow for this gaging station is estimated at 25,000 sec.-ft. or about 23 sec.-ft. per square mile of drainage area.

The average discharges at this station from 1918 to 1928, inclusive, were compiled from the biennial reports of the State Engineer as follows:

TABLE NO. 2

DISCHARGE OF THE CACHE LA POUDRE RIVER AT MOUTH NEAR GREELEY - DAILY MEAN SEC. FT.

Drainage Area = 1,985 Sq. Miles - Elev. = 4,610

	Mean Second-Feet												Run-off
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Acre-feet
1903	-	-	-	145	77	794	66	39	54	92	-	-	-
1904	-	-	-	-	-	-	(42)	42	43	106	101	-	-
1914	-	119	162	258	1,420	968	36	41	44	132	112	-	-
1915	-	-	(140)	141	136	86	48	99	99	241	183	(122)	-
1916	-	-	-	(88)	95	103	58	72	72	184	163	133	-
1917	118	113	118	115	873	2,390	412	63	80	178	149	137	285,470
1918	(132)	141	120	110	79	658	262	66	129	192	143	(136)	130,390
1919	(150)	142	132	85	38	30	42	32	45	66	85	(80)	55,660
1924	101*	78*	132*	426*	252*	1,590	32	23	38	109	104	97	178,740
1925	82	101	80	31	21	82	40	40	18	98	107	89	47,420
1926	79	104	83	302	119	537	90	24	42	139	115	104	104,320
1927	93	88	104	119	29	61	79	56	47	140	129	104	63,170
1928	93	88	79	52	241	337	316	42	32	123	161	127	102,470
Avg.	106	108	115	156	282	636	117	49	57	139	129	113	121,000

Figures enclosed thus () are partly estimated.
* Indicates record from Water Comm's. reports.

Discharge records were published by the U.S.G.S. for the Cache La Poudre River near Elkhorn and near the Fort Collins water works for the years 1909, 1910 and 1911. The gaging station near Elkhorn is described as being located at Fry's ranch (near Rustic) about 8 miles above the mouth of Elkhorn Creek. The station near the Fort Collins water works was below the water works intake, and above the mouth of the North Fork of the Cache La Poudre River.

The results obtained at these two gaging stations are given below in Tables 3 and 4.

TABLE NO. 3

DISCHARGE OF THE CACHE LA POUDRE RIVER NEAR ELKHORN (FRY'S RANCH) - DAILY MEAN SECOND-FEET

Drainage Area = 224 Sq. miles

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Run-off Acre-feet
	Mean Second-Feet												
1909	31	29	37	39	274	1,882	1,010	348	220	91	52	35	244,500
1910	29	26	38	125	607	846	272	102	127	61	48	37	140,100
1911	30	22	31	43	543	1,400	469	133	73	84	54	25	176,000
Avg.	30	26	35	69	475	1,376	584	194	140	79	51	32	186,870

TABLE NO. 4

DISCHARGE OF THE CACHE LA POUDRE RIVER NEAR FORT COLLINS WATER WORKS (BELOW INTAKE AND ABOVE MOUTH OF NORTH FORK)

Drainage Area = 487 Sq. miles

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Run-off Acre-feet
	Mean Second-Feet												
1909	44	41	66	144	488	2,567	1,322	391	259	113	76	51	334,360
1910	52	39	64	156	747	994	312	143	147	86	67	48	172,600
1911	53	45	56	80	896	1,690	724	230	108	138	65	49	250,000
Avg.	50	42	62	126	710	1,750	786	255	171	112	69	49	252,320

DRAINAGE AREAS OF CACHE LA POUDRE RIVER MEASURED ON U.S.G.S. TOPOGRAPHIC MAPS

Total Drainage Area Above Mouth of River - - - - - - - - - - 1,965 Sq. Mi.

Area Above Canyon Gaging Station - - - - - - - - - - - - - - 1,071 " "

Main Fork Above Junction with North Fork - - - - - - - - - - 487 " "

Total North Fork Above Mouth - - - - - - - - - - - - - - - - 584 " "

North Fork Above Halligan Reservoir - - - - - - - - - - - - 365 " "

North Fork Below Halligan Reservoir - - - - - - - - - - - - 219 " "

3. Areas Irrigated By Cache La Poudre River

There is considerably more land in the Poudre Valley than can be supplied by the available water supply. Existing canals command over 100,000 acres of land, not irrigated on account of lack of water, which would be developed in a short time if water were available. At the present time expansion of the irrigated area is practically at a standstill.

TABLE NO. 5

AREAS IRRIGATED BY CACHE LA POUDRE RIVER - 1902-1928

Year	Acres Irrigated	Increase in %per year	Authority
1902	145,203		U. S. Census
1913	225,190	5.0	State Engineer, 17th Biennial Report
1916	246,845	3.0	" " 18th " "
1925	267,630	0.9	" " 23rd " "
1928	268,540	0.1	" " 24th " "

4. Temperature and Precipitation at Fort Collins

Fort Collins is a little north of the center of the irrigated area in District No. 3 but is the location of the weather bureau station, the records of which must closely represent average conditions for the whole district. Forty-nine years of precipitation records and 34 years of temperature records, including 1928, are available at this station.

Below are tabulated, from U. S. Weather Bureau reports, temperature and precipitation records for the past 10 years with averages for the whole periods of record.

TABLE NO. 6

MONTHLY AVERAGE TEMPERATURE, DEGREES FAHRENHEIT, AT FORT COLLINS

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1919	29.4	27.3	33.0	47.1	54.6	64.2	71.4	68.2	61.5	42.6	29.8	22.4	46.0
1920	26.8	29.2	35.0	36.6	54.2	62.2	68.8	66.2	58.6	48.0	33.0	28.1	45.6
1921	27.7	32.4	42.0	43.2	55.3	65.0	69.1	67.8	61.3	52.4	38.5	29.4	48.7
1922	19.9	26.5	36.5	43.5	55.5	66.3	68.4	71.2	62.3	48.2	34.8	29.5	46.9
1923	34.0	24.2	28.8	44.8	54.4	62.4	70.1	66.8	58.0	42.4	38.2	27.0	45.9
1924	21.2	33.8	25.1	44.5	51.4	64.1	68.4	68.5	56.8	50.2	39.2	20.7	45.3
1925	23.7	36.2	40.7	50.5	57.4	65.9	70.9	66.8	61.1	40.4	34.6	26.8	47.9
1926	24.8	35.0	35.6	45.8	55.8	64.0	67.4	68.4	57.9	50.0	39.2	22.8	47.2
1927	30.2	31.3	33.6	45.2	56.2	62.0	67.6	64.2	58.8	50.1	39.8	20.8	46.6
1928	30.6	29.6	37.8	43.4	55.7	57.3	67.9	66.2	58.5	47.0	35.0	24.4	46.1
Avg. 34 yrs.	26.2	27.4	36.0	44.8	53.8	63.1	68.0	67.5	59.2	48.0	36.1	27.2	46.4

TABLE NO. 7

INCHES OF RAINFALL AT FORT COLLINS

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1919	T	0.30	1.65	0.93	0.45	0.19	0.64	0.61	2.61	1.93	1.22	0.39	10.92
1920	0.54	0.64	0.14	3.60	1.95	0.60	0.58	1.72	0.60	0.50	0.24	0.54	11.65
1921	0.96	0.19	0.13	1.71	1.97	3.66	1.40	2.55	0.68	0.37	0.32	0.89	14.83
1922	0.35	0.53	0.36	2.80	0.87	1.03	0.80	0.73	0.02	0.74	1.44	0.31	9.98
1923	0.19	1.39	2.74	2.18	4.46	6.23	4.50	0.62	1.36	3.55	0.10	0.25	27.57
1924	0.51	0.54	1.83	0.93	3.90	0.22	0.21	0.05	0.84	0.78	0.09	0.74	10.64
1925	0.27	0.09	0.58	0.10	1.18	1.50	1.85	1.32	1.96	3.26	0.89	1.50	14.50
1926	0.25	0.28	1.54	2.99	1.76	1.58	0.93	0.86	1.03	1.15	0.36	0.83	13.56
1927	0.04	0.40	1.87	2.69	0.91	2.17	2.19	2.10	1.10	1.05	1.00	0.25	15.77
1928	0.26	0.52	1.38	0.98	3.35	2.73	0.83	0.69	0.09	1.50	1.15	0.06	13.54
Avg. 49 yrs.	0.44	0.61	0.93	2.15	2.84	1.49	1.83	1.22	1.28	1.07	0.47	0.46	14.77

Avg. for irrigation season, May-Oct., incl. = 9.73 in. = 0.81 acre-ft. per acre

5. Seepage and Return Flow in District No. 3

The latest available seepage determinations for the Cache La Poudre are those made during 1916 and 1917 by R. G. Hemphill and published in agricultural Bulletin No. 1026. These measurements are the results of continuous records covering the two year period.

TABLE NO. 8

CACHE LA POUDRE SEEPAGE RETURN - FROM AGRICULTURE BULLETIN NO. 1026

	Mean Second-Feet													Annual
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Av. Annual	Acre Ft.
1916	75	73	76	105	184	160	224	216	172	186	179	121	148	
1917	107	110	128	130	*	*	238	233	165	140	171	104	156	
Avg.	91	92	102	118	184	160	231	225	169	163	175	113	152	110,000

* Record interrupted for these two months on account of floods.

Return flow measurements were made by Prof. L. G. Carpenter, formerly of the Colo. Agricultural College Experimental Station, each year during the period 1889 to 1910, inclusive. The determinations were usually made in the fall of the year, when the river was low, by a progressive series of measurements of inflow and outflow from the mouth of the canyon to the mouth of the river. The operation usually occupied about one week's time or less and fairly represents the return flow for the time of the year and for the period in which such measurements were made.

TABLE NO. 9

CACHE LA POUDRE SEEPAGE RETURN - FROM PROF. L. G. CARPENTER'S BULLETIN NO. 180

Year	Month	Seepage Return Second-Feet
1889	Oct.	98.97
1890	Oct.	100.79
1891	Oct.	79.53
1892	Mar. & Oct.	96.11 & 96.28
1893	Nov.	98.68
1894	Mar. & Aug.	82.32 & 118.17
1895	Oct.	162.47
1896	Nov.	Incomplete
1897	Oct.	Incomplete
1898	Aug.	125.18
1899	Sept.	134.12
1900	Aug.	110.02
1901	July & Aug.	167.50
1902	July	119.43
1903	Aug.	186.37
1904	Sept.	173.49
1905	Sept.	180.83
1906	Sept.	216.13
1907	Sept. & Oct.	203.15
1908	Sept.	225.32
1909	Oct.	208.54
1910	Oct.	159.72
Avg.	22 meas.	142.87

The average shown in the above table is that for 22 completed sets of measurements of the entire stretch of the river from the canyon to the mouth.

TABLE NO. 10

CACHE LA POUDRE SEEPAGE RETURN - FROM STATE ENGINEER'S REPORTS

Year	Month	Seepage Return Second - Feet
1906	Oct.-Nov.	163.07
1907	Oct.	138.40
1908	Nov.	165.51
1913	Oct.	174.60
1914	Oct.	153.20
Avg.	5 meas.	158.96
Avg.	1913 & 1914	163.90
Avg.	1906-7 & 8	155.66
Prof. Carpenter's Av.	1906-7 &-8	214.87

It is evident from Table 9, above, that the return to the river increased as much as 50% from 1889 to 1910 but, comparing the average October return for 1913 and 1914 as determined by the State (163.90 sec. ft.) and Hemphill's October average for 1916 and 1917 (163.0 sec. ft.), no increase is indicated for this period.

The present seepage return is probably somewhat greater than it was in 1917 but available data will not permit reliable deductions on the increase.

In the following computations, return flow, as far as available, has been added to the water supply as given for the monthly average for 1916 and 1917 in Table 8 above. This table provides the latest available data and probably is not far from representing present conditions.

About 80% of the return flow occurs above the lowest diversion in the valley, the Ogilvy ditch and is available for irrigation. Seventy-two per cent comes in below Fossil Creek reservoir inlet and 55% below the intake for Greeley Canal No. 3.

6. Use of Water in District No. 3.

The following tabulation of use of water and shortages in District No. 3 was compiled from data taken from reports of the Water Commissioner and from biennial reports of the State Engineer:

TABLE NO. 11

	(Acre-Feet)				(Head-gate duty of water)	
Year	Cache La Poudre R. at Canon	Total water Used for Irr'g.	Total acres Irrigated Dist. No. 3	Acre-ft. used per acre Irr'g.	Shortage on basis of 1.4 A.- ft. per A	Shortage on basis of 1.3 A.-ft. per A.
1917	518,000	330,000	251,510	1.31	22,600	0
1918	314,350	325,000	259,850	1.25	39,000	13,000
1919	161,100	179,000	261,540	0.69	185,000	159,500
1920	365,810	379,000	264,315	1.43	0	0
1921	394,790	371,000	264,340	1.40	0	0
1922	203,120	218,000	265,940	0.82	154,000	127,650
1923	455,160	383,000	266,940	1.43	0	0
1924	442,800	319,000	266,940	1.20	53,400	26,700
1925	228,120	264,000	267,630	0.99	110,000	83,000
1926	373,210	430,000	267,640	1.61	0	0
1927	263,200	345,000	268,140	1.29	29,500	2,680
1928	300,300	348,000	268,540	1.30	26,850	0
Avg.	335,000	324,250	264,444	1.23	51,700	34,400
Avg. 1921-28	332,600	334,750	267,014	1.25	46,700	30,000

Avg. of 9 fair or good years - - - - - - - -1.36 (with over 1 A.Ft. per A. Used)

The report of the Bureau of Reclamation on Cache La Poudre Investigations of May, 1928 is quoted as follows:

"The region supplied with irrigation water by the Cache La Poudre River, augmented by transmountain diversions from the Laramie, North

Platte and Colorado River drainage areas, comprises the largest highly developed general farming community in the inter-mountain region of the West. Lands of superior soil and topography far exceed the area that can be adequately irrigated with available water supply. The dearth of irrigation water has brought about an exceptionally high duty of water. The availability of lands of good quality has resulted in an expansion of irrigation distribution systems to an area far beyond that which can be supplied year in and year out, with present storage facilities."

Even allowing for a duty of 1.3 acre-feet per acre, shortages are shown in the above table for 5 years out of the 12 (disregarding 1927 which is not of consequence), the more serious shortage occurring in the years 1919, 1922 and 1925, or about every third year.

On the basis of 1.4 acre-feet per acre irrigated, 1919 had over a 50% shortage; 1922 had a shortage of 40% and 1925 about 30%.

It was estimated by the Colorado Agricultural College Experimental Station that lack of water for late irrigation in 1925 reduced the yield of sugar beets by 75%, involving a crop loss in the valley of around $1,000,000 for this crop alone.

The Superintendent of the North Poudre Irrigation Company states that the 1925 loss in all crops, due to water shortage under the North Poudre Canal, amounted to about $500,000. It is probable that the value of the total crop loss in the Poudre Valley on account of insufficient water during 1925, with a 30% shortage, was around $3,000,000.

The losses for 1919, with a 50% shortage, and for 1922, with a 40% shortage, were probably greater than those for 1925.

It is noted that the extremely short years usually follow one or more years of surplus supply when excess water would have been available for additional storage in channel reservoirs and could have been drawn on to supply most of the shortages.

Consumptive Use of Water in District No. 3.

The consumptive use of water, as indicated by records of inflow and outflow and stored water, was computed for the years 1925, 1926, 1927 and 1928. These years represent poor, average and good conditions. The inflow consists of the flow of the Cache La Poudre river at the canyon plus the diversions above the gaging station made by the Poudre Valley Canal, the North Poudre Canal and Fort Collins water works. The outflow is the record of the Cache La Poudre at the mouth near Greeley. For each year the amount of water in storage at the beginning of the year was added to the difference between inflow and outflow and the amount held in storage at the end of the year was subtracted.

The actual amount of water consumed by crops evidently is usually less than crop requirements.

TABLE NO. 12

CONSUMPTIVE USE OF WATER IN DISTRICT NO.3

Year	Total inflow acre-ft.	Outflow River at Mouth Acre-ft.	In storage first of year	In storage end of year	Consumptive use for year	Acres Irrigated	Cons. use Acre-ft. per acre irrigated
1925	246,810	47,420	23,920	51,240	172,070	267,630	0.64
1926	411,070	104,320	51,240	56,600	301,390	267,640	1.13
1927	285,750	63,170	56,600	54,060	225,120	268,140	0.84
1928	340,740	102,470	54,060	40,280	252,050	268,540	0.94

Agricultural Bull. No. 1026 gives the consumptive duty as 1.25 acre-ft. per acre. The total average annual water supply of the district is as follows:

TABLE NO. 13

AVERAGE ANNUAL WATER SUPPLY OF DISTRICT NO. 3

Origin of Supply	Acre-feet	Remarks
Cache La Poudre River	320,000	Avg. at Canyon 1884-1928
North Poudre Canal	26,000	Diverts above canyon gage-Avg. 1921-28
Poudre Valley Canal	6,300	Do
Fort Collins Water Works	2,000	Do
Available Seepage Return	88,000	80% of Avg. for 1916 and 1917.
Total Average Supply	442,300	Acre-Feet.

The 24th Biennial Report of the State Engineer shows 268,540 acres irrigated in District No. 3 in 1928 and 388,540 acres "that can be irrigated" in the district. The total average supply given in the above table represents 1.65 acre-feet per acre irrigated in 1928 and 1.14 acre-feet per irrigable acre. The present district water supply is not much more than enough to serve the present irrigated area after additional storage facilities have been provided. Future expansion of the irrigated area in this district should come through increased trans-mountain diversions.

7. Canal Diversion in District No. 3.

Below is given a list of the principal diversions from the Cache La Poudre River and North Fork, with priorities, decreed rights, canal capacities and irrigated areas reported for 1928. The priorities and decreed rights have been taken from current records of the State Engineer's office. Canal capacities and irrigated areas are as reported in 1928 by the Water Commissioner of District No. 3. The canals are listed in the geographical order in which they divert from the river.

TABLE NO. 14

PRINCIPAL DIVERSIONS IN DISTRICT NO. 3

	Name of Canal	Year of Main Priority	Total Decreed Rights Sec.Ft.	Canal Capacity Sec.-ft.	Acres Irrigated 1928
1.	North Poudre*	1880	383.67	310	35,000
2.	Poudre Valley	1873	30.86	200	5,000
3.	Pleasant Val. & Lake	1879	137.93	135	7,000
4.	Larimer County	1881	496.32	700	52,000
5.	Dry Creek (Jackson)	1861-1879	50.92	51	2,500
6.	Little Cache La Poudre	1869	82.50	100	1,700
7.	Taylor and Gill	1866	12.17	20	600
8.	Larimer Co. No. 2	1873	178.50	175	7,200
9.	New Mercer	1880	170.53	120	6,700
10.	Fort Collins (Arthur)	1873	109.00	55	3,600
11.	Larimer & Weld	1878	720.00	1,000	60,000
12.	Vandewark	1874	10.17	5	160
13.	Josh Ames	1867	17.97	16	710
14.	Lake	1872	163.28	165	8,000
15.	John G. Coy	1865	31.63	20	290
16.	Chaffee	1872	22.38	22	500
17.	Box Elder	1866	52.76	30	2,200
18.	Greeley No. 2	1870-1877	585.00	585	50,000
19.	Whitney	1862	61.18	50	2,500
20.	B. H. Eaton	1864	41.70	50	1.300
21.	Wm. R. Jones	1867	15.52	20	900
22.	Canal No. 3(Greeley #3)	1870-1873	172.79	130	4,500
23.	Boyd and Freeman	1862	87.28	10	740
24.	Ogilvy	1881	91.00	90	4,000
	Totals		3,725.06	4,059	257,100

* Diverts from North Fork of Cache La Poudre River.

In addition to the above list, there are a number of small ditches which divert mainly from high tributaries of the North Fork and have little effect on the district water supply.

The water supply for the Cache la Poudre Valley during the irrigation season of 1926 was the most favorable that has occurred in the past 12 years. There were no excessive floods but the river flow was well sustained, allowing practically full diversions throughout the season to supply all irrigation demands. The amount of water actually diverted per acre irrigated, was 1.61 acre-feet which is the maximum use reported for the past 12 years and about 0.4 of an acre-foot per acre greater than the 12 year average. Precipitation at the Fort Collins Weather Bureau Station was below normal and the temperature was above normal.

In general, if the canals in District No. 3 could divert every year as they did in 1926, the present irrigated area would experience no shortage of water for irrigation. The 1926 demand was therefore used in computing the surplus water in the district available for additional storage.

Below is a summary of the diversions by the principal canals, which are supplied by the Cache La Poudre River below the canyon gaging station, for the season of 1926.

TABLE NO. 15

SUM OF DAILY DIVERSIONS IN 1926 FROM CACHE LA POUDRE RIVER BELOW CANYON GAGING STATION (From Water Commissioner's Field Book)

Day	May	June	July	Aug.	Sept.	Oct.
1	17	2,736	2,620	886	346	113
2	69	2,721	2,476	841	344	113
3	69	2,696	2,295	753	407	113
4	706	2,684	2,053	791	544	113
5	982	2,603	1,924	943	454	110
6	1,563	2,588	1,750	873	344	110

TABLE NO. 15 (Cont'd.)

Day	May	June	July	Aug.	Sept.	Oct.
7	1,558	2,729	1,989	888	322	80
8	1,505	2,735	1,849	975	536	30
9	1,509	2,698	1,816	872	491	30
10	1,358	2,624	1,807	927	333	15
11	1,311	2,694	1,667	858	288	15
12	1,257	2,542	1,569	758	278	15
13	1,264	2,050	1,630	669	263	15
14	1,335	1,562	1,580	653	258	15
15	1,263	1,562	1,530	552	253	15
16	1,466	1,353	1,482	557	233	15
17	1,674	1,234	1,467	555	246	15
18	1,848	1,184	1,455	535	246	15
19	1,731	709	1,442	473	236	15
20	1,778	749	1,257	475	225	15
21	1,966	778	1,207	475	225	15
22	2,440	1,054	1,165	415	158	15
23	2,471	1,437	1,195	460	158	15
24	2,825	1,814	1,144	450	140	15
25	2,904	1,964	1,087	444	140	15
26	2,993	2,083	1,055	444	140	0
27	3,008	2,228	1,064	444	128	0
28	2,966	2,054	1,066	416	128	0
29	2,838	2,084	1,056	450	98	0
30	2,777	2,162	1,051	450	98	0
31	2,720	xxx	974	333	xxx	0
Total	54,172	60,200	47,730	19,615	8,060	1,052
A.Ft.	107,400	119,600	94,800	38,900	16,000	2,090

Total Acre-Ft. = 378,800

8. Surplus Available for Additional Storage at Canyon.

In estimating surplus waters that would have been available in the past for additional storage at the Cache la Poudre canyon gaging station, the sums of the daily diversions of the canals, which diverted below the canyon during 1926, were subtracted from the recorded mean daily flows at the canyon, increased by 80% of the average return flow, as determined for 1916 and 1917 (Agricultural Bulletin No. 1026). Surplus flows were found to have been available only during the months of May, June and July.

It was realized that if shortages existed in Districts Nos. 1 and 64, which take water from the South Platte River below the mouth of the Cache La Poudre, at the same time that there was surplus water at the Poudre canyon, as much of the surplus as was required by the lower districts could be demanded and withheld from storage above. Accordingly the demands for Platte shortages were deducted from determined daily surplus flows at the Poudre canyon whenever they occurred on the same dates. However, as South Platte shortages were seldom reported at times when there was considerable surplus for additional storage, the allowing for such shortages did not have a great effect on the amount of available storage.

Below are given summaries, in acre-feet, for the period 1909 to 1928, inclusive, of surplus flows at the Poudre canyon that would have been available for additional storage. Amounts are shown, first, with Platte shortages disregarded, and second, with the shortages deducted.

TABLE NO. 16

SUMMARY OF SURPLUS AVAILABLE FOR ADDITIONAL STORAGE AT CANYON OF CACHE LA POUDRE R. - USING 1926 DIVERSIONS OF CANALS BELOW THE CANYON GAGING STATION.

	Surplus--Platte Shortages Disregarded				Surplus--Platte Shortages Supplied				
Year	May	June	July	Acre-feet Total	May	June	July	Acre-ft. Total	Shortage on basis 1.3 A-Ft. per acre
1909	2,550	114,500	33,500	150,550	2,550	113,700	31,850	148,100	
1910	2,350	680	0	3,030	1,460	60	0	1,520	
1911	1,730	12,050	0	13,780	1,730	6,110	0	7,840	
1912	2,990	22,000	2,780	27,770	2,990	21,540	2,780	27,310	
1913	1,600	2,900	0	4,500	700	620	0	1,320	
1914	35,100	48,800	0	83,900	35,100	48,800	0	83,900	
1915	2,870	12,700	0	15,570	2,870	7,380	0	10,250	
1916	2,940	14,200	0	17,140	2,000	8,190	0	10,190	
1917	8,000	131,300	42,500	181,800	4,900	131,300	42,500	178,700	0
1918	1,840	54,150	3,070	59,060	1,840	54,150	3,070	59,060	13,000
1919	1,950	1,310	0	3,260	1,950	0	0	1,950	159,000
1920	3,960	49,060	930	53,950	3,960	49,060	130	53,150	0
1921	3,190	72,800	0	75,990	2,600	72,800	0	75,400	0
1922	1,780	12,300	0	14,080	1,780	6,270	0	8,050	127,650
1923	2,520	110,800	18,530	131,850	2,520	110,800	14,560	127,880	0
1924	5,640	106,300	0	111,940	4,380	106,300	0	110,680	26,700
1925	2,450	8,480	0	10,930	1,560	7,920	0	9,480	83,000
1926	6,390	24,050	0	30,440	6,390	24,050	0	30,440	0
1927	2,410	13,700	0	16,110	2,410	13,700	0	16,110	2,680
1928	6,990	9,260	119	16,449	4,440	9,260	147	13,847	0
Avg.	4,963	41,067	5,075	51,105	4,407	39,600	4,752	48,759	34,400
Avg. 1917-28	3,927	49,460	5,429	58,816	3,228	48,800	5,034	57,062	34,400
1918-28	3,556	42,020	2,059	47,635	3,075	41,301	1,628	46,004	37,500

Note: The figures for the years 1909 to 1926, incl., were taken from "Progress Report on Additional Storage in Cache la Poudre Basin, July, 1927", by the Bureau of Reclamation, but with no allowances for increased diversions by the Poudre Valley Canal. The surplus flows for 1927 and 1928 and the period averages have been computed independently.

9. Present Reservoirs in District No. 3.

A total of 56 reservoir and reservoir enlargement decrees were granted in District No. 3 in 1909. The decreed capacities total 158,090 acre-feet.

The Water Commissioner reported on 70 reservoirs in 1928, the estimated total capacities for which are given as 178,000 acre-feet. Twenty-one of the reservoirs in the report, most of small capacity, did not store water in 1928.

According to the water commissioner, the estimated reservoir capacities are frequantly inaccurate and, generally, in excess of those to which it is safe to permit storage on account of danger from wave action.

Most of the reservoirs are in natural depressions away from the stream and are fed by inlet canals. There are a few channel reservoirs on high tributaries, the principal ones being Halligan and Chambers Lake.

The maximum storage in all the reservoirs at one time, as reported, was 139,655 acre-feet on July 1, 1926. A total of 48 reservoirs were operating in 1926 with total estimated capacities of 155,500 acre-feet. The present maximum safe aggregate holding capacity for operating reservoirs in the district is probably about 140,000 acre-feet.

10. Transmountain Diversions into Cache la Poudre River.

Diversions are being made from the Western Slope into the Cache la Poudre River Drainage area from districts 47, 48 and 51. All diversions are made at high altitudes by means of short open canals across the divide, with the exception of the Laramie-Poudre Tunnel which is 11,306 feet in length.

Diversions from District 47 are from Michigan River, a tributary of the North Platte River; out of District 48, from the Laramie River water shed, also tributary to the North Platte; and from District 51 out of Grand River, a tributary of the Colorado River.

The reports of the division engineer for Division No. 1 give the following transmountain diversions into District No. 3 for the period 1909-1928 inclusive.

TABLE NO. 17

TRANSMOUNTAIN DIVERSIONS INTO CACHE LA POUDRE RIVER

ACRE-FEET

Year	From Michigan R. Dist.No.47	From Laramie River - Dist. No. 48: Skyline Ditch	Laramie-Poudre Tunnel	From Tributary Creeks	Total from Dist.No.48	From Grand River Dist.#51	Total into Dist. #3
1909	2,856				13,678	15,400	31,934
1910	2,428				18,113	10,228	30,769
1911	2,202				18,874	9,835	30,911
1912	4,482				28,068	15,722	48,272
1913	2,982				16,642	10,094	29,718
1914	2,786				11,004	7,616	21,406
1915	2,534		4,978		21,168	12,208	35,910
1916	6,496		3,645		27,470	14,518	48,484
1917	1,484	11,502	392	0	11,894	7,588	20,966
1918	2,660	15,724	10,722	3,262	29,708	14,371	46,742
1919	2,660	14,415	4,090	2,373	20,878	10,124	33,662
1920	4,130	13,882	12,366	1,122	27,370	15,162	46,662
1921	2,716	14,330	9,233	1,546	25,109	9,205	37,030
1922	3,654	16,272	7,196	3,930	27,398	12,446	43,498
1923	5,096	16,028	10,252	5,378	31,658	12,558	49,312
1924	1,672	10,372	4,378	394	15,144	7,510	24,326
1925	8,212	15,134	10,470	5,054	30,658	16,796	55,666
1926	5,090	17,136	5,644	2,626	25,406	14,428	44,924
1927	5,385	22,150	7,750	4,754	34,654	16,488	56,527
1928	4,583	19,397	10,217	1,992	31,606	13,535	49,724
Avg.	3,705	15,529	7,238	2,703	23,275	12,292	39,322
Avg. 1918-28	4,160	15,894	8,393	2,948	27,235	12,966	44,361

In 1922 a decree of the U. S. Supreme Court limited diversions by the Laramie-Poudre Tunnel to 15,500 acre-feet each year.

The Laramie-Poudre Tunnel, through lack of collection ditches has never been able to divert its full allotment.

The following table shows approximately the average seasonal possibilities for transmountain diversions under present schemes:

TABLE NO. 18

Name of Ditch	Sq. Miles Drainage Area Commanded	Elevation Drainage Area	Est. Run-off A.Ft. per sq.m. May-Sept. incl.	Total available runoff May-Sept. incl. Acre-ft.	Possible mean annual diversion	Diversions Limited to
Michigan	6.2	10,300 to 12,953	1,800	11,000	8,000	8,000
Skyline	17.6	9,150 to 12,965	1,500	26,400	21,000	
Laramie-Poudre)	9.0	8,600 to 10,000		9,000		
Rawah Ditch)	20.3	8,600 to 12,463		14,000	17,000	15,500*
From tribs. of Laramie River					5,000	5,000
Grand R.	14.0	10,200 to 12,953	1,600	22,400		
Ext. of So. Ditch to Milner Pass and Main D. to Baker Gulch	11.3	10,700 to 12,000	1,500	17,000	30,000	30,000
Totals				99,800	81,000	

* Limited by decree of 1922.

TABLE NO. 19

SUMMARY PRESENT TRANSMOUNTAIN DIVERSIONS AND FUTURE DEVELOPMENT.

ACRE-FEET

Diversion Ditch	Avg. Diversion 1918-1928 incl.	Possible Mean Annual Diversion	Remarks
Michigan	4,160	8,000	Canal improvements required.
Skyline	15,894	18,000 to 26,000	
Laramie-Poudre	8,393	15,500	Tunnel repairs and completion of Rawah ditch. Lim. by decree
Tribs. of Laramie River	2,948	5,000	Improvements
Grand River	12,966	30,000	Canal Improvements, extension of collection ditches and additional storage required.
	44,361	76,500 to 84,500	

All of the transmountain ditches, with the possible exception of the Skyline, are in need of more storage facilities to enable them to realize the full benefit from run-off on their drainage areas.

Grand River ditch, by improvements to its present collection ditches, to decrease leakage, should be able to divert about 17,000 acre-feet on the average instead of the present 13,000 acre-feet, and could divert about 13,000 acre-feet more by an extension of its South Feeder ditch for about 4.5 miles and its main ditch to Baker Gulch. Its past diversions have been considerably less than that available, mostly on account of lack of storage. Long Draw Reservoir, with a capacity of about 5,000 acre-feet, is being constructed to serve this system and will be in operation during the season of 1930. This reservoir no doubt will materially increase diversions by the Grand River ditches but considerably more storage will be needed before the entire run-off from the drainage area can be made available.

The Rawah collection ditch, to connect with the Laramie-Poudre tunnel is under construction and when completed should allow the tunnel to divert its full decreed right of 15,500 acre-feet instead of its present average of 8,400 acre feet.

If Elkhorn reservoir were constructed, it could be operated so as to handle the early season surplus from all transmountain diversions from the Laramie River, and make it available for later irrigation.

The winter outflow from Elkhorn would be increased to make space for next season's transmountain water which would result in increased power output and revenues and increased yield of the reservoir for irrigation.

Investigations are now being made to determine the feasibility of diverting considerable quantities of surplus water from the North Platte River and tributaries in North Park, by means of a tunnel to the Laramie River, and thence thru the present Laramie Poudre Tunnel into the Poudre River.

CHAPTER IV

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

BIG THOMPSON RIVER - WATER DISTRICT NO.4 - WATER SUPPLY

Contents

CHAPTER IV.

SOUTH PLATTE SYSTEM - IRRIGATION DIVISION NO. 1

BIG THOMPSON RIVER - WATER DISTRICT NO. 4 - WATER SUPPLY

1. Discharge Records and Run-off.

District No. 4 is irrigated from the Big Thompson River, Buckhorn Creek and Little Thompson Creek, the first mentioned being the main source of supply.

Stream flow records, mainly during the irrigation season, were kept on the Big Thompson River by the State Engineer, in the vicinity of Arkins from 1888 to 1911, inclusive, except the years 1893 and 1894. From 1888 to 1892, inclusive, the record did not include the flow of the Handy Ditch. From 1895 to 1898, inclusive, the flows of both the Handy and Home Supply Ditches were excluded. From 1899 to 1911, the Handy Ditch diversions, only were excluded.

From 1917 to 1926, inclusive, gaging stations were maintained by the U. S. G. S. about 1½ miles and 1 mile east of Drake (the station was moved above the Loveland dam on June 16, 1921.) Since 1927 the record has been kept at a point in the river canyon about 5 miles east of Drake. All gaging locations since 1917 have been above all principal diversions on the stream.. The present station is below the tail race of the Loveland power plant.

The drainage area above the Arkins station was reported as 305 sq. miles, above the Drake station as 274 sq. miles, and that above the present station in the canyon as 307 sq. miles.

In the run-off table given below, additions have been made to include the diversions of the Handy Ditch for 1888 to 1892 and from 1899 to 1911, incl. From 1895 to 1898, inclusive, the diversions of both the

Handy and Home Supply Ditches have been added. From 1918 to 1928, inclusive, the recorded flow represents the available supply furnished by the river and no corrections were made for this period.

TABLE NO. 1

RUN-OFF BIG THOMPSON RIVER IN CANYON MEAN DAILY SEC. FT.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-Off Acre-Ft.
1888							(72)	174	510	312	191	75	
1889	(51)							(418)	464	269	118	62	
1890	55							(495)	611	509	422	164	
1891	80	(76)							(930)	449	188	108	
1892								(371)	786	564	180	65	
1895								(366)	931	679	423	185	
1896	114							270	363	260	168	161	
1897	96							571	695	379	196	101	
1898	54	37						214	499	318	112	55	
1899	23	12					293	353	968	775	311	95	
1900	54						386	1240	1345	365	138	81	
1901								600	859	531	261	72	
1902							29	316	508	181	90	90	
1903	98						114	274	885	568	170	(102)	
1904										(423)	255	133	
1905	(85)	55	48	29	(31)	(26)	170	516	1149	527	217	(52)	175,630
1906	55	42	42			(40)	183	548	805	711	239	(186)	
1907	139	148	88				(145)	504	1114	1123	371		
1908							89	149	422	419	364	137	
1909	61	60					(149)	(430)	(1286)	(860)	(294)	(211)	
1910	(64)	38	28	29	26	39	(62)	(297)	(435)	(250)	(108)	(127)	91,030
1911	(53)	27	26					(338)	595	358	126		
1918	41	34	29	(18)	(19)	(28)	54	311	(932)	(312)	(121)	(121)	21,880
1919	(93)	(52)	(34)	(26)	(21.5)	26	58	246	251	214	135	111	76,790
1920	59	46	36	32	(34)	(23)	(40)	290	971	533	305	176	153,970
1921	78	(46)	(35)	25	22	26	122	460	1450	578	275	137	196,430
1922	61	38.5	32	34	28	30	58	305	671	323	210	86	113,510
1923	43	36	33	23	19	26	82	447	1420	1010	355	155	221,480
1924	132	115	73	43	35	27	154	654	1550	662	144	81	221,660
1925	68	37	19.5	19	25	24	52	208	390	284	209	145	89,760
1926	136	73	36	22	18	24	317	883	1170	726	245	89	226,509
1927	55	35	29	22	20	26	76	379	696	439	223	99	127,080
1928	77	49	31	29	25	32	45	661	807	656	212	68	163,430
Averages	74	53	39	27	25	28	125	429	827	502	224	114	149,390
Av.1918-28	76.8	51.0	35.2	26.6	24.2	26.5	96.2	440	937	521	221	116	155,682

Av. Run-off 1924-1928, inclusive - 165,688 Acre-Feet.

Note: Figures enclosed thus ( ) indicate record partly estimated or supplied from Water Commissioner's weekly reports. These figures are considered fairly close approximations.

The maximum momentary flow was recorded from a highwater mark on July 31, 1919 and was estimated (by curve extension) at 8,000 sec. ft. or 29 sec. ft. per sq. mile drainage area. The high water mark and flood estimate are subject to error, and it is probable that the results are somewhat too large.

Run-off records are ~~available~~ on the Big Thompson near the mouth from April 1 to November 30, ~~1914, and from~~ March 1, 1927 to date.

TABLE NO. 2

RUN-OFF BIG THOMPSON AT MOUTH - DAILY MEAN SEC. Ft.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1914							467	1040	534	20.6	7.3	21.5	
1915	41.4	37.8											
1927				(45)	(45)	55.3	42.8	11.3	36.4	21.4	24.3	18.1	
1928	90.2	68.6	55.2	45.1	32.1	47.1	16.2	71.9	106	93.1	31.9	29.6	41,674

Run-off for calendar year 1927 = 30,995 acre-feet.
( ) Indicates from W. C.'s Weekly Reports.

TABLE NO. 3
RUN-OFF BUCKHORN CREEK - DAILY MEAN SEC.-FT.
(From Water Commissioner's Weekly Reports)

Note: The 2 tables below are "estimates" of flow and approximate only.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1924	28.3	52.3	22.0	14.6	14.3	13.1	97.8	235	337	26.2	6.4	0	51,048
1925	3.6	3.0	1.3	0.7	4.0	4.6	5.8	3.0	2.6	0	0.6	1.7	1,841
1926	3.5	6.6	5.5	5.0	5.0	5.8	122	126	77.6	34.2	25.7	7.3	25,629
1927	3.8	4.5	6.5	5.0	5.0	5.0	15.7	21.4	24.3	12.7	7.2	3.2	6,886
1928	2.6	3.0	3.0	3.0	3.0	6.5	15.0	60.0	32.1	16.1	7.0	0.9	9,301
Avg.	8.4	13.9	7.7	5.7	6.3	7.0	51.3	89.1	94.7	17.8	9.4	2.6	18,941
Avg. 1925 to 1928, incl.-													10,914

TABLE NO. 4

RUN-OFF LITTLE THOMPSON CREEK MEAN DAILY SEC. FT.

(From Water Commissioner's Weekly Reports)

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1924	34.5	43.7	18.9	12.7	11.2	11.0	132	232	251	54,0	12.6	0.4	49,166
1925	0	0	0	0	0	0	0	0	0	0	0.9	1.5	143
1926	3.3	4.8	9.3	6.4	5.6	5.0	347	204	82.2	45.6	29.4	17.5	45,663
1927	11.0	0	0	0	0	0	23.6	24.3	34.5	19.3	16.7	7.4	8,280
1928	5.4	0	0	0	0	3.8	8.5	148	37.0	18.1	9.1	3.5	14,231
Avg.	10.8	9.7	5.6	3.8	3.4	4.0	102.2	121.7	80.9	27.4	13.7	6.1	23,497
Avg. 1925 to 1928, incl.													17,080

2. Temperature and Precipitation at Greeley

Thirty-four years of temperature records and 40 years of precipitation records (including 1928) are available for the Weather Bureau station at Greeley, which is situated near the east edge of the irrigated area of District No. 4. The recorded temperatures at Greeley, are probably a little higher and the precipitation a little less, than the average for the whole irrigated area in District No. 4.

Below are given monthly and annual average temperatures and precipitation for the period 1921-1928, and averages for the periods of record.

TABLE NO. 5

MONTHLY AVERAGE TEMPERATURE, DEGREES FAHRENHEIT, AT GREELEY

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	26.2	29.8	40.8	43.8	56.6	67.0	72.0	70.0	61.1	51.0	37.4	26.6	48.5
1922	18.8	25.2	36.3	43.8	56.2	68.4	70.5	73.0	62.4	49.2	33.9	27.7	47.1
1923	32.3	23.7	29.2	40.8	55.8	65.2	72.6	68.4	59.4	44.0	38.4	21.4	45.9
1924	20.3	32.7	26.2	45.6	52.0	66.0	70.4	70.0	59.0	54.0	39.6	14.9	45.9
1925	19.6	35.5	40.2	50.8	59.4	66.8	73.0	68.7	63.4	41.8	35.8	26.0	48.4
1926	22.0	34.6	37.6	46.7	58.4	66.2	70.6	71.1	60.3	51.0	39.0	19.4	48.1
1927	28.4	31.4	34.9	46.7	58.4	64.8	70.6	66.1	61.2	51.2	39.2	20.2	47.8
1928	29.4	29.8	39.3	44.3	57.5	60.8	71.1	69.1	60.1	48.6	35.6	20.6	47.2
Avg. 34 yrs.	26.0	27.8	38.0	47.4	56.8	66.6	70.9	70.0	61.2	49.1	36.6	26.0	48.0

TABLE NO. 6

INCHES OF RAINFALL, AT GREELEY

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	1.41	0.18	0.27	1.32	2.83	2.70	1.64	2.93	0.21	0.47	0.12	0.40	14.48
1922	0.29	0.36	0.15	1.73	1.25	0.25	1.46	1.72	0.05	0.02	0.61	0.43	8.32
1923	0.07	1.39	2.12	0.82	2.14	4.54	0.96	1.80	1.03	2.94	0.01	0.38	18.20
1924	0.20	0.49	1.45	0.84	2.59	0.38	0.05	T	1.88	1.04	0	0.80	9.72
1925	0.21	0.05	0.26	0.06	1.01	3.09	1.76	4.25	0.22	3.05	0.66	1.27	15.89
1926	0.34	0.25	0.37	1.03	0.97	1.44	1.82	0.59	0.94	1.71	0.55	1.10	11.11
1927	T	0.63	1.75	2.34	0.88	2.78	2.29	1.32	0.46	0.23	1.50	0.13	14.31
1928	0.08	0.15	0.54	0.87	2.87	6.04	2.78	1.39	T	0.51	1.05	0.03	16.31
Avg. 40 yrs.	0.32	0.41	0.73	1.71	2.47	1.41	1.85	1.13	0.96	0.92	0.33	0.41	12.65

Avg. May-Oct. = 8.74 in. = 0.73 acre-ft. per acre.

3. Seepage and Return Flow in District No. 4.

TABLE NO. 7

FROM PROF. L. G. CARPENTER'S BULLETIN NO. 180

Big Thompson River			Little Thompson Creek		
Year	Month	Sec.Ft. Inflow	Year	Month	Sec.Ft. Inflow
1897	Nov.	64.08	1897	Nov.	10.63
1898	Nov.	52.76	1898	Nov.	8.89
1899	Nov.	37.38	1899	Nov.	13.15
1900	July 18-21	57.85	1900	Sept. 15-16	21.92
1901	Sept. 15-20	53.65	1901	July 20	28.24
1902	July 28-30	42.09	1902	Aug. 1	14.73
1903	Aug. 27-29	62.05	1903	Aug. 30-31	21.62
1904	Sept. 19-21	55.23	1904	Sept. 24	32.76
1905	Oct. 4-5	43.76	1905	Oct. 6	23.38
1906	Nov. 12-14	55.98	1906	Nov. 12	25.28
1907	Sept.23,Oct.6	59.52	1907	Oct. 11	29.68
1908	Oct. 1-3	55.78	1908	Oct. 7	24.77
1909	Oct. 13-15	62.18	1909	Oct. 16	24.64
1910	Oct. 13-15	39.10	1910	Oct. 20	17.92
Avg.		52.96	Avg.		21.26

Total Avg. for both Creeks = 74.22 sec. ft.

TABLE NO. 8

FROM STATE ENGINEER'S BIENNIAL REPORTS

Big Thompson River

Year	Month	Sec.Ft. Inflow	
1906	Nov.	65.31	
1907	Nov.	43.6	
1908	Nov.	41.3	
1913	Oct.	47.3	
1914	Oct.	84.6	Flood conditions
Avg.		56.4	

Avg. omitting 1914 = 49.4

Note: Most of the seepage from Buckhorn Creek diversions returns to Big Thompson River.

TABLE NO. 9

SEEPAGE RETURN FROM WATER COMMISSIONER'S WEEKLY REPORTS

For District No. 4

Month	Reported Inflow	Avg. Reported Inflow	Month	Reported Inflow	Avg. Reported Inflow
Jan.	45	45	July	50	50
Feb.	45	45	Aug.	40-50	42
Mar.	45 to 50	48	Sept.	50-60	54
Apr.	50	50	Oct.	50-60	55
May	50	50	Nov.	60	60
June	50	50	Dec.	60	60

Annual Avg. = 50.75 Sec. Ft.

Note: The Water Commissioner's estimates of return flow, probably are for the Big Thompson River, only.

Assumed Seepage Return for Dist. No.4.

A conservative estimate of the average seepage return for the district is about 50 sec. ft. for Big Thompson River, and 20 sec. ft. for Little Thompson Creek. The total seepage return for District 4 (ignoring return to Buckhorn Creek, which, evidently, is small) then, would average about 70 sec. ft. or 50,600 acre-feet per year.

An amount of 50 sec. ft. is considered a fair average value for the seepage return from Big Thompson River during the irrigation season.

4. Use of Water in District No. 4.

The total average annual water supply for the district is as follows:

TABLE NO. 10

Origin of Supply	Acre-Feet	Remarks
From Big Thompson R.	155,700	Avg. 1918 to 1928, incl.
From Little Thompson Cr.	22,000	" 1924-28 corrected to 1918-28.
From Buckhorn Cr.	17,800	" " " " "
From Seepage Return	50,600	Avg. 70 sec. ft.
Total Supply	246,100	Acre Ft.

The reports of the Water Commissioner show 141,430 acres irrigable and 141,430 acres irrigated in 1928. Therefore, the total average supply for the district amounts to 1.74 acre-ft. per irrigable and irrigated acre. This latter figure is probably based upon results of land cruise in 1930. - See Article X.

The following table of gross use of water by canals in District No. 4 was compiled from data given in the biennial reports of the State Engineer:

TABLE NO. 11

WATER USED BY CANALS FOR IRRIGATION IN DISTRICT NO. 4.

Acre-Feet

Year Ending Sept. 30	Run-off Big Thompson near Drake	Diverted by ditches from Natural Flow	Diverted from Storage	Total used for Irrigation	Total Acres Irrigated in Dist. #4	Acre-Ft. Per Acre Irrigated	Shortage basis of 1.35 A.F. Per Acre
*1921	196,430	135,282	53,326	188,608	129,480	1.46	0
1922	113,510	91,708	**37,405	129,113	140,060	0.92	60,200
*1923	221,480	137,424	**35,402	172,826	140,775	1.23	16,900
*1924	221,660	132,022	**49,131	181,153	141,276	1.28	9,900
1925	89,760	86,454	26,968	113,422	127,940	0.89	58,850
*1926	226,509	172,972	37,980	210,952	141,070	1.49	0
1927	127,080	123,172	23,174	146,346	141,420	1.04	43,840
*1928	163,430	144,107	37,408	181,515	141,430	1.28	9,900
Avg.	169,982	127,892	37,599	165,491	137,931	1.20	25,000

* Average 5 good years - 1.35 Acre Ft. per acre.
** These figures supplied from W. C.'s Weekly Reports.

The years 1922, 1925 and 1927 were years of serious shortages, each occurring after a year of surplus water. About 40,000 to 60,000 acre-feet of additional water on an average of every third year could be used to good advantage in this district.

Consumptive Use of Water in District No. 4.

Parallel records of flow into and out of the district and storage records are available for the calendar year 1927 and for the season ending September 30, 1928.

TABLE NO. 12

CONSUMPTIVE USE IN DISTRICT NO. 4 FOR CALENDAR YEAR 1927 - ACRE-FEET.

Big Thompson in Canyon	Little Thompson	Buckhorn Creek	Big Thompson at Mouth	In Storage Jan. 1, 1927	In Storage Dec. 31 1927	Cons. Use 1927	Areas Irri. 1927	Cons. Use Ac.Ft. Per Acre Irr.
129,460	7,931	6,510	30,995	40,276	39,600	113,582	141,420	0.80

TABLE NO. 13

CONSUMPTIVE USE IN DISTRICT NO. 4 FOR YEAR ENDING SEPTEMBER 30, 1928.
ACRE-FEET

Big Thompson R. in Canyon	Little Thompson Cr.	Buckhorn Creek	Big Thompson R. at Mouth	In Storage Oct. 1, 1927	In Storage Sept. 30, 1928	Cons. Use yr. Ending Sept. 30, 1928	Acres Irr. 1928	Cons. Use Ac.Ft. Per Acre Irr.
163,430	14,231	9,301	41,674	31,019	41,752	134,555	141,430	0.95

The consumptive use or depletion is evidently about 1.0 acre-feet per acre, based upon the reports of the Water Commissioner of area irrigated, which is probably too large. See Article X, Page 35.

5. Canal Diversions in District No. 4.

Below is a list of principal canals which divert in District No. 4 as reported in 1928, when all of the irrigable area in the district was irrigated.

TABLE NO. 14

Identi. No.	Name of Canal	Years of Priority	Total Decreed Rts. S.F.	Canal Capacity S.F.	Acres Irr. in 1928
		Canals Diverting from Big Thompson R.			
1.	Handy	1863-1880	200.57	225	15,000
2.	Home Supply	1861-1881	349.63	240	25,000
3.	South Side	1863-1880	56.30	40	2,250
4.	George Rist	1873	195.00	300	4,650
5.	Louden Irrigating	1861-1883	306.78	200	16,000
6.	Barnes (Loveland & Greeley C.Co)	1865-1873	49.25	700	2,000
7.	Rist and Goss	1866-1875	86.48	6	320
8.	Loveland and Greeley	1865-1881	395.54	520	32,000
9.	Big Thompson Ditch & Mfg. Co.	1863-1872	64.88	35	2,600
10.	Farmers Irrigating	1861-1878	75.26	75	5,200
11.	Hillsborough	1861-1881	216.71	150	12,000
12.	Hill and Brush	1866	61.80	40	1,500
13.	Big Thompson & Platte River	1865-1876	121.18	75	3,500
14.	Evanstown	1871	29.28	50	3,000
	Totals		2208.66	2556	125,020

TABLE NO. 14 (Cont'd.)

Identi. No.	Name of Canal	Years of Priority	Total Decreed in S.F.	Canal Capacity Sec. Ft.	Acres Irri. in 1928
	Canals Diverting from Little Thompson Creek				
1.	Bee Line	1887	40.00	20	500
2.	Boulder & Larimer Co.	1875-1877	66.72	200	10,000
3.	W. R. Blower No. 1	1869-1876	44.93	12	320
4.	Eagle	1877	15.60	4	300
5.	Jim Eglin	1869-1872	3.64	8	300
6.	Lykens	1868-1869	5.20	3	100
7.	Munson Seepage	Filing 1898	No decree	2	0
8.	Miner and Longan	1893	40.80	30	600
9.	Osborne and Caywood	1861-1875	19.76	8	500
10.	Rockwell	1883	21.00	8	500
11.	Supply Lateral	1867-1878	74.57	35	1,500
	Total		332.22	330	14,620
	Canals Diverting from Buckhorn Creek				
1.	Buckhorn Pipeline	1883	9.00	8	250
2.	Buffum	1879	2.60	3	40
3.	Kirchner	1874	6.81	4	100
4.	Neville	1879	3.12	8	200
5.	Neville No. 2 (Carter)	1869-1896	9.80	8	300
6.	Perkins	1874-1881	7.57	5	200
7.	Union	1889-1891	12.00	10	200
8.	Victory Irrigating	1879-1887	18.00	10	500
	Total		68.90	56	1,790
	Grand Total		2,609.78	2,942	141,430

Note: The acreage irrigated in 1928 is the greatest irrigated to date and is reported as the same as the irrigable area in the district.

The sum of the daily diversions of the above canals diverting from Big Thompson River during the good water year of 1926 was tabulated as a reasonable demand against the supply furnished by the Big Thompson in past years, in computing the annual amounts of surplus water available for additional storage. The year 1926 was the best water year for the district in the past 10 years, when practically the whole district was irrigated and all the lands were well supplied with water. Diversions in 1926 are shown in the following table:

TABLE NO. 15

SUM OF DAILY DIVERSIONS FROM BIG THOMPSON RIVER - 1926, SEC. FT.
(From Water Commissioner's Field Book)

Day	April	May	June	July	Aug.	Sept.	Oct.
1	0	32	1,102	1,135	430	178	82
2	0	32	1,124	950	374	180	90
3	0	32	1,089	942	364	180	90
4	0	32	1,128	874	349	180	90
5	0	32	1,128	1,057	414	193	90
6	0	32	1,127	1,033	414	182	90
7	0	32	1,157	916	474	182	90
8	0	32	1,137	787	471	182	90
9	0	531	977	792	471	185	90
10	0	530	883	799	467	178	90
11	0	520	862	699	412	177	90
12	0	520	911	634	381	175	0
13	0	531	861	691	379	169	0
14	0	538	335	757	347	158	0
15	0	546	457	725	342	122	0
16	0	556	484	691	317	105	0
17	15	585	404	681	281	154	0
18	15	569	434	681	285	102	0
19	15	604	423	660	274	117	0
20	15	653	421	610	274	122	0
21	15	743	443	592	274	130	0
22	15	968	654	589	244	130	0
23	15	984	768	563	240	118	0
24	15	1197	591	533	218	119	0
25	15	1011	643	511	198	108	0
26	15	974	664	453	198	108	0
27	15	1059	698	447	198	108	0
28	15	1248	750	447	183	71	0
29	15	1205	802	442	177	71	0
30	32	1095	826	436	177	71	0
31	xx	1140	xxx	447	177	xxx	0
Total	227	18563	23283	21574	9804	4255	982
Acre-Ft.	450	36800	46200	42800	19450	8440	1950

Total for season diverted from natural flow = 156,090 Acre-Ft.

Note: 1928 record for Canal No. 13 for June, used, as 1926 record was missing.

TABLE NO. 16.

SUM OF DAILY DIVERSIONS FROM LITTLE THOMPSON CREEK - 1926, SEC. FT.
(From Water Commissioner's Field Book)

Day	May	June	July	Aug.	Sept.
1	0	117	40	35	15
2	0	95	42	37	16
3	0	95	40	31	16
4	0	98	43	19	21
5	0	97	44	21	21
6	0	106	36	18	21
7	0	95	42	21	19
8	0	98	44	38	16
9	15	86	40	49	16
10	15	87	45	45	16
11	15	86	38	41	16
12	15	89	33	41	17
13	15	76	33	43	19
14	15	77	54	48	14
15	15	71	47	39	14
16	101	71	59	25	14
17	101	80	59	23	14
18	101	81	46	24	14
19	101	80	50	23	13
20	85	56	42	24	13
21	72	54	44	20	12
22	72	54	42	19	12
23	85	49	44	19	12
24	86	44	43	18	12
25	85	48	38	18	12
26	71	47	36	18	0
27	88	42	42	18	0
28	149	41	34	17	0
29	129	37	37	15	0
30	117	39	38	15	0
31	118	xxx	38	15	xxx
Total	1,666	2,196	1,313	837	385
Acre-Ft.	3,300	4,350	2,600	1,660	764

Total diverted from natural flow in 1926 = 12,674 Acre-Feet.

TABLE NO. 17

SUM OF DAILY DIVERSIONS FROM BUCKHORN CREEK - 1926, SEC. FT.

(From Water Commissioner's Field Book)

Day	May	June	July	Aug.	Sept.
1	0	37	32	35	12
2	0	37	32	34	5
3	0	39	32	34	5
4	0	39	32	33	6
5	0	39	37	31	4
6	0	39	36	30	4
7	0	39	36	30	3
8	0	39	36	30	3
9	5	39	36	30	3
10	5	39	36	30	3
11	5	42	36	30	3
12	5	42	36	30	3
13	5	42	36	28	3
14	5	42	31	28	0
15	5	42	31	28	0
16	10	42	31	27	0
17	10	42	31	20	0
18	10	42	32	20	0
19	10	42	30	20	0
20	10	42	30	20	0
21	16	42	30	20	0
22	16	33	30	20	0
23	24	33	30	18	0
24	32	33	30	18	0
25	36	33	30	18	0
26	36	33	30	18	0
27	37	33	30	18	0
28	38	32	30	18	0
29	38	32	30	18	0
30	37	32	30	14	0
31	37	xx	30	12	xx
Total	432	1,142	999	760	57
Acre-Ft.	856	2,270	1,980	1,510	113

Total Diverted from natural flow in 1926 = 6,729 Acre-Ft.

TABLE NO. 18

SUM OF DAILY DIVERSIONS FROM BIG THOMPSON RIVER, LITTLE THOMPSON CREEK

AND BUCKHORN CREEK IN 1926 - SECOND-FEET.

(Sum of Tables 15, 16 and 17 above)

Day	April	May	June	July	Aug.	Sept.	Oct.
1	0	32	1,256	1,207	500	205	82
2	0	32	1,256	1,024	445	201	90
3	0	32	1,223	1,014	429	201	90
4	0	32	1,265	949	401	207	90
5	0	32	1,264	1,138	466	218	90
6	0	32	1,272	1,105	462	207	90
7	0	32	1,291	994	525	204	90
8	0	32	1,274	867	539	201	90
9	0	551	1,102	868	550	204	90
10	0	550	1,009	880	542	197	90
11	0	540	990	773	483	196	90
12	0	540	1,042	703	452	195	0
13	0	551	979	760	450	191	0
14	0	558	454	842	423	172	0
15	0	566	570	803	409	136	0
16	0	667	597	781	369	119	0
17	15	696	526	771	324	168	0
18	15	680	557	759	329	116	0
19	15	715	545	740	317	130	0
20	15	748	519	672	318	135	0
21	15	831	539	666	314	142	0
22	15	1,056	741	661	283	142	0
23	15	1,093	850	637	277	130	0
24	15	1,315	668	606	254	131	0
25	15	1,132	724	579	234	120	0
26	15	1,081	744	519	234	108	0
27	15	1,184	773	519	234	108	0
28	15	1,435	823	511	218	71	0
29	15	1,372	871	509	210	71	0
30	32	1,249	897	504	206	71	0
31	xxx	1,295	xxx	515	204	xxx	0
Total	227	20,661	26,621	23,886	11,401	4,697	982
Acre-Ft.	450	41,000	52,800	47,400	22,600	9,320	1,950

Total Diversions from natural flow in 1926 = 175,520 Acre-Ft.

6. Surplus Available for Additional Storage in District No. 4.

The flows of Little Thompson and Buckhorn Creeks are erratic. According to the water commissioner's estimates, their combined monthly average flows vary from zero to about 450 second-feet. The occasional surplus waters from Little Thompson Creek come into the Big Thompson too low down to be available for any of the canals except the Evanstown, while the Buckhorn empties into the Big Thompson above canals having an aggregate capacity of 1651 second-feet.

Therefore, in estimating the water available for additional storage, the supply from Buckhorn should be considered as available as well as that from the Big Thompson River. Unfortunately daily flow records of Buckhorn Creek have not been kept, the only available record being estimated weekly flows from the Water Commissioner's reports. According to these reports, there are occasional large floods in Buckhorn Creek in May or June which yield considerably more water than is needed for Buckhorn diversions and a large part of which could be stored or used to replace water needed to supply Big Thompson requirements or Platte River shortages downstream.

The available surplus at the canyon for Big Thompson River alone, was computed for the period 1918 to 1928 inclusive by subtracting the daily 1926 diversions from Big Thompson River from the daily recorded flow of Big Thompson near Drake, increased by an allowance of 50 sec. feet for available seepage return. Surplus amounts in second-feet were computed for each day of the period considered and summarized by months. The months of May, June and July ordinarily contained all of the possibilities for additional storage although small surplus flows were found in April, 1926 and in August, 1923.

The results obtained by this method are summarized below:

TABLE NO. 19

SURPLUS AVAILABLE FOR ADDITIONAL STORAGE FROM BIG THOMPSON RIVER USING 1926 DAILY DIVERSIONS FROM BIG THOMPSON RIVER.

Year	Surplus Acre-Feet Platte Shortages Disregarded						Surplus Acre-Feet Platte Shortages Supplied					
	Apr.	May	June	July	Aug.	Total	Apr.	May	June	July	Aug.	Total
1918	0	0	21500	0	0	21,500	0	0	6130	0	0	6,130
1919	0	0	8	184	0	192	0	0	0	0	0	0
1920	0	0	18900	884	0	19,784	0	0	3500	0	0	3,500
1921	0	4490	43500	2490	0	50,480	0	4490	43500	494	0	48,484
1922	0	0	6830	0	0	6,830	0	0	0	0	0	0
1923	0	0	44100	23500	5680	73,280	0	0	44100	18500	4370	66,970
1924	0	1490	49200	4950	0	55,640	0	1100	49200	0	0	50,300
1925	0	0	1900	0	0	1,900	0	0	0	0	0	0
1926	1980	20100	26300	5580	0	53,960	1980	20100	25300	1580	0	48,960
1927	0	325	8920	80	0	9,325	0	0	7530	0	0	7,530
1928	0	6230	8780	2760	0	17,770	0	4690	8780	1480	0	14,950
Avg.	180	2967	20904	3675	516	28,242	180	2762	17095	2005	397	22,439

The left hand side of the above table shows the surplus flows in the Big Thompson River passing the gaging station in the canyon near Drake and not required for irrigation requirements in District No. 4.

In the right-hand side of the table, reported shortages in Districts Nos. 1 and 64 have been subtracted on parallel dates to arrive at surplus flows that could be stored without interfering with any irrigation rights in lower districts. It is probable that the estimates of shortages are too high and cover too long periods of time, as reported, but it is noted that shortages ordinarily are not reported in the lower districts at times when large surplus flows occur in the upper Thompson River. It is thought that rather larger quantities than shown in the right hand table and somewhat smaller than shown in the left-hand table, could be counted on for additional storage from the flow of the Big Thompson River alone.

An estimate was made of the surplus at the canyon, from the combined flows of the Big Thompson River and Buckhorn Creek. The accurately recorded daily flow of the Big Thompson near Drake, plus estimated seepage return was combined with the Water Commissioner's estimated flows of Buckhorn Creek. From the combined daily flows, thus obtained, were subtracted, day by day, the sums of the daily diversions from the Big Thompson River and from Buckhorn Creek for 1926, the differences being taken as surplus flows from the two streams combined.

The following table is a summary of these surplus flows in Acre-feet and also a summary of results obtained by subtracting reported Platte River shortages on the dates on which they were reported as effective:

TABLE NO. 20

SURPLUS AVAILABLE FOR ADDITIONAL STORAGE FROM BIG THOMPSON RIVER AND BUCKHORN CREEK

	Surplus-- Acre-Feet Platte Shortages Disregarded						Surplus - Acre-Feet Platte Shortages Supplied					
Year	April	May	June	July	Aug.	Total	April	May	June	July	Aug.	Total
1918	0	0	24000	0	0	24000	0	0	8640	0	0	8640
1919	0	0	0	147	0	147	0	0	0	0	0	0
1920	0	0	19700	714	0	20414	0	0	3720	0	0	3720
1921	0	5000	53900	2370	0	61270	0	5000	53900	488	0	59388
1922	0	0	6160	0	0	6160	0	0	0	0	0	0
1923	0	38	66300	27200	7660	101198	0	38	66300	22000	5730	94068
1924	0	9970	64200	4520	0	78690	0	7010	64200	0	0	71210
1925	0	0	1380	0	0	1380	0	0	0	0	0	0
1926	5250	22750	28800	5360	0	62160	5250	22750	27800	1500	0	57300
1927	0	91	8540	28	0	8650	0	0	7220	0	0	7220
1928	0	6660	8450	2230	0	17340	0	5190	8450	1080	0	14720
Avg.	477	4046	25585	3870	696	34674	477	3635	21839	2279	521	28751

The right hand side of the above table headed "Surplus Acre-Feet, Platte Shortages Supplied," shows an average annual surplus for the period 1918 to 1928, inclusive, of 28,751 acre-feet from Big Thompson and Buckhorn, combined or 6,312 acre-feet more than the average from Big Thompson River alone, as shown in Table 19, above.

The surplus from the two streams would have been available at their junction near the mouth of the canyon and would have been available at the Drake gaging station on the Big Thompson River to the extent that it was flowing in the river on the dates when it became available as surplus.

A comparison of the daily recorded flow near Drake and the estimated daily surplus flows from the two streams, shows only 4 months in the 1918-1928 period, in which the flows at Drake fell below the estimated surplus flows, summarized as follows:

TABLE NO. 21

Year	Month	Acre-Feet Surplus not Available at Drake	Acre-feet. Surplus Available at Drake
1921	May	656	4,344
1923	June	7,260	59,040
1926	April	286	4,964
1926	May	38	22,712

Inserting these values in the right hand side of Table 20, above, we have the following annual summary of the surplus available for additional storage at Drake, on Big Thompson River with Platte shortages supplied.

TABLE NO. 22

SURPLUS AVAILABLE FOR ADDITIONAL STORAGE ON BIG THOMPSON RIVER NEAR DRAKE

Year	Annual Surplus - Ac. Ft. Platte Shortages Supplied	Year	Annual Surplus - Ac. Ft. Platte Shortages Supplied.
1918	8,640	1924	71,210
1919	0	1925	0
1920	3,720	1926	56,976
1921	58,732	1927	7,220
1922	0	1928	14,720
1923	86,808		
		Avg.	28,002

Practically all of the surplus from the Big Thompson River and Buckhorn Creek can be stored on the Big Thompson River near Drake.

Under paragraph 4, above it was shown that serious shortages occurred in the District during 1922 (60,200 acre-feet), 1925 (58,850 acre-feet) and during 1927 (43,840 acre-feet).

The surplus of 1921 (58,732 A. F.), if it had been stored, would have supplied about 98 per cent of the following years' shortage.

The surplus of 1924 (71,210 A. F.) would have more than supplied the 1925 shortage.

The surplus of 1926 (56,976 A. F.) would have more than supplied the shortage of 1927.

A channel reservoir of not less than 60,000 acre-feet available capacity and probably about 65,000 acre-feet actual capacity, in the channel of the Big Thompson River below the Drake gaging station, would ordinarily fill with surplus water during years of excess river flows and fully supply the serious shortages that occur every 2 or 3 years in the district and the lesser shortages that come more frequently.

7. Reservoirs in District No. 4.

There are 21 reservoirs in the district, of which 18 are supplied from Big Thompson River, 2 from Little Thompson Creek and 1 from Buckhorn Creek. Buckhorn Reservoir on Buckhorn Creek is the only one on a main stream channel. The aggregate capacity of all reservoirs is about 101,000 acre-feet. Seventeen of the reservoirs have decrees for storing water, and the other 4 have filings on record in the State Engineer's office.

There is a small terminal reservoir, with an estimated capacity of 73 acre-feet, created by the Loveland Power Dam (Idylwilde) in the Big Thompson Canyon below Drake, which is used for power purposes. This reservoir is not included in the list of 21 reservoirs reported by the water commissioner.

Below is a list of the active reservoirs in District No. 4 with their recorded decrees and estimated capacities:

TABLE NO. 23.

	Name of Reservoir	Decreed Rights Acre-Feet	Capacities by Water Comm.	Remarks
Reservoirs from Big Thompson River and Tributaries.				
1.	Boyd Lake	44,100	44,100	
2.	Bacon Lake	Not decreed	284*	Filing for 284 A. Ft.
3.	Cemetery L.	460	460	Gr. West. Sugar Factory Supply
4.	Fairport	555	555	
5.	Home Supply	9,180	9,180	
6.	Loveland	2,150	2,150	
7.	Loveland & Greeley	14,250	14,250	
8.	Lawn (Lake Loveland)	760	760	
9.	Glacier (Lost L.)	Not decreed	138	Filing for 138 Ac. Ft.
10.	Louden	1,150	500	
11.	Mariano	4,130	5,360	Filing for Enl.
12.	Rockwell	257	505	
13.	Ryan Gulch	730	914	
14.	Rist	Not decreed	344	Filing for 272 Ac. Ft.
15.	Rist & Benson	Not decreed	344	Filing for 374 Ac. Ft.
16.	Seven Lakes	8,440	8,440	
17.	South Side	351	654	
18.	Welch Lakes (5)	4,570	4,550	
Reservoirs from Little Thompson Creek.				
19.	Boulder & Lar. Co.	7,340	7,340	
20.	Culver	148	148	
Reservoir from Buckhorn Creek (in channel).				
21.	Buckhorn	1,190	626	Filing for Enl. to 14,600 Ac. Ft.
	Totals	99,761	101,602	

*Capacity from filing.

CHAPTER V.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

ST. VRAIN CREEK - WATER DISTRICT NO. 5 - WATER SUPPLY

Contents

CHAPTER V.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

ST. VRAIN CREEK - WATER DISTRICT NO. 5 - WATER SUPPLY

1. Discharge Records and Run-off.

The water supply of District No. 5 is mostly secured from the North and South Forks of St. Vrain Creek and from seepage return in the lower part of St. Vrain Creek. Some water for irrigation is diverted from Left Hand and Dry Creeks. The last named two creeks are small, and present little opportunities for storing any appreciable amount of water.

The gaging station on St. Vrain Creek near the town of Lyons, is on the main creek below the junction of the North and South Forks, and also below the headgates of the Supply, South Lodge and Left Hand Canals.

Records have been kept at or near this station since 1888 but are more or less intermittent until 1909. Some winter months are missing between 1909 and 1917, but since the latter date, the run-off record is complete for all months.

Gaging stations have been maintained at the mouths of St. Vrain and Left Hand Creeks since March, 1927.

TABLE NO. 1

RUN-OFF ST. VRAIN CREEK NEAR LYONS IN MEAN DAILY SEC. FT. (Without Diversions Above Gage)

Drainage Area - 226 sq. mi. - Elev. = 5349

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Feet	
1909	39	37	(18)	(14)	(12)	(20)	(250)	298	726	514	191	128	135,812	
1910	46	27	20	17	13	24	40	150	241	146	76	68	52,522	
1911	26	15	14	11	8	18	42	205	425	250	102	61	71,271	
1912	49	19	8	7	6	13	64	353	629	536	175	85	117,896	
1913	66	27	(18)	(12)	(16)	(21)	(96)	254	312	190	88	99	72,138	
1914	85	33	(18)	(14)	(12)	58	238	537	768	356	192	80	144,752	
1915	56	29	(18)	(14)	(12)	(20)	248	315	518	325	159	125	111,242	
1916	94	42	(21)	(14)	(12)	(34)	71	273	427	311	175	86	94,586	
1917	72	45	17	9	10	17	93	472	703	481	149	66	129,477	
1918	20	17	15	12	11	17	43	162	784	352	147	87	100,449	
1919	76	24	17	11	7	10	49	225	262	176	172	69	66,642	
1920	34	11	9	12	12	12	49	478	505	352	189	78	105,625	
1921	29	18	17	16	12	16	172	404	1090	384	174	75	145,111	Max.
1922	19	16	18	10	6	13	43	161	376	175	89	35	58,248	
1923	11	11	11	11	10	20	82	351	825	581	234	110	136,695	
1924	124	139	55	31	26	28	212	399	819	340	116	49	141,160	
1925	29	16	9	11	15		25	135	232	181	109	77	51,545	Min.
1926	66	51	30	27	23		347	431	652	402	175	59	139,050	
1927	17	14	14	14	12	15	100	267	428	291	157	92	86,070	
1928	28	18	22	16	15	13	39	479	454	354	144	53	99,374	
Avg.	49.3	30.4	18.4	14.1	12.5	21.0	115.	317	559	335	151	79.1	102,983	
1917-28													104,954	
1918-28													102,724	

Note: Figures enclosed thus ( ) indicate records estimated from incomplete data.

The maximum seasonal run-off occurred in 1921, (145,100 acre-feet).
The minimum was in 1925, (51,500 acre-feet).

The maximum recorded mean daily discharge was 2,020 sec. ft. in June, 1921. Estimated probable maximum flood flow to be expected is about 5,000 sec. ft. (About 23 sec. ft. per square mile drainage area).

Average run-off 1924 to 1928, incl. = 103,440 Ac. Ft.

TABLE NO. 2

RUN-OFF ST. VRAIN CREEK AT MOUTH IN MEAN DAILY SEC. FT.
(From State Records)

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Ac.Ft.
1927				(100)	(80)	104	219	204	248	207	269	156	
1928	149	117	114	127	88	118	101	1150	646	271	159	101	190,880
For calendar year 1927 (partly estimated) - - - - - - - - - - - - -													118,900

Left-Hand, Dry, Boulder and Idaho Creeks empty into the St. Vrain above its mouth.

TABLE NO. 3

RUN-OFF LEFT-HAND CREEK AT MOUTH - MEAN DAILY SEC. FT.
(From State Records)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Ac. Ft.
1927				(6)	(6)	5	29	38	31	17	24	6	
1928	7	7	7	7	6	4	8	144	55	23	13	5	17,419

Run-off Calendar Year 1927 (partly est.) = 11,000

Run-off Boulder Creek at Mouth for year ending Sept. 30, 1928 = 63,854 A.F.

Run-off Boulder Creek at Mouth for calendar year 1927 = 35,315 A.F.

TABLE NO. 4.

DIVERSIONS BY SUPPLY CANAL, 1918 - 1928, INCL.
(From Water Comm.'s Field Books)

Year	Acre-Ft. Diverted from St. Vrain Creek	Year	Acre-Ft. Diverted from St. Vrain Creek
1918	7,928	1924	6,292
1919	436	1925	618
1920	7,982	1926	8,034
1921	6,418	1927	8,322
1922	468	1928	8,766
1923	8,802		

Avg. 1918 - 28 = 5,824

TABLE NO. 5

DIVERSIONS BY SOUTH LEDGE CANAL, 1918-1928, INCL.

1918	390	1924	590
1919	0	1925	0
1920	494	1926	404
1921	412	1927	556
1922	0	1928	396
1923	820		

Avg. 1918-28 = 369

No record seems to be kept of the Left-Hand Ditch which diverts from the South Fork of St. Vrain Creek and from Left-Hand Creek, high in the mountains near the continental divide. The canal has a capacity of 275 sec. ft. and irrigates 11,600 acres of land. It is understood it has prior rights to all of the low water flow in South St. Vrain at its diversion point. The ditch also receives water from Gold Lake Reservoir, which is supplied from St. Vrain Creek and from Left-Hand Reservoir, which receives its storage from Left Hand Creek.

The Water Commissioner's field book for 1924, a good water year, gives a record of Left-Hand Ditch diversions as obtained from the ditch superintendent. It shows 12,356 acre-feet diverted including storage water from Gold Lake. Deducting 436 acre-feet or the amount of stored water used from the Reservoir, there remains 11,920 or practically 12,000 acre-feet as the amount of water diverted from South St. Vrain Creek in 1924.

2. Temperature and Precipitation at Longmont.

Temperature and precipitation records for 22 years, including 1928, are available from the weather bureau station at Longmont, which is centrally located in the irrigable area of District 5.

TABLE NO. 6

MONTHLY AVERAGE TEMPERATURE, DEGREES FAHRENHEIT, AT LONGMONT

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	28.4	33.2	42.8	43.3	55.9	65.5	69.8	68.0	60.2	51.4	38.9	30.8	49.0
1922	20.0	26.7	37.5	44.3	55.9	67.3	68.6	71.3	62.6	50.0	35.4	31.0	47.6
1923	35.4	24.4	31.2	45.8	56.2	64.1	72.2	68.8	60.3	43.8	40.4	27.8	47.5
1924	22.0	34.8	28.4	46.6	52.9	66.7	70.2	70.8	58.6	52.0	40.4	19.7	46.9
1925	28.2	37.8	42.8	52.6	60.4	67.8	73.2	69.2	62.6	42.9	37.2	28.4	50.3
1926	23.8	37.0	37.8	48.0	58.0	66.8	70.0	71.0	59.8	52.4	40.9	24.3	49.2
1927	32.9	34.4	36.2	48.6	60.0	65.2	70.2	66.0	59.8	51.7	40.6	22.1	49.0
1928	33.6	30.4	40.4	46.0	57.0	60.0	69.4	67.8	60.0	48.3	36.4	24.5	47.8
Avg. 22 yrs.	26.6	29.0	38.0	46.1	56.0	65.6	69.8	68.8	60.1	48.0	36.6	26.4	47.6

TABLE NO. 7

INCHES OF RAINFALL, AT LONGMONT

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	0.76	0.12	0.24	3.78	2.12	6.33	2.83	1.64	0.17	1.10	0.38	0.91	20.38
1922	0.29	0.28	0.43	1.66	0.16	0.38	1.45	1.02	0.29	0.24	1.84	0.34	8.38
1923	0.17	0.88	1.25	1.21	3.05	5.46	3.73	1.34	0.76	3.23	0.23	0.39	21.70
1924	0.58	0.32	1.19	1.03	3.38	0.30	1.32	0.17	2.18	1.02	0.04	0.92	12.45
1925	0.05	T	0.33	0.04	1.46	2.74	3.30	2.46	0.85	3.73	0.61	1.01	16.58
1926	0.52	0.40	1.13	2.06	2.85	0.91	0.66	0.76	0.75	0.88	0.14	1.11	12.17
1927	0.04	0.21	1.17	2.05	1.36	2.13	3.02	1.35	1.09	0.45	1.03	0.22	14.12
1928	0.10	0.26	1.16	1.03	2.75	3.12	1.16	0.92	0.21	1.59	1.05	0.09	13.44
Avg. 22 yrs.	0.30	0.65	0.83	2.05	2.34	1.59	2.21	1.20	1.21	1.13	0.61	0.63	14.75

Avg. May-Oct. = 9.68 in. = 0.81 acre-feet per acre.

3. Seepage and Return Flow in District No. 5.

TABLE NO. 8

FROM PROF. L. G. CARPENTER'S BULL. NO. 180 - FOR ST. VRAIN CREEK, SEC. FT.

Year	Date	Total Seepage	Year	Date	Total Seepage
1898	Oct. 26-28	*32.29	1904	Sept. 27-29	48.95
1899	Nov. 9-11	41.76	1905	Oct. 26-28	51.34
1900	Oct. 17-19	36.41	1907	Oct. 12-15	**63.39
1901	July 29-Aug. 1	28.74	1908	Oct. 8-10	**57.04
1902	Aug. 12-14	13.38	1909	Oct. 17-20	**69.24
1903	Sept. 8-11	24.30	1910	Oct. 21-23	**44.80

Avg. 12 years = 42.64 sec. ft.
Avg. final 6 years = 55.79 sec. ft.
Avg. final 5 years = 57.16 sec. ft.

* Corrected for error in table.

** Changed to include Left-Hand Creek in inflow, as in previous measurements.

The final 5 years of Prof. Carpontor's measuremonts (1905, 1907, 1908, 1909 and 1910) shows an average seepage return for St. Vrain Creek of 57.16 sec. ft., for the month of October.

The average point of least flow in St. Vrain Creek is below the headgate of the Oligarchy Canal during the non-irrigation period, November to April, inclusive, and below the intake of the South Flat ditch, during the period May to October, incl. (The South Flat ditch is the next to divert below the Niwot). Ninety per cont of the seepage return enters St. Vrain Creek below the Oligarchy heading, 86 per cent enters below the South Flat ditch, and 12 per cent of the seepage occurs below all diversions on the creek.

Seepage Return for Left-Hand Creek from Bull. 180.

Prof. Carpenter gives the average return for Left-Hand Creek for the period 1899 to 1903, inclusive, as 7.63 soc. ft.

TABLE NO. 9

ST. VRAIN SEEPAGE FROM STATE ENGINEER'S REPORTS

Year	Month	Seepage Return
1906	Oct.	29.98 s.f.
1907	Sept.-Oct.	51.80
1908	Oct.	54.00
1913	Oct.	44.00
1914	Oct.	51.80
Avg.		46.31

TABLE NO. 10

SEEPAGE IN DISTRICT FROM W. COM.'S WEEKLY REPORTS FOR 1928.
1928

Month	Seepage (avg.)	Month	Seepage (avg.)
Jan.	50 s.f.	July	50 s.f.
Feb.	50 s.f.	Aug.	50 s.f.
Mar.	50 s.f.	Sept.	45 s.f.
Apr.	50 s.f.	Oct.	40 s.f.
May	50 s.f.	Nov.	40 s.f.
June	50 s.f.	Dec.	40 s.f.

Note: 88 per cent of the seepage return occurs above the lowest diversion on St. Vrain Creek and is available for the ditches in Dist. No. 5.

Proposed Seepage and Return Flow for St. Vrain Water Supply Computations.

The latest available seepage measurement is the one made by the State in October, 1914. It shows a return flow of 51.80 sec. ft. which probably is not far off from present conditions.

An average of 50 sec. ft. total return flow for St. Vrain Creek during the irrigating months, May to October, inclusive, and about 40 sec. ft. for the winter months, November to April, inclusive, are considered reasonable amounts for use in estimating St. Vrain Creek water supply.

As 88 per cent of the return flow comes into the creek above the lowest ditch diversion, the available seepage would be as follows:

Available Seepage Return St. Vrain Creek

May to October, inclusive - 45 sec. ft.

Nov. to April, inclusive - 35 sec. ft.

4. Use of Water for Irrigation in District No. 5.

The total average supply in acre-feet, for the district is estimated as follows:

TABLE NO. 11

Origin of Supply	Acre-Foot	Remarks
St. Vrain Creek below Lyons	103,000	20 yrs. avg. at gaging sta.
South Ledge Ditch	400	Diverts above gage
Supply Canal	6,600	Diverts above gage
Left-Hand Canal	11,000	Diverts above gage in high m't'ns.
Left-Hand Creek	5,000	Estimated by W. Com.
Available seepage return	29,000	88 per cent of total
Total average supply	155,000	

Note: The above total does not include inflow from Boulder & Idaho Creeks which enter the St. Vrain too low to be diverted by the principal canals of the district.

The total area irrigated in District No. 5 in 1928 was reported as 89,264 acres. The average total available supply, therefore, amounts to 1.74 acre-feet per acre irrigated in 1928, and 1.49 acre-feet per acre for the 103,773 acres of irrigable land reported in 1928.

The total amounts of water, from natural stream flow and from storage, diverted by the canals of the district for the period 1921 to 1928, inclusive, was compiled from data given in the State Engineer's reports.

This computation is given below and represents gross headgate diversions plus water released to canals from storage.

TABLE NO. 12

WATER USED BY CANALS FOR IRRIGATION IN DISTRICT NO. 5

Year Ending Sept.30	Run-off St.Vrain Cr. at Lyons	Diverted by ditches from nat. flow	Diverted from storage	Total used for Irrigation	Total Acres irrigated. Dist.No.5.	Acre-Ft. Per Acre Irrigated.
1921	145,111	68,743	22,781	91,529	85,755	1.07
1922	58,248	57,226	*20,219	77,445	68,825	1.13
1923	136,695	80,522	*24,254	104,776	90,526	1.16
1924	141,160	82,295	*27,419	109,714	87,505	1.25
1925	51,545	51,776	4,065	55,841	48,220	1.16
1926	139,050	91,678	23,446	115,124	91,406	1.26
1927	86,070	76,312	24,225	100,537	91,019	1.10
1928	99,374	82,640	30,712	113,352	89,264	1.27
Avg.	107,160	73,900	22,140	96,040	81,565	1.18

* These figures derived from W. Com's. weekly reports.

The water used, as shown in the above table, is incomplete on account of no diversion records having been kept on several ditches in the district, although the acreages irrigated by these ditches were included.

Subtracting the reported irrigated areas under the canals whose diversions were not recorded, we have the following corrected gross use of water for the land irrigated under the recorded diversions:

TABLE NO. 13

CORRECTED TABLE-GROSS USE OF WATER IN DISTRICT NO. 5.

Year	Total Recorded Use for Irr. Acre-Ft.	Total Acres Irrigated Dist.No.5.	Acres Irrigated under ditches not recorded.	Acres Irrig. under Recorded Ditches	Acre-Ft. Per A. Irrigated under Recorded Ditches
1921	91,529	85,755	12,234	73,521	1.25
1922	77,445	68,825	12,302	56,523	1.37
1923	104,776	90,526	13,500	77,026	1.36
1924	109,714	87,505	440	87,065	1.25
1925	55,841	48,220	4,600	43,620	1.28
1926	115,124	91,406	13,815	77,591	1.48
1927	100,537	91,019	13,610	77,409	1.30
1928	113,352	89,264	13,620	75,644	1.50
Avg.	96,040	81,565	10,515	71,050	1.35

During the dry years of 1922 and 1925, the irrigated areas evidently were cut down to suit the water supply which makes the acre-feet per acre used near the average, although there were serious water shortages in those years for the total irrigated area in Dist. 5. About ½ of the irrigated area (53% in 1928) is ordinarily planted to cereals and it is in this section that the principal reduction in irrigated area is made during short years.

In 1922, 68,825 acres were irrigated but in the following year of fair water supply, 90,526 acres were irrigated, an increase of 21,701 acres. The area irrigated in 1926 (91,406 acres) was 43,186 acres more than that of 1925.

It appears that on the average in a good water year, about 91,000 acres are irrigated at the rate of 1.35 acre-feet per acre and that when the reported acreage irrigated falls below 91,000 acres, a shortage is indicated.

TABLE NO. 14

SHORTAGES IN DIST. 5 ACCORDING TO AREAS IRRIGATED

	Areas Irrigated	91,000 minus, area Irrig.	Shortage at 1.35 ac.ft.per A.
1918	94,282	0	0
1919	58,608	32,392	43,700
1920	90,013	987	1,330
1921	85,755	5,245	7,080
1922	68,825	22,175	29,900
1923	90,526	474	640
1924	87,505	3,495	4,720
1925	48,220	42,780	57,900
1926	91,406	0	0
1927	91,019	0	0
1928	89,264	1,736	2,340
Avg.	81,402	9,935	13,419

The above table shows that serious water shortages of from about 30,000 to 60,000 acre-feet occur about every third year (1928 being an exception).

Sufficient records are not available for computing the consumptive use of water in this district.

5. Canal Diversions in District No. 5.

Following is a list of canals which divert in District No. 5 from St. Vrain, Dry and Left-Hand Creeks:

TABLE NO. 15

DECREED CANALS DIVERTING IN DISTRICT NO. 5.

No.	Name of Ditch	Years of Priority	Decreed Rights	Max. Capacity	Area Irrigable	Acres Irrigated in 1928	Diverts from
1.	**Left-Hand	1863-70	726.00	275	20,000	11,600	(St.Vrain & (Left-Hand Crs.
2.	South Ledge	1870-84	31.00	12	1,100	397	So.St.Vrain Cr.
3.	Supply	1878	92.20	125	7,500	7,500	St. Vrain Cr.
4.	Highland	1871-1902	324.03	400	35,000	33,600	"
5.	Rough & Ready	1869-73	83.34	115	7,760	6,760	"
6.	St.Vr.& Palmerton	1865-74	164.31	60	1,500	1,200	"
7.	Swede	1871-73	24.55	45	4,150	4,000	"
8.	Smead	1862	16.27	12	640	557	"
9.	Baker & Weese	1865	2.80	3	80	80	"
10.	Weese	1865	3.96	3	100	20	"
11.	Clough & True	1862	9.11	5	92	92	"
12.	Goss Nos. 1 & 2	1865	29.51	16	177	110	"
13	Montgomery	1862	3.96	4	160	141	"
14.	Clough	1863	10.50	5	110	90	"
15.	True & Webster	1862	10.50	3	80	80	"
16.	Webster & McCaslin	1865	13.23	8	300	160	"
17.	James	1868-77	27.11	35	2,000	1,710	"
18.	Davis & Downing	1866-76	16.24	23	960	960	"
19.	Longmont Supply	1865	53.37	50	3,500	3,500	"
20.	Chapman & McCaslin	1862	98.13	15	400	241	"
21.	Oligarchy	1866-70	237.51	125	6,500	6,500	"
22.	**McCaslin,Nos.1 to 4	1863-68	12.65	17	140	140	"
23.	Denio & Taylor	18 65-73	29.40	20	975	975	"
24.	Runyan	1863	10.80	8	240	111	"

TABLE No. 15 (Cont'd.)

DECREED CANALS DIVERTING IN DISTRICT NO. 5.

No.	Name of Ditch	Years of Priority	Decreed Rights	Max. Capacity	Area Irrigable	Acres Irrigated in 1928	Diverts From
25.	Zweck & Turner	1864	82.61	35	560	560	St.Vrain Cr.
26.	Niwot	1865-69	40.04	30	679	660	"
27.	Pella	1862-73	42.64	40	455	455	"
28.	South Flat	1863	16.70	25	900	900	"
29.	J. R. Mason	1860	5.45	3	80	45	"
30.	**Cushman	1861	13.45	4	120	50	"
31.	Beckwith	1861	14.21	12	240	240	"
32.	**Hager's Meadow	1864	2.66	3	40	5	"
33.	Island	1864	4.52	4	80	80	"
34.	*Coffman	1864-67	14.57	7	400	00*	"
35.	**Dickens	1862	15.47	6	200	200	"
36.	**Bonus	1861-65	23.23	20	800	790	"
37.	Last Chance	1872	96.94	40	2500	2000	"
38.	*Hayseed	1860	41.54	10	500	00*	"
39.	Peck	(charged to	Pella Ditch)	30	920	920	"
40.	Clover Basin	"	"	30	1000	1000	"
41.	**Upper Baldwin	1872	9.10	15	400	400	South DryCr.
42.	**Lower Baldwin	1873	4.55	7	150	150	"
43.	**Rice or Mill	1872-84	5.20	3	55	55	"
44.	**John Rice	1884	7.81	5	120	120	"
45.	**Belcher No. 1	1884	6.00	7	110	110	Left-Hand Cr.
	Totals		2477.17	1720	103773	89264	

* No water used in 1928.
** No record kept of water used in 1928.

Note: Left-Hand, South Ledge and Supply Ditches divert above Lyons Gaging Station.

It is noted above that the point of minimum flow in St. Vrain Creek is below the intake of the South Flat ditch during May to October, inclusive, and that 86 per cent of the observed seepage return occurs below this point. Therefore, 14 per cent of the seepage return, or about 7 second-feet only, is available for the ditches diverting above the point of minimum flow.

The total acres reported in 1928 as irrigated, from St. Vrain Creek (including Left-Hand Ditch) is 88,429 acres or 99 per cent of the total area irrigated in the district. There were only 5,330 acres irrigated by canals diverting below the South Flat ditch. The supply for this area consists of the surplus over needs above, about 38 sec. ft. of available seepage return, and the inflow from Left-Hand and Boulder Creeks which aggregated 81,273 acre-feet for the seasonal year ending Sept. 30, 1928. Evidently the 5,330 acres supplied by canals diverting below the South Flat ditch, is assured of sufficient irrigation water without demand on the flow of St. Vrain Creek at Lyons.

The ditches which divert below the Lyons gaging station and above the point of minimum flow in St. Vrain Creek, are those numbered 4 to 28, inclusive, in the above list of decreed canals diverting in District No. 5. The total area irrigated by these ditches in 1928 was reported as 63,702 acres. The demand for this area is considered as the total demand on the flow in St. Vrain Creek at the Lyons gaging station, the only point on the creek where a long time record has been kept. The diversion of the canals serving this area during the good water season of 1926 are considered to aggregate a fair allowance for this demand for use in estimating the surplus water that could be stored at the Lyons gaging station without interfering with present needs for irrigation.

The following table is a summary of the direct flow diversions of ditches numbered 4 to 28, inclusive, during the season of 1926.

TABLE NO. 16

TOTAL CANAL DIVERSIONS FROM ST. VRAIN CREEK - 1926.

(Below Lyons Gaging Station and Including So. Flat Ditch)
(Daily Mean Second-Feet.)

Day	May	June	July	Aug.	Sept.	Oct.
1	5	446	493	206	66	39
2	5	450	491	188	70	35
3	5	443	500	178	62	40
4	5	448	497	235	69	40
5	0	447	453	217	70	40
6	0	528	493	251	75	34
7	0	555	517	342	67	34
8	0	607	496	275	60	34
9	0	642	478	254	56	34
10	75	598	431	237	55	40
11	120	598	373	212	52	37
12	120	558	356	178	57	34
13	167	559	336	170	53	13
14	172	492	374	148	62	11
15	182	428	338	138	75	11
16	187	322	333	130	70	11
17	177	283	314	122	50	8
18	177	272	316	112	57	13
19	210	264	331	110	56	13
20	237	321	350	135	52	14
21	242	316	352	114	46	21
22	262	352	319	108	49	24
23	262	346	294	105	45	25
24	322	393	270	117	38	21
25	349	414	253	104	41	25
26	430	399	238	95	40	25
27	445	448	228	81	40	25
28	444	470	234	85	40	25
29	425	476	238	70	39	10
30	433	434	226	73	37	10
31	424	xxx	214	78	xxx	10
Total	5882	13309	11136	4868	1649	756
A. Ft.	11660	26400	22100	9650	3270	1500

Total diversions for the year 1926 = 74,580 Ac. Ft.

6. Surplus Available for Additional Storage at Lyons.

Comparisons were made of the daily flows at the Lyons gaging station, increased by 7 sec. ft., for available seepage return and the daily diversions in 1926 of all canals which divert between the Lyons gaging station and the South Flat ditch, inclusive, for the period 1917 to 1928, incl. The table below is a summary of the excess creek flows over 1926 diversions or the amounts of water storable at Lyons:

TABLE NO. 17

SUMMARY SURPLUS AVAILABLE FOR ADDITIONAL STORAGE AT LYONS-USING 1926 DIVERSIONS FOR CANALS BETWEEN LYONS AND SOUTH FLAT DITCH, INCL.
Acre-Feet.

	Surplus-Platte Shortages Disregarded.					Surplus-Platte Shortages Supplied.				
Year	May	June	July	Aug.	Total	May	June	July	Aug.	Total
1917	17800	17400	7920	0	43620	17800	17900	1940	0	37640
1918	1910	23000	2160	0	27070	840	11700	320	0	12860
1919	3270	402	1520	3860	9052	2220	0	0	0	2220
1920	18200	4870	1100	2960	27130	17900	2080	125	0	20105
1921	14000	39000	3720	2580	59300	14000	39000	880	1840	55720
1922	2130	1835	0	0	3965	1575	0	0	0	1575
1923	10300	23300	14050	5220	52870	5140	23000	9720	3360	41220
1924	13300	22800	365	170	36635	11200	22800	0	0	34000
1925	1330	14	0	700	2044	0	0	0	0	0
1926	15300	13000	3130	1720	33150	15300	12850	1320	0	29470
1927	6500	2800	710	1430	11440	4420	2260	0	646	7326
1928	18200	4840	1515	1040	25595	9640	4840	590	516	15586
1919-28 Av.	10253	11286	2611	1968	26,118	8140	10683	1263	636	20,722
1917-28 Av.	10187	12813	3016	1640	27,656	8336	11369	1242	530	21,477
1918-28 Av.	9495	12351	2570	1789	26,205	7476	10775	1178	578	20,007

The left side of the above table, entitled "Surplus-Platte Shortages Disregarded" shows the actual excess in creek flow at Lyons, over the 1926 canal diversions. The right side has deducted from it (as far as available) the sum of the reported shortages for irrigation in Districts 1 and 64 on parallel dates. The South Platte Shortages are as given in the Monday-Thursday reports of the Water Commissioners of Districts 1 and 64. It was assumed that these shortages continued after the date reported, until changed by a succeeding report.

More or less serious irrigation shortages occur on St. Vrain Creek on the average of once every three years with intervening years of surplus. This shortage may occasionally be as great as about 58,000 acre-feet, as in the extremely dry year of 1925, but averages about 33,000 acre-feet for dry years.

7. Allowable Annual Draft for Reservoirs of Various Capacities.

The approximate annual yields of various reservoirs on St. Vrain Creek near Lyons for the period 1918 to 1928, incl., are given in the following table:

TABLE NO. 18

Reservoir Cap. Acre-Feet	Average Annual Yield
20,000	12,700
30,000	16,300
40,000	18,500
50,000	19,500

A storage reservoir of about 50,000 acre-feet capacity or larger, probably would be justified, in the vicinity of Lyons, to carry water over from surplus years to supply the shortage usually occurring every third year.

It would be advisable, if capacity were available, to abandon many of the small reservoirs scattered over district No. 5 and concentrate the storage in one large reservoir in the creek channel which would conserve all surplus waters either of winter flow or spring or summer floods and, hence, be available for the majority of the canals. This reservoir should have a capacity of about 75,000 acre-feet to take care of ordinary storage needs as well as the surplus for the periodical shortages.

8. Reservoirs in District No. 5.

There are decrees for 69 reservoirs in this district, varying in size from 5 acre-ft. to the largest (Union) of 12,739 acre-ft. capacity, and aggregating a total storage capacity of about 43,000 acre-ft.

Six of the smaller decreed reservoirs are reported as abandoned, two (Allen's Lake and Independent) are operating but not yet decreed, and two (Copeland and Green Lake) have conditional decrees but are not reported as operating.

All the reservoirs of any material size are located off the St. Vrain channel, and supplied by feeder or combined feeder and irrigation canals, although there are a few small channel reservoirs on tributaries of the Forks of the St. Vrain, and in gulches of intermittent flow.

There is little opportunity in the district for storing the usual early summer flood flows.

All the reservoirs are used for irrigation only, with the exception of two with a combined capacity of 662 acre-ft., which are used by Longmont for domestic, power and irrigation purposes.

SUMMARY WATER COMMISSIONER'S RESERVOIR REPORT FOR 1928.

Number Reservoirs Reported	Acres Area high water line	Acre-Ft. Combined Capacity	Total in Storage May 1st.	Total in Storage Nov. 1st.	Total Diverted from Storage.
63	2,560	42,542	40,369	11,467	30,712

Note: There were about 7,500 acre-feet reported as stored during the irrigation season of 1928.

Note: The Union Reservoir of nearly 13,000 acre-feet capacity, the largest in the District, delivers its stored water to the South Platte River for use in lower districts.

CHAPTER VI

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

BOULDER CREEK - WATER DISTRICT NO. 6-WATER SUPPLY

Contents

CHAPTER VI.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

BOULDER CREEK - WATER DISTRICT NO. 6 - WATER SUPPLY

1. Discharge Records and Run-off.

Records of the water supply of this district are available for main Boulder Creek, from State and U. S. Geological Survey records at Boulder and at Orodell from 1895 to date (with intermissions): and for Coal Creek, from the Water Commissioner's weekly reports.

(A). Main (Middle) Boulder Creek Records.

Prior to 1909, the records are not complete, the winter months usually being lacking. The record is more nearly complete from 1909 to date, excepting for the years 1915 and 1916.

In the tabulation shown below for the period 1909 to 1928, inclusive, the 1909 to May 12, and 1917 records were taken near Boulder below the mouth of Four Mile Creek, while the 1917-1928 records are from Orodell, above the mouth of Four Mile Creek. The drainage area above Boulder is estimated at 129 sq. miles, and that above Orodell at 105 sq. miles.

It was reported in U. S. Geological Survey Water Supply Paper No. 246 for 1908 that several small power plants were developing about 1,000 H.P. above the gaging station and that the Eastern Colorado Power Company was constructing a plant for 20,000 H.P. (power house about 1 mile above Orodell) which could be made to produce about 50,000 H.P. during 6 months of the year. (This is evidently now the plant of the Public Service Co., including Barker Meadow Reservoir, Kossler Reservoir and Boulder Pipe Line, (See paragraph (7)).

Comparative U. S. Geological Survey records at Boulder, below Four Mile Creek, and at Orodell above Four Mile Creek, were tabulated as follows:

1907 (Mean Daily Sec. Ft.)

At	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Boulder	--	--	322	589	565	186	59	29	(24)	--
Orodell	(40)	70	234	467	460	164	62	32	16	(8)

1908 (Mean Daily Sec. Ft.)

Boulder	--	40	103	256	161	120	43	18	(17)	(13)
Orodell	10	47	103	252	159	119	55	20	20	10

( ) Indicates incomplete record - estimated.

The parallel records are not of sufficient length to clearly establish the relation between them.

Boulder station runs higher than Orodell during the summer months in 1907, but about the same in 1908.

Four Mile Creek probably has a small flow during the irrigation season and does not figure materially in the water supply. It is not mentioned in the reports of the Water Commissioner for District 6, although it must deliver some water on account of the size and elevation of its drainage area.

Four Mile Creek Drainage Area.

Elev.	Drainage Area Sq. Miles
6,000 to 8,000	12
8,000 to 11,000	12
Total	24

At 350 acre-feet per square mile of drainage area, the average annual run-off from Four Mile Creek would be 8,400 acre-feet.

The maximum recorded mean daily flood flow at Orodell was 1,170 second-feet in June, 1921.

The maximum possible flood flow at Orodell is estimated at 2,500 second-feet and 3,000 second-feet at Boulder.

TABLE NO. 1

RUN-OFF MAIN BOULDER CREEK IN MEAN DAILY SEC. FT.

Drainage area, 1909-1916 = 129 sq. mi. - 1917-1928 = 105 sq. mi.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Ac.Ft.
1909	23	20	(13)	9	10	11	70	173	482	372	183	114	89,600
1910	35	18	9	7	7	18	42	107	184	106	60	28	37,500
1911	15	8	(7)	4	7	4	20	150	318	171	63	(36)	48,600
1912	(15)	(18)	(13)	(10)	(23)	(9)	(20)	(162)	(343)	(460)	(121)	(108)	79,000
1913	(47)	(32)	(27)	30	34	(27)	(57)	83	243	143	70	68	51,900
1914	50	38	54	49	42	28	94	(294)	(482)	269	134	(72)	97,100
1915	(45)	(50)											
1916			No record			83	75		(350)	239	145	48	
(a)1917	32	42	27					(141)	283	298	96	37	
1918	28	32	45	48	45	40	49	151	478	314	110	56	84,300
1919	57	56	60	54	48	40	47	164	220	139	101	30	61,580
1920	23	31	16	14	23	18	28	177	336	272	156	76	70,900
1921	39	21	14	35	30	28	53	178	813	304	113	42	100,630
1922	20	18	38	58	37	84	117	156	371	165	75	26	70,370
1923	20	19	24	27	22	29	44	154	505	334	117	52	81,240
1924	83	96	84	62	60	36	76	194	460	209	73	55	89,960
1925	73	51	37	35	26	20	34	127	207	130	57	62	51,820
1926	25	24	36	31	32	36	158	263	518	324	151	59	100,120
1927	44	40	32	32	34	22	55	158	281	232	117	68	67,440
1928	49	58	56	28	27	30	37	195	396	320	104	61	82,470
Avg.	38	35	33	31	30	31	60	167	383	253	108	58	74,200
Avg. A.F.	2340	2080	2030	1910	1670	1905	3570	10250	22800	15500	6640	3450	

Avg. 1918-28 = 78,257 A.F.

1909-1916	33	26	21	18	20	26	55	162	343	251	111	68	68,600 (near Boulder)
1917-1928	41	41	39	38	35	35	63	172	406	253	106	52	77,400 (near Orodell)
1909-1913	27	19	14	12	16	14	42	115	314	250	99	71	61,320
1924-1928	55	54	49	38	36	29	72	187	372	243	100	61	78,400

Avg. 1918-28 = 78,257 A.F.

Note: On the average, 75% of the run-off occurs from May to Aug., incl. (Mos. of surplus)
On the average, 84% of the run-off occurs from Apr. to Sept., incl. (Irrig. Season)

(a) Gage moved above Four Mile Creek May 12, 1917.

(B). South Boulder Creek Records.

The gaging station on South Boulder Creek is near the mouth of the canyon at Eldorado Springs. It was established May 15, 1895. All year records start with the year of 1909.

The Community and South Boulder and Coal Creek ditches divert above the gaging station.

The maximum recorded mean daily flow at the Eldorado Station is 1,050 second-feet in June, 1921. The probable maximum flood flow is estimated at about 2,600 second-feet.

TABLE NO. 2

RUN-OFF SOUTH BOULDER CREEK AT ELDORADO SPRINGS IN MEAN DAILY SECOND FEET

Elev. - 5,800 ft. - Drainage Area = 114 sq. mi.

Mean Sec. Ft.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Ac.Ft.
1909	18	16	(14)	12	11	18	106	258	571	253	98	101	89,110
1910	36	21	13	9	8	21	35	104	118	50	24	12	27,310
1911	11	9	7	3	3	16	29	139	234	120	37	17	37,870
1912	17	13	9	3	6	8	40	204	339	213	63	28	57,060
1913	23	17	-	-	-	-	58	170	180	72	26	33	---
1914	36.5	23	(17)	-	-	29	177	588	409	162	83	30.5	---
1915	32	20	-	-	-	(21)	128	288	435	180	62	37.5	---
1916	34	27	24	17	17	23	48.5	152	223	91.5	60	24	44,900
1917	36	23	-	-	-	21	61	207	354	150	49	18	---
1918	14	16	(14)	(12)	(12)	28	64	252	425	158	46	38	65,240
1919	40	29	14.5	(13)	(13)	12.5	79	222	146	76	66	28	44,890
1920	15	11	10	12	10	20	70	371	314	118	60.5	28	62,990
1921	17.5	12	8	(15)	(20)	28	108	379	626	166	48	17	87,150
1922	16.5	4	5	(15)	(10)	(22)	39	148	209	65.5	27	13	34,670
1923	12	12	10	10	10	19	57	236	440	219	103	44	70,900
1924	44	56	34	20	24	23	145	362	423	103	13	9	75,900
1925	19	16	(12.5)	(8)	(12)	16	35	99	121	53	26	40	27,610
1926	26	27	18	15	16.5	25	180	401	349	163	56	15	78,240
1927	15.5	19	13.5	14	15	17	48	222	240	103	46.5	18	46,670
1928	19	18	17	12	11	15.5	35	296	281	162	36	16	55,750
Avg.	24.1	19.4	14.2	11.9	12.4	20.2	77.1	255	322	134	51.5	28.3	
Avg.A.F.	1480	1154	872	732	688	1240	4590	15700	19150	8240	3170	1680	58,700

(515 A.F. per sq. mi.)

Avg.A.F. 1924 to 1928 incl. = 57,000   Avg. 1918-28 = 59,100 A.F.

Note: 79% of the average flow of South Boulder Creek occurs during the period May to August, incl.; 89% occurs during the April to Sept. incl., irrigation season.

For total supply from South Boulder Creek, it is necessary to add the diversions by the Community Ditch and the South Boulder and Coal Creek Ditch, to the above table as these two ditches take out above the gaging station on the Creek.

The average sum of the annual diversions by the two ditches for the period 1924 to 1928, inclusive, is 6,000 Acre-Feet.

(C). Coal Creek - Run-off.

The supply from Coal Creek for the period 1924 to 1928 inclusive, which period shows an average flow close to the long time average for Main Boulder and South Boulder Creeks, has been compiled from the Water Commissioner's weekly reports as follows:

TABLE NO. 3.

COAL CREEK - Mean Sec. Ft. Drainage Area = 20 sq. miles.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Ac.Ft.
1924	5.0	12.3	9.6	5.7	5.8	5.3	10.6	35	50.0	11.0	4.1	3.8	9190
1925	3.7	4.9	4.6	3.2	5.0	5.4	4.7	4.1	5.2	4.1	5.2	5.8	3370
1926	7.1	6.1	6.1	6.0	6.1	7.2	19.8	35	19.6	3.8	4.1	3.5	7520
1927	5.0	4.9	4.1	4.3	5.3	5.8	13.9	26	6.9	5.6	5.5	4.8	5590
1928	6.0	6.0	6.0	5.4	5.2	6.2	8.2	34	20	8.5	4.4	3.5	6850
Avg.	5.3	6.8	6.1	4.9	5.5	6.0	11.4	26.8	20.3	6.6	4.6	4.3	-
Avg.A.F.	325	405	375	302	305	369	678	1650	1210	406	283	256	6560

(= 328 A.F. per sq. mi.)

A gaging station was established by the State at the mouth of Boulder Creek on Mar. 16, 1927, to record the water leaving the district, and has been continued to date.

TABLE NO. 4

RUN-OFF BOULDER CREEK AT MOUTH - MEAN DAILY SEC. FT.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Ac. Ft.
1927	(22)	(24)	46	87.5	92.1	76.7	29	85	5.1	33.2	32.8	49.9	35,315
1928	49.9	41.9	66.3	45.5	363	248	94.4	23.4	3.1	(3.5)	(13.4)	(22.8)	59,200

Note: Figures enclosed thus ( ) were supplied from the Water Commissioner's weekly reports.

2. Temperature and Precipitation at Boulder.

Thirty-three years of temperature, and 36 years of precipitation records, including the year 1928, have been kept by the U. S. Weather Bureau at Boulder, on the west edge of the irrigated area in District No. 6. Monthly records for the past 8 years with long time averages for the periods of record, are given below:

TABLE NO. 5

BOULDER, COLO. - MONTHLY AVERAGE TEMPERATURE, DEGREES FAHRENHEIT

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	34.3	37.4	45.5	46.0	56.8	66.2	71.6	70.4	64.3	57.2	44.4	36.2	52.5
1922	26.4	31.0	40.6	45.7	57.6	70.4	70.6	72.6	66.7	52.8	37.7	36.1	50.7
1923	38.2	29.0	33.6	47.2	55.4	66.8	70.4	67.0	59.8	43.6	41.8	32.3	48.8
1924	29.8	40.9	29.4	47.9	54.2	68.5	72.0	74.0	57.4	52.0	43.8	24.8	49.6
1925	30.5	41.0	44.1	51.5	58.6	65.9	73.2	68.4	63.2	41.5	40.2	32.1	50.8
1926	31.4	39.0	37.8	46.5	57.8	65.4	70.4	71.2	61.0	55.2	43.0	30.0	50.7
1927	36.3	38.4	37.0	49.3	59.2	63.4	69.4	65.4	61.0	54.4	44.7	26.6	50.4
1928	36.3	32.7	39.6	45.9	56.8	60.4	69.2	69.0	63.0	51.6	38.2	31.6	49.5
Avg. 33 years	33.0	32.6	40.4	48.2	56.4	66.0	70.8	70.6	63.2	52.2	42.2	33.8	50.8

TABLE NO. 6

BOULDER, COLO. - INCHES OF RAINFALL

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	0.11	0.31	0.77	4.81	1.50	3.62	1.53	2.00	0.17	1.13	0.98	1.46	18.39
1922	0.63	0.59	0.81	3.32	1.02	0.62	1.04	1.50	T	1.13	2.58	0.56	13.80
1923	T	1.71	2.99	1.29	3.47	4.44	2.46	2.68	0.84	5.43	0.40	0.88	25.89
1924	0.33	0.36	1.77	1.98	2.77	T	0.38	0.47	2.06	1.47	0.16	1.33	13.08
1925	0.06	T	0.35	0.25	1.61	1.86	2.10	1.83	2.24	4.72	0.99	1.18	17.19
1926	0.72	0.65	2.69	3.05	3.22	0.55	1.33	2.03	0.41	0.95	0.33	1.97	17.90
1927	0.22	0.47	2.66	3.46	1.72	3.47	2.39	1.26	1.29	0.86	0.95	0.69	19.44
1928	0.07	1.71	2.72	1.55	5.48	2.84	1.34	0.66	0.23	1.78	2.09	0.04	20.51
Avg. 36 years	0.40	0.76	1.40	2.81	1.14	1.41	2.14	1.46	1.50	1.52	0.65	0.83	16.12

3. Seepage and Return Flow in District 6.

TABLE NO. 7

BOULDER CREEK SEEPAGE AND RETURN FROM INVESTIGATIONS OF PROF. L. G. CARPENTER, AGRIC. BULL. NO. 180

Year	Date Measured	Sec.Ft. Net Inflow
1900	Oct. 24 - 25	27.60
1901	Sept. 3 - 4	16.19
1902	Sept. 18-20	(2.71) Probably erroneous
1903	Sept. 18-19	25.60
1904	Oct. 4-5	24.60
1905	Nov. 14-15	27.16
1906	Nov. 15-16	(27.27) Incomplete
1907	Oct. 17-18	19.35
Avg.	(Without 1902 & 1906)	23.4

TABLE NO. 8

BOULDER CREEK SEEPAGE & RETURN FLOW AS SHOWN BY STATE ENGINEER'S REPORTS

Year	Date Measured	Net Inflow
1902	September	12.48
1906	November	39.36
1907	September	10.80
1908	October	2.00 Probably erroneous acct. operations Colo. Power Plant.

South Boulder Creek Seepage and Return Flow.

Average by Prof. Carpenter 1900-1910 = 2.28 sec.ft.

Average from St. Eng'rs. Rep.1900,1906,1907,1908 & 1913 = 0.20 sec. ft.

It is evident that South Boulder Seepage Return is negligible.

TABLE NO. 9

BOULDER CREEK SEEPAGE RETURN FROM WATER COMMISSIONER'S WEEKLY REPORTS FOR 1928

Second Feet

Month	Inflow	Avg.	Month	Inflow	Avg.
Jan.	10-15	12	July	10-15	14
Feb.	10-15	14	Aug.	15	15
Mar.	10-15	11	Sept.	10-15	14
Apr.	10	10	Oct.	10-15	14
May	10-15	14	Nov.	10-15	12
June	15	15	Dec.	10	10

Note: All except 2 or 3 sec. ft. return flow below the mouth of Idaho Creek is divertible in the district.

TABLE NO. 10

SUGGESTED AVAILABLE SEEPAGE AND RETURN FLOW TABLE FOR DISTRICT NO. 6

Month	Avg. Inflow Sec. Ft.	Month	Avg. Inflow Sec. Ft.
Jan.	12	July	24
Feb.	14	Aug.	22
Mar.	16	Sept.	20
Apr.	18	Oct.	18
May	20	Nov.	16
June	22	Dec.	14

4. Use of Water for Irrigation in District No. 6.

The average total seasonal water supply for District No. 6 in acre feet is as follows:

TABLE NO. 11

From Main Boulder Cr. (20 yrs.Avg.)	From South Boulder Cr. Eldorado Sprs. (20 yrs.Avg.)	Diverted by Community & S.B. & Coal Cr. Ditches above Eldorado Sprs.	From Coal Creek (Avg.last 5 yrs.)	From Inflow	Total Avg. Supply Dist. No. 6.
74,200	58,700	6,000	6,560	13,040	158,500 A.F.

The total area that could be irrigated in the district in 1928 is given as 200,655 acres in the 24th Biennial Report of the State Engineer.

The total area irrigated in 1928 is reported by the Water Commissioner as 173,223* acres.

Seventy-three per cent of the area reported as irrigated in 1928, was in grains and natural grasses, which do not require as much water as other irrigated crops in the South Platte Valley. This condition probably accounts in part for the low duty of water in the district. It also appears likely that the areas reported as irrigated are considerably exaggerated.

If all the district water supply were conserved and used, it would amount to only 0.92 of an acre-foot per irrigated acre and 0.79 of an acre-foot per irrigable acre, based upon the report of the Water Commissioner.

There is no doubt that additional storage in this district is most desirable for equalizing stream flow to irrigation demands.

The following table of use of water in District 6 has been compiled from the reports of the State Engineer and represents gross headgate

* This figure is, doubtless, too high as indicated by results of the land cruise in 1930. See Article X, page 34.

diversions plus amounts used from storage.

TABLE NO. 12

USED BY CANALS FOR IRRIGATION IN DISTRICT NO. 6 (HEAD-GATE DUTY).

Year	Acre-Ft. Run-off Main Boulder Cr. Plus So. Boulder	Acre-Ft. Used for Irrigation.	Acres Irrigated Dist. No. 6.	Acre-Feet per Acre Irrigated
1921	187,780	121,586	95,681	1.27
1922	105,040	112,162	86,875	1.29
1923	152,140	188,836	168,505	1.12
1924	165,860	203,487	170,433	1.19
1925	79,430	116,410	170,407	0.68
1926	178,360	170,820	172,503	0.99
1927	114,110	154,511	170,834	0.91
1928	138,220	159,202	173,223	0.92
Avg.	140,120	153,380	151,060	1.05

Consumptive Use in District 6.

There is evidently a large area in this district which is only partially irrigated, if the reported area is correct. This makes the average consumptive use for the whole district very low. Based upon the results of the land cruise made in 1930, the average gross headgate diversion for the years shown above would be 2.12 ac. ft. per acre.

The indicated average consumptive use of irrigation water for the entire area of 170,834 acres irrigated in 1927 is shown by the following table:

TABLE NO. 13

Cal. Year	Ac.Ft. Main Boulder Cr.	Ac.Ft. South Boulder Creek	Community and S.B. & Coal Cr. Ditches	Coal Cr.	Total Inflow	Outflow Boulder at Mouth	In (+) Storage Jan.1	In (-) Storage Dec.31	A.F. Consumptive Use	Consumptive Use Ac.Ft. per A.
1927	70300	47080	4520	5826	127726	35315	16430	17342	91499	1.13

5. Canal Diversions in District No. 6.

Lists of decreed canal diversions from Main Boulder Creek, South Boulder Creek and from Coal Creek are given below, in alphabetical order.

TABLE NO. 14.

DECREED CANALS DIVERTING FROM MAIN BOULDER CREEK

Identi-fication No.	Name of Canal	Years of Priority	Total Decreed Rights Sec. Ft.	Canal Capacity Sec. Ft.	Acres Irrigated in 1928
1.	Anderson	1860	21.50	25	2,609
2.	G. Berkley (Dry Creek)	1862	15.00	3	230
3.	Town of Boulder	1860	9.07	10	2,275
4.	Boulder & Left Hand(+D.H.Nichols)	1862-72-73	86.80	35	3,769
5.	Boulder & Weld Co. (+Houck No. 1)	1871-1883	61.90	40	4,927
6.	Boulder & White Rock	1873	216.58	140	13,575
7.	Butte Mill	1865	110.86	25	2,793
8.	Carr & Tyler(+N.K.Smith & Tyler)	1861	35.23	3	621
9.	Tom Delehant	1865	37.12	6	927
10.	Farmers'	1862	67.72	73	7,807
11.	Gooding, Dailey & Plumb	1861-65	30.44	15	2,633
12.	Green	1862	34.58	10	1,454
13.	Hardon	1862	21.00	6	1,474
14.	Highland South Side (Gooding)	1865	99.70	45	4,720
15.	Houck No. 2	1861	7.16	3	475
16.	Howell	1859	47.55	4	600
17.	Leggett	1868	31.35	90	6,245
18.	Lower Boulder	1859-70	122.00	150	16,085
19.	Martha M. Mathews	1861	4.60	5	1,183
20.	McCarthy	1862	5.00	4	743
21.	No.Boulder Farmers'	1862-63	48.00	48	2,290
22.	Plumb	1862	5.10	5	475
23.	Rural P.M.	1862-63	221.04	65	4,935
24.	Silver Lake	1888-1900	45.00	20	3,326
25.	Smith & Emmons	1863	47.16	10	1,405
26.	Smith & Goss	1859	44.30	8	808
27.	Wellman	1878	12.74	10	1,452
	Totals		1,486.00	858	89,836

TABLE NO. 15.

DECREED CANALS DIVERTING FROM SOUTH BOULDER CREEK

Identi-fication No.	Name of Canal	Years of Priority	Total Decreed Rights S. F.	Canal Capacity S. F.	Acres Irri. in 1928
1.	Andrews & Farewell	1864-71	8.96	7	925
2.	Central & South	1866	6.34	3	385
3.	*Community	1885-1903	402.40	350	20,855
4.	Cottonwood No. 2	1863	33.70	35	2,305
5.	Davidson	1872-75	221.35	125	6,925
6.	Davidson (Dry Creek)	1863	19.80	20	1,863
7.	Dry Creek No. 2	1864	69.00	30	2,871
8.	East Boulder	1862-72	229.50	65	1,512
9.	Enterprise	1865-66-81	128.09	35	1,743
10.	Howard	1860	36.00	25	2,456
11.	Jones & Donnelly	1860	14.36	10	385
12.	Leyner & Cottonwood No. 1	1865-70	66.72	65	6,592
13.	Marshallville	1865	46.68	40	2,318
14.	McGinn	1860-65	17.25	17	2,047
15.	Schearer	1860	26.08	10	592
16.	So. Boulder & Bear Creek	1862-71	226.80	20	2,490
17.	So. Boulder Canyon	1870-71	66.00	75	5,550
18.	*So. Boulder & Coal Creek	1872	53.55	65	3,238
19.	So. Boulder & Foot-hills	1883	20.00	10	1,478
20.	So. Boulder & Rock Cr. (Goodhue)	1873-75	116.09	114	6,122
	Totals		1808.67	1121	72,652

*These Canals divert above South Boulder Creek gaging station.

TABLE NO. 16.

DECREED CANALS DIVERTING FROM COAL CREEK

1.	Autery & Eggleston	1860	4.16	4	353
2.	Church	1870	18.11	20	1,751
3.	Eggleston No. 1	1869	6.58	6	406
4.	Eggleston No. 2	1862	4.65	4	525
5.	Erie & Coal Creek	1894	25.00	25	1,328
6.	Wm. C. Hake	1861	2.94	3	255
7.	Harris	1876	7.00	3	250
8.	Kerr Nos. 1 & 2	1861-68	10.98	4	403
9.	Kinnear Ditch & Res. Co.	1872	26.47	40	2,515
10.	Last Chance	1870	10.78	15	1,730
11.	Moffet	1889	3.00	3	212
12.	McKinzie No. 2	1866	18.00	15	620
13.	Minks & Autery	1863	9.00	9	271
14.	Wallace	1872	9.00	9	140
15.	Willis	1870	9.00	5	250
	Totals		164.67	165	11,009
	Totals for all 3 Creeks, as reported by Water Commissioner --------------		3459.34	2144	173,497

Reported by Cruise in 1930 - 72,142 acres.

The year 1926 was the best water year of recent years in this district, as in other districts tributary to the South Platte River.

The canal diversions for 1926 have been used, therefore, as the basis for a reasonable demand against the run-off in past years, in computing surplus water supply for additional storage.

TABLE NO. 17.

SUM OF CANAL DIVERSIONS FROM MAIN BOULDER CREEK DURING 1926 (SEC.FT.)
(All Divert Below Orodell Gaging Station)
(From Water Commissioner's Field Book)

Day	April	May	June	July	August	Sept.	Oct.
1		48	472	531	171	109	58
2		50	472	528	185	109	61
3		75	472	528	185	109	61
4		85	482	524	198	109	64
5		90	502	524	184	109	64
6		94	502	508	183	109	64
7		94	593	514	198	109	64
8		94	607	523	198	109	64
9		94	612	495	218	109	64
10		134	625	411	206	93	66
11		134	625	411	206	93	66
12		134	625	351	190	93	66
13		134	625	351	190	94	66
14		134	519	351	185	94	66
15		140	519	290	145	91	66
16		140	519	290	145	91	66
17		140	519	296	106	91	66
18		140	489	321	108	91	66
19		135	499	321	103	91	66
20		184	446	313	108	78	66
21		184	443	337	108	78	66
22		234	443	337	106	78	66
23		243	482	362	117	94	66
24		244	504	344	103	94	66
25		270	482	344	88	90	66
26		273	495	334	75	99	66
27		273	502	302	74	99	66
28		302	531	292	74	84	66
29		302	531	292	74	84	66
30	0	305	531	292	83	88	62
31	xxx	305	xxx	242	83	xxx	62
Total	0	5208	15668	11859	4397	2869	2008
Acre-Feet	0	10320	31100	23500	8720	5690	3980

Total for season = 83,310 Ac. Ft.

TABLE NO. 18

SUM OF CANAL DIVERSIONS FROM SOUTH BOULDER CREEK DURING 1926 (SEC.FT.)

(Except Community and S. B. & Coal Creek Ditches, which divert above The Eldorado Springs Gaging Station) (From W. Com's Field Book.)

Day	April	May	June	July	Aug.	Sept.	Oct.
1	0	43	248	240	93	32	28
2	0	43	313	292	67	32	28
3	0	51	253	250	77	29	26
4	0	49	269	237	77	31	26
5	0	59	269	237	77	31	26
6	0	60	306	248	77	19	23
7	0	60	324	225	170	19	41
8	0	60	324	255	170	29	41
9	0	60	330	255	170	29	41
10	0	50	319	300	169	28	46
11	0	50	319	300	106	28	46
12	0	61	319	246	106	28	46
13	0	61	321	196	106	24	33
14	0	61	321	206	103	24	33
15	0	61	301	202	103	24	39
16	0	61	301	207	76	26	39
17	0	61	301	207	76	25	39
18	0	61	241	202	68	31	39
19	0	71	262	202	54	31	45
20	0	86	262	189	56	32	41
21	0	121	262	187	52	33	37
22	0	126	275	135	52	33	37
23	0	141	302	126	52	33	37
24	0	225	284	114	52	33	37
25	0	231	277	114	52	33	49
26	0	264	292	114	46	33	49
27	0	179	272	100	39	33	49
28	0	92	294	84	38	33	35
29	25	127	291	84	38	33	35
30	43	147	291	89	33	33	38
31	xxx	147	xxx	89	39	xxx	38
Total	68	2969	8743	5932	2494	882	1167
Acre-Ft.	135	5880	17350	11760	4950	1750	2310

Total for season = 44135 Acre-Feet.

TABLE NO. 19

SUM OF CANAL DIVERSIONS FROM COAL CREEK DURING 1926 (IN SEC. FT.)
(From Water Commissioners' Field Book)

Day	April	May	June	July	Aug.	Sept.
1	0	44	53	17	5	0
2	0	44	53	13	5	0
3	0	44	53	13	5	0
4	0	44	53	13	5	0
5	0	44	53	13	5	0
6	0	46	53	13	5	0
7	0	46	53	13	5	0
8	0	46	53	13	5	0
9	0	46	53	13	5	0
10	0	48	53	13	5	0
11	0	48	53	13	5	0
12	0	48	41	13	5	0
13	0	48	41	13	5	0
14	0	48	46	13	5	0
15	0	48	42	12	5	0
16	0	48	42	12	5	0
17	0	48	42	12	5	0
18	0	48	42	12	5	0
19	0	48	42	12	5	0
20	0	50	32	10	5	0
21	0	50	31	10	5	0
22	0	50	28	7	5	0
23	0	50	28	7	5	0
24	0	50	28	5	5	0
25	0	53	22	5	5	0
26	0	53	22	5	5	0
27	0	53	22	5	5	0
28	0	53	22	5	5	0
29	0	53	22	5	5	0
30	20	53	22	5	5	0
31	xxx	53	xxx	5	5	xxx
Total	20	1505	1200	320	155	0
Acre-Ft.	40	2980	2380	634	307	0

Total for season = 6,341 acre-ft.

TABLE NO. 20

SUMMARY

TOTAL CANAL DIVERSIONS IN DISTRICT NO.6 FOR 1926 (SEC. FT.)

(Sum of Tables 17, 18 and 19 Above)

Day	April	May	June	July	Aug.	Sept.	Oct.
1	0	135	773	788	269	141	86
2	0	137	838	833	257	141	89
3	0	170	778	791	267	138	87
4	0	178	804	774	280	140	90
5	0	193	824	774	266	140	90
6	0	200	861	769	265	128	87
7	0	200	970	752	373	128	105
8	0	200	984	791	373	138	105
9	0	200	995	763	393	138	105
10	0	232	997	724	380	121	112
11	0	232	997	724	317	121	112
12	0	243	985	610	301	121	112
13	0	243	987	560	301	118	99
14	0	243	886	570	293	118	99
15	0	249	862	504	253	115	105
16	0	249	862	509	226	117	105
17	0	249	862	515	187	116	105
18	0	249	772	535	181	122	105
19	0	254	803	535	162	122	111
20	0	320	740	512	169	110	107
21	0	355	736	534	165	111	103
22	0	410	746	479	163	111	103
23	0	434	812	495	174	127	103
24	0	519	816	463	160	127	103
25	0	554	781	463	145	123	115
26	0	590	809	453	126	132	115
27	0	505	796	407	118	132	115
28	0	447	847	381	117	117	101
29	25	482	844	381	117	117	101
30	63	505	844	386	121	121	100
31	xxx	505	xxx	336	127	xxx	100
Total	88	9682	25611	18111	7046	3751	3175
Acre-Ft.	174	19200	50800	35900	14000	7440	6290

Total for season - 133,800 Ac. Ft.

6. Surplus Available for Additional Storage from District No. 6 Water Supply - Using Daily Canal Diversions of 1926.

The total 1926 daily canal diversions, from Main Boulder, South Boulder and Coal Creeks, as given in Table 20, were subtracted day by day from the total daily supply from the three creeks, including estimated return flow for the 12 year period, 1917 to 1928, inclusive.

Reported South Platte River shortages in Districts Nos. 1 and 64 were subtracted from the surplus flows thus obtained, the remainder being considered available for additional storage in District No. 6. The Platte River shortages are usually under canals junior in right to those in District No. 6, but such junior canals would be senior to any new storage development in District No. 6.

Opportunities for additional storage for irrigation occurs only during the months of May to August, inclusive.

TABLE NO. 21.

SUMMARY IN ACRE-FT. SURPLUS AVAILABLE FOR ADDITIONAL STORAGE FROM DISTRICT NO. 6 WATER SUPPLY (MAIN BOULDER, SOUTH BOULDER AND COAL CREEKS).

	Surplus-Platte Shortages disregarded					Surplus-Platte Shortages supplied				
Year	May	June	July	Aug.	Total	May	June	July	Aug.	Total
1917	5270	1910	530	0	7710	5270	1910	0	0	7180
1918	8830	10350	796	0	19976	864	7710	0	0	8574
1919	8080	0	0	3300	11380	4135	0	0	0	4135
1920	18950	0	97	2800	21847	17990	0	0	0	17990
1921	21070	43100	825	1370	66365	21070	43100	130	686	64986
1922	3790	0	0	0	3790	1158	0	0	0	1158
1923	9160	15800	2180	3000	30140	3913	15800	1130	2175	23018
1924	18390	8790	0	0	27180	13440	8790	0	0	22230
1925	130	0	0	472	602	0	0	0	0	0
1926	24830	6182	107	1000	32119	24830	6182	107	0	31119
1927	7640	0	0	110	7750	3190	0	0	14	3204
1928	14340	1273	292	198	16103	7363	1273	127	175	8938
AVG. 1919-1928	12638	7514	350	1225	21727	9709	7514	149	305	17677
Avg. 1917-1928	11707	7284	402	1021	20414	8602	7064	124	254	16044
Avg. 1918-1928	12292	7772	391	1114	21569	8905	7532	136	277	16850

The surplus water available for additional storage on main Boulder Creek alone, was computed in a similar manner to that employed above for the whole district, with results as follows:

TABLE NO. 22

SUMMARY IN ACRE-FEET - SURPLUS AVAILABLE FOR ADDITIONAL STORAGE FROM MAIN BOULDER CREEK (1926 DIVERSIONS)

	Surplus-Platte Shortages Disregarded					Surplus-Platte Shortages Supplied				
Year	May	June	July	Aug.	Total	May	June	July	Aug.	Total
1919	1710	0	0	2200	3910	442	0	0	0	442
1920	3060	0	177	2330	5567	3060	0	0	0	3060
1921	3200	18900	844	1020	23964	3200	18900	0	520	22620
1922	1670	329	0	10	2009	309	0	0	0	309
1923	1040	5790	1740	986	9556	470	5790	496	619	7375
1924	3630	3880	0	40	7550	2980	3880	0	0	6860
1925	561	0	0	540	1101	0	0	0	0	0
1926	7100	2920	744	2060	12824	7100	2920	610	0	10630
1927	1400	0	0	512	1912	906	0	0	274	1180
1928	3040	587	593	562	4782	826	587	87	315	1815
Avg.	2641	3241	410	1026	7318	1929	3208	119	173	5429

Main Boulder Creek flood flows are pretty well controlled by the Barker Meadow Reservoir, at Nederland, with a decreed capacity of 11,700 ac. ft.

The small available surplus at Orodell evidently originates principally below this reservoir.

An examination of the U. S. G. S. topographic map does not show any possibilities for storing water in Boulder Creek canyon below the Barker Meadow Reservoir.

A 10,000 acre-foot reservoir near Orodell would yield about 4,000 acre-feet per year.

Subtracting the final column of the above table, for Main Boulder Creek available storage, from the final column of the previous table of total water available in the District for additional storage, the following amounts represent surpluses available for additional storage on South Boulder, and Coal Creeks combined, South Platte River shortages considered.

TABLE NO. 23.

ACRE-FEET SURPLUS AVAILABLE FOR ADDITIONAL STORAGE FROM SOUTH BOULDER AND COAL CREEKS COMBINED.

(South Platte Shortages supplied, based upon 1926 Diversions)

Year	Total Surplus May to Aug. incl.
1919	3,693
1920	14,930
1921	42,366
1922	849
1923	15,643
1924	15,370
1925	0
1926	20,489
1927	2,024
1928	7,123
Avg.	12,248

The average annual run-off of Coal Creek for the period 1924 to 1928, inclusive, was 6,560 acre-feet and 56,830 acre-feet for South Boulder Creek for the same period.

The following table gives the estimated surplus available from South Boulder Creek, alone:

TABLE NO. 24.

ACRE-FEET SURPLUS AVAILABLE FOR ADDITIONAL STORAGE FROM SOUTH BOULDER CREEK

Year	Surplus A.-Ft. May to Aug., incl.
1919	3,320
1920	13,440
1921	38,130
1922	764
1923	14,080
1924	13,840
1925	0
1926	18,440
1927	1,820
1928	6,410
Avg.	11,024

Approximate average annual yields available for new channel reservoirs on South Boulder Creek at the gaging station, for various capacities, disregarding evaporation and seepage losses, are as follows:

TABLE NO. 25

Reservoir Capacity	Avg Annual Yield A.F. 1919 to 1928, incl.
10,000 Acre-Feet	6,231 Acre-feet
20,000 Acre-Feet	9,211 Acre-feet
30,000 Acre-Feet	10,211 Acre-Feet
38,000 Acre-Feet	11,011 Acre-feet

A reservoir of about 20,000 acre-feet capacity, to yield annually about 9,000 acre-feet of water, would be justified on South Boulder Creek, near Eldorado Springs if a feasible reservoir site were available.

7. Present reservoirs in District No. 6.

The reservoirs in District No. 6 are summarized from the Water Commissioner's 1928 report as follows:

TABLE NO. 26

Reservoir Used For:	Number	Acre-Feet Combined Capacity	Remarks
Domestic	5	3,450	City Water Supply for Boulder, Erie & Louisville.
Power	2	13,490	*Barker Meadow (11,700 Ac.Ft.) in channel
Irrigation	22	29,520	None in creek channels
Totals	29	46,460	

* Barker Meadow capacity corrected.

All of the reservoirs, with the exception of the Barker Meadow power reservoir owned by the Public Service Company, are in depressions away from the creeks and are mostly fed by the irrigation canals of the district.

Barker Meadow Reservoir.

Storage in the Barker Meadow Reservoir (or Nederland Lake) is usually at a low point at the beginning of the irrigation season and nearest the capacity thereof at the end of the irrigation season, as its main purpose is to equalize stream flow for power development thruout the year.

This reservoir evidently benefits the irrigation reservoirs below by catching most of the early summer flood flows of main Boulder Creek and releasing this water in the winter for power development, in amounts that can be handled by the irrigation reservoir feeder canals.

Barker Meadow Reservoir, which was completed in August, 1910, is operated in conjunction with the Boulder Power Pipe Line and Kossler Reservoir for power purposes only. It is now the property of the Public Service Company of Colorado. The Kossler Reservoir is the small terminal reservoir at the upper end of the pressure line to the power plant.

The final decrees for this system were entered by the district court in favor of the Colorado Power Company on Oct. 18, 1920, as follows:

Name Res. or Pipe Line	Priority No.	Priority Date	Decreed Capacity	Remarks	Estimated Cost.
Barker Meadow Reservoir	3	12/16/1906	11,700 A.F.	Fill once each year	$580,891
Boulder Power Pipeline	5	9/9/1905	50 S.F.		550,000
Kossler Reservoir		11/17/1906	129 A.F.	Fill and refill	35,000
				Total	$1,165,891

The available power head from Kossler Reservoir to the power house on Boulder Creek is given in filing (No. 3791) as 1,845 feet, which indicates the power capacity of the plant to be 10,500 theoretical horse-power. The filing contemplates building another reservoir of 12,000 acre-feet capacity on Main Boulder Creek, about 2 miles above Barker Meadow and increasing the capacity of the supply pipe line from 50 to 150 second-feet, which would increase the power possibilities to about 31,500 theoretical horse-power.

Other power decrees in District 6 are given below:

Power Diversion	Priority Date	Decreed Capacity	Diverts from
Recluse Ditch	9/1/1888	39.06 s.f.	North Boulder Creek
Water Wheel	12/31/1894	1.0 "	Main Boulder Creek
Ingold Flume and Ditch	3/15/1897	60.0 "	South Boulder Creek
B.A. Langridge Pipe Line	12/20/1904	25.0 "	South Boulder Creek

CHAPTER VII.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

CLEAR CREEK - WATER DISTRICT NO. 7 - WATER SUPPLY

Contents

CHAPTER VII

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

CLEAR CREEK - WATER DISTRICT NO. 7 - WATER SUPPLY.

1. Discharge Records and Run-off.

Stream flow records on this creek date back to 1899 when a gaging station was established at Forks Creek about 13 miles upstream from Golden, and below the mouth of North Fork. Diversions above this point are made by about a dozen small power plants developing about 4,000 H. P. and using a small amount of storage, according to U. S. G. S. W. S. Paper 266 for 1909.

In December, 1908, a station was established about two miles above Golden and records have been continued to date at or near this location, with the exceptions of intermissions in 1910 and 1911.

There is only one diversion above this point, that of the Golden (Welch) Canal with decrees for 27.52 sec. ft., capacity of 31 sec. ft. and average annual diversions (1921-1928) of 4,000 Acre-feet.

Flows at the two stations mentioned above are closely comparable during the greater part of the year, but differ somewhat during June and July in higher than average years on account of run-off entering between the stations and the diversions by the Golden (Welch) Canal.

The following months of parallel records at Forks Creek and the station above Golden, were obtained from records of the U. S. G. S. and State Engineer.

Station at:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
					1909 - Mean S. F.							
Forks Creek	-	-	-	-	357	979	753	450	438	205	92	-
Golden	60	49	56	101	333	1260	1120	425	461	211	121	108
Welch Ditch	-	-	-	-	9	17	9	15	10	7	1	-
					1911 - Mean S. F.							
Forks Creek	23	24.	37.	81	321	717	517	192	104.	74.	61	41.
Golden	-	-	-	-	-	704	504	176	104	-	-	-
					1912 - Mean S. F.							
Forks Creek	(30)	(30)	(35)	59	358	1130	963	508	179	122	-	-
Golden	(32)	(30)	(40)	59	343	1290	1200	409	166	125	83	(50)

Note: In years of below average run-off like 1910 and 1911, it appears that inflow between the two gaging stations is practically offset by the Golden (Welch) diversions during June and July and the records for all months are nearly the same.

Figures enclosed thus ( ) are partly estimated.

A study of long-time records on this stream and on the Cache la Poudre River indicates that the 20 year period 1909 to 1928 covers practically all the ranges in discharges that are likely to occur.

A table of run-off in mean monthly second-feet with acre-feet summaries for calendar years for 1909-1928 is given below:

TABLE NO. 1

Dr. Area - 380 Sq. Mi. - Elev. 5620 — Run-off, Mean Second-Feet, Clear Creek at Golden.

	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Run-off Acre-Feet	
	1909	60	48.6	56	101	333	1260	1120	425	461	211	121	108	261,000	
(a)	1910	(40)	(45)	46.6	94.9	295	511	251	199	163	71.1	(52.8)	(29.4)	109,000	Min.
(a)	1911	23	24.4	37.2	81.1	321	717	517	192	104	73.5	60.6	40.8	133,000	
	1912	(32)	(30)	(40)	58.7	343	1290	1200	409	166	125	83.1	50	230,000	
	1913	(50)	(50)	53	104.	450	692	484	266	(266)	185	136	(74)	167,940	
	1914	(65)	(60)	(65)	219.	1120	1710	777	431	170	121	70.7	(50)	294,350	Max.
	1915	(50)	(50)	(60)	108.	405	1080	644	247	136	116	(80)	(50)	183,020	
	1916	(45)	(55)	(60.7)	95.5	311	651	439	330	182	124	63.9	49.5	145,700	
	1917	48.5	(51.8)	52.2	84.8	304	1030	769	265	98.4	75.3	(60)	(50)	174,850	
	1918	(50)	(50)	(60)	(100)	434	1340	687	(225)	(122)	113	(85)	(60)	200,900	
	1919	(50)	(60)	(65)	112	525	533	369	248	166	98.7	77.3	(60)	143,200	
	1920	(55)	(57)	(56)	71.1	519	1020	550	306	186	125	(80)	(70)	187,380	
	1921	(65)	(55)	64.8	159.	745	1980	765	319	187	106	84	58.8	277,130	
	1922	(55)	(50)	(50)	(69.8)	271	689	318	208	112	74	(58)	(55)	121,520	
	1923	(50)	(50)	(55)	81.9	358	878	815	483	223	(120)	(100)	(75)	199,340	
	1924	(70)	(60)	51	134.	664	1300	497	178	96.4	99.5	(80)	(60)	198,870	
	1925	(55)	(55)	(60)	91.4	249	430	269	168	180	133	(80)	(60)	110,590	
	1926	(60)	(55)	57.6	228.	844	1320	665	319	136	102	73.7	(52)	236,830	
	1927	(50)	(55)	(60)	101.	470	721	490	330	149	110	79.5	(60)	162,070	
	1928	(50)	(50)	(50)	70.1	641	913	593	228	111	82	(60)	(50)	175,650	
	Average	51.	51.	55.	108.	480.	1003	611.	289.	169.	113.	79.	58.	185,617	Mean
	20 years													180,188	
	1909-1913	(critical period)												181,490	
	1921-1925													185,200	
	1921-1928													176,800	
	1924-1928													183,040	=98.6% Mean.
	1918-1928														

Note: (a) indicates Forks Creek record; the others are all from Golden gaging station

Figures enclosed thus ( ) indicate that the daily record is incomplete and that the mean has been estimated from available data.

The maximum momentary discharge for the Golden station was 4,420 sec. ft. on July 31, 1921 and the minimum 18 sec. ft. on Jan. 11, 1918, according to U.S.G.S. Water Supply papers. The maximum possible flood flow is estimated at 8,000 sec.ft.

The average annual total supply for the district has been tabulated from gaging records and from the reports of the Water Commissioner of District No. 7 as follows:

TABLE NO. 2

AVERAGE ANNUAL WATER SUPPLY - DIST. NO. 7

Year	Golden (Welch) Ditch	Ralston Creek	Estimated Return Flow	20 yrs. Average Clear Creek	Total Avg. Supply Dist. No. 7.
1921	4882 Ac. Ft.	11800 Ac. Ft.			
1922	(3300) Ac. Ft.	5090 Ac. Ft.			
1923	3082 Ac. Ft.	6930 Ac. Ft.			
1924	4028 Ac. Ft.	7750 Ac. Ft.			
1925	3204 Ac. Ft.	4200 Ac. Ft.			
1926	4788 Ac. Ft.	12000 Ac. Ft.			
1927	4556 Ac. Ft.	2690 Ac. Ft.			
1928	3330 Ac. Ft.	4480 Ac. Ft.			
Average	4000 Ac. Ft.	6900 Ac.Ft.	14700 Ac.Ft.	185600 A.Ft.	211200 A.Ft.
% Total	1.9	3.3	7.0	87.8	100

The Water Commissioner's report for 1927-28 gives the irrigable area of Dist. No. 7 as 118,335 acres in 1928 and the area actually irrigated as 104,913 acres*.

If all of the water supply for Dist. 7 were conserved and used, there would be available on the average 1.79 acre-feet per acre for the irrigable area, and 2.01 acre-feet per acre for the 104,915 acres actually irrigated in 1928.

There is a court decree allowing the diversion of 53 sec. ft. from the headwaters of the Fraser River over Berthoud Pass to the West Fork

* The cruise of irrigated lands in 1930 by the State Engineer shows but 76,000 acres irrigated in District #7.

of Clear Creek. This water, which amounts to around 1,000 Ac. Ft. per annum, is diverted for the Westminster Pipe Line via the Church ditch and is included in that reported for the Golden gaging station.

A gaging station is being maintained by the State near the mouth of Clear Creek and below all diversions. Records are available from April 1, 1914 to Nov. 30, 1914 and from Feb. 25, 1927, to date.

A summary of data available for this station is given below:

TABLE NO. 3.

RUN-OFF CLEAR CREEK AT MOUTH

Run-off - Mean Sec. Ft.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. A. F.
1914	--	--	--	592	926	775	223	121	12.7	37.4	42.5	--	
1927	(20)	(16)	53.4	23.5	54.6	240	78.2	157	15.6	22.1	17.5	37.4	44,550
1928	34.3	26.1	23.2	11.8	425.	543	90.5	25.5	8.4	(7)	(9)	(26)	74,340

2. Use of Water for Irrigation in District No. 7.

The following table of water uses for the period 1921-1928 has been compiled from the weekly reports of the Water Commissioner of District No. 7, and from State Engineer reports, and is understood to include all water from all sources used by canals for irrigation in the district, or the gross headgate diversions plus amounts used from storage:

TABLE NO. 4.

GROSS USE OF WATER IN DISTRICT NO. 7

Year	Run-off Clear Cr. above Golden (A.F.)	A. F. Used for Irrigation.	Acres Irrigated Dist. 7.	A. F. per Acre Irrigated	*Shortage on Basis 1.5 A.F. Per Acre.	
*1921	277,130	159,650	102,590	1.56	----	A.F.
1922	121,520	131,000	102,620	1.28	22,600	"
*1923	199,340	145,700	104,460	1.39	11,500	"
*1924	198,870	161,200	104,595	1.54	----	"
1925	110,590	124,700	104,843	1.19	32,500	"
*1926	236,830	172,900	104,813	1.65	-----	"
*1927	162,070	150,000	104,773	1.43	7,330	"
1928	175,650	136,000	104,913	1.30	20,980	"
Average	185,250	147,644	104,201	1.42	11,860	"
*Average 5 good years	- - - - -	- - - - -	- - - - -	1.51		

* These indicated shortages would be changed if based upon the irrigated area shown by the land cruise of 1930.

It appears from the above tabulation that serious shortages in the water supply for the area now irrigated, of from about 21,000 to 33,000 acre-feet, occur on the average of every third year and lesser shortages oftener.

It is probable that any additional water conserved by storage in this district can be used to best advantage on the lands now irrigated or under ditch and not irrigated on account of lack of water.

The year 1927 is the nearest in average gross use for the 8 year period considered, but a little below the use in a good water year, and there is a record of the outflow for the district at the mouth of Clear Creek for this year.

The following table shows conditions in 1927 indicating a consumptive use of 1.19 acre-feet per acre irrigated. (All records are considered fair except that for Ralston Creek flow, which was estimated by the Water Commissioner.)

TABLE NO. 5.

CONSUMPTIVE USE IN 1927.

Year	Acre-Feet Inflow: Clear Creek at Golden	Acre-Feet Inflow: Golden (Welch) Ditch	Acre-Feet Inflow: Ralston Creek	Acre-Feet Inflow: Total Inflow	Outflow at Mouth Ac. Ft.	Stored Jan. 1 1927 Ac. Ft.	Stored Jan. 1 1928 Ac. Ft.	Consump. Use 1927 Ac. Ft.	Consump. Use A.F. Per Acre.
1927	162,070	4,556	2,690	169,316	44,548	985	690	125,063	1.19*

* See foot note on page 178.

3. Seepage and Return Flow in District 7.

No return flow measurements have been made on Clear Creek within late years, but a series of measurements made by Prof. L. G. Carpenter during the period 1900 to 1910, measurements made by the State in 1906, 1908, 1913 and 1914 and estimates made weekly by the District Water Commissioner are available.

The results of these measurements are summarized below:

TABLE NO. 6.

CLEAR CREEK SEEPAGE AND RETURN FROM INVESTIGATIONS OF PROF. L. G. CARPENTER (AGRICULTURAL BULLETIN NO. 180)

Year	Date Measured	Net Inflow
1900	Oct. 29-Nov. 17	15.8 s.f.
1901	Sept. 8-10	24.2 s.f.
1902	Sept. 1-2	8.8 s.f.
1903	Oct. 20-22	32.7 s.f.
1904	Oct. 24-25	24.8 s.f.
1905	Nov. 18-20	21.7 s.f.
1907	Oct. 23-25	32.5 s.f.
1908	Oct. 28-31	29.8 s.f.
1909	Oct. 29-31	19.6 s.f.
1910	Nov. 26-30	19.0 s.f.
Avg.	Sept.-Nov.	22.9 s.f.

TABLE NO. 7

CLEAR CREEK SEEPAGE RETURN AS SHOWN BY STATE ENGINEER'S REPORTS

Year	Date Measured	Net Inflow	
1906	Oct.-Nov.	13.7 s.f.	
1908	Sept.	11.9 s.f.	
1913	Oct.	28.8 s.f.	
1914	Oct.	62.3 s.f.	Probably erroneous
Avg. (without 1914)		18.1 s.f.	

TABLE NO. 8.

CLEAR CREEK SEEPAGE RETURN FROM WATER COMMISSIONER'S WEEKLY REPORTS FOR 1928.

Month	Inflow	Avg.	Month	Inflow	Avg.
Jan.	10-15	12.5	July	30	30
Feb.	10-12	11	Aug.	25-30	27.5
Mar.	10-20	15	Sept.	20-25	22.5
Apr.	15	15	Oct.	15-20	17.5
May	20-30	25	Nov.	10-15	12.5
June	20-30	25	Dec.	10-15	12.5

All seepage measurements were made in the fall, and these vary more than would be expected. In one year, 1908, there are parallel records by the State and by Prof. Carpenter of 11.9 and 29.8 sec. ft. respectively.

The seepage inflow in this district is undoubtedly small but probably a little more at present than when the above measurements were made and the summer return flow is probably at least twice that of the winter return.

Continuous records of seepage and return flow on the Cache la Poudre River made by R. C. Hemphill in 1916 and 1917 indicate considerable fluctuation in average monthly flows as follows:

TABLE NO. 9

SEEPAGE AND RETURN FLOW, CACHE LA POUDRE RIVER

Month	Avg. Inflow Sec. Ft.	Month	Avg. Inflow Sec. Ft.
Jan.	91	July	231
Feb.	92	Aug.	225
Mar.	102	Sept.	169
Apr.	118	Oct.	163
May	184	Nov.	175
June	160	Dec.	113

About 10% of the return flow into Clear Creek comes in below the lowest diversion (the Clear Creek and Platte River Ditch) and is not available for irrigation in District No. 7.

The following table is suggested as giving reasonable and safe quantities for present average monthly return flows available for use in District No. 7, based upon the evidence at hand.

TABLE NO. 10.

SUGGESTED, AVAILABLE SEEPAGE AND RETURN FLOW, CLEAR CREEK

Month	Avg Inflow Sec. Ft.	Month	Avg. Inflow Sec. Ft.
Jan.	12	July	30
Feb.	14	Aug.	27
Mar.	16	Sept.	25
Apr.	18	Oct.	22
May	20	Nov.	20
June	25	Dec.	15

4. Diversions from Clear Creek Below Golden Gaging Station.

The decreed diversions below Golden gaging station in District

No. 7 are given below in the geographical order in which they take out from the creek:

TABLE NO. 11

DIVERSIONS FROM CLEAR CREEK BELOW GOLDEN.

Identification No.	Name of Canal	Years of Priority	Total decreed rights s.f.	Canal Capacity s.f.	Acres Irrigated in 1928
1.	Golden City & Ralston Cr. (Church)	1862-1881	113.03	120.	15,000
2.	Agricultural	1860-1883	159.186	180.	15,010
3.	Golden Canal (Farmer's Highline)	1860-1895	733.605	350.	45,650
4.	Wannemaker	1860-1868	21.00	23.	1,020
5.	Lee, Stewart & Eskins	1861-1871	41.79	20.	2,300
6.	Rocky Mountain	1861-1878	190.00	125.	7,650
7. (a)	Croke (Standley L. Inlet)	No decree	-	-	
8.	Miles & Eskins	1861	3.61	3.	183
9.	Reno & Juchem	1861-1878	34.575	18.	1,870
10. (b)	The Slough (19 small ditches)	1860-1874	103.34	40.	2,275
11.	Lees & Baugh	1860	3.37	4.	135
12.	Ouelette	1860	7.89	8.	425
13.	Cort, Graves & Hughes	1861	7.00	8.	190
14.	Boyles	1863	1.50	3.	70
15.	Fisher	1861	35.00	35.	2,570
16.	Colo. Agricultural	1863-1874	82.56	50.	2,400
17.	Clear Cr. and Platte River	1861	49.50	50.	2,500
18.	Kershaw	1861	9.00	10.	350
19.	Ralston Cr. Diversions	1860-1873	63.84	63.	900
	Totals		1659.796	1,110.	100,498*

(a) Feeds Standley Lake which is in Dist. No. 2-diverts mostly in winter--has filing as of 3/4/1902, but no decree has ever been granted.

(b) Capacity of 19 small outlets is given as 96 s.f. but capacity of Slough feeding them is but 40 s.f.

* See Page 34.

All diversions of decreed canals given in the above tablulation were plotted for the years 1924 to 1928, inclusive, from the Water Commissioner's Field Book, and a table of total <u>maximum</u> daily diversions for the period made from these plottings.

The following table shows the maximum daily diversions in second-feet of all canals below the Golden gaging station, including Ralston Creek diversions, for the period 1924-1928, inclusive.

TABLE NO. 12.

MAXIMUM DIVERSIONS BELOW GOLDEN, 1924-1928, DAILY MEAN SEC. FT.

Day	April	May	June	July	Aug.	Sept.	Oct.
1	57	386	844	960	678	424	292
2	57	394	836	968	678	424	280
3	59	484	822	953	665	399	308
4	80	488	847	939	680	368	277
5	100	483	845	928	630	347	239
6	105	512	860	926	715	395	245
7	113	495	882	848	710	384	211
8	113	569	889	812	698	483	213
9	100	616	873	825	662	366	237
10	100	640	850	821	640	358	281
11	98	509	885	824	625	355	280
12	127	495	827	756	602	377	291
13	168	592	817	741	558	426	295
14	201	562	851	696	557	464	295
15	261	584	802	686	552	417	287
16	282	622	803	760	506	334	294
17	284	663	795	759	558	291	302
18	237	689	865	813	453	308	299
19	258	749	925	852	474	312	294
20	360	742	868	873	441	297	315
21	385	771	803	831	436	322	306
22	407	789	905	829	454	293	266
23	393	785	910	815	496	353	262
24	359	870	902	799	536	358	245
25	329	803	881	754	557	347	259
26	325	808	881	731	563	315	239
27	381	830	910	752	562	355	239
28	425	810	947	751	586	334	269
29	438	835	924	741	607	322	258
30	382	871	938	637	451	305	247
31	xxx	864	xxx	655	410	xxx	245
Total	6984	20310	25987	25035	17740	10833	8370
A. F.	13850	40300	51500	49600	35200	21500	16600
Grand Total A. F. -							228,550

Note: Diversions for Croke Canal are not included in above table as they are not reported by Water Commissioner during the period considered.

The only record given for the Croke Canal in Water Commissioner's Field Books for 1921-1928, is for the season of 1922, which is as follows:

TABLE NO. 13.

DIVERSIONS BY CROKE CANAL, 1922.

Daily Sec.Ft.

Day	Feb.	Mar.	Apr.
1	35	60	45
2	35	40	50
3	35	40	55
4	30	50	60
5	30	3	30
6	30	3	30
7	30	3	-
8	30	30	4
9	55	40	-
10	55	40	-
11	55	20	-
12	55	20	-
13	55	30	-
14	70	3	-
15	70	6	-
16	70	6	-
17	70	6	-
18	75	50	-
19	75	45	-
20	75	45	4
21	60	50	6
22	60	50	6
23	50	50	6
24	50	60	-
25	55	60	-
26	55	50	-
27	55	45	-
28	30	55	-
29	--	50	-
30	--	50	-
31	--	50	-
Total	1,450	1,110	296
Ac.Ft.	2,870	2,200	590

Ac.Ft. for season - - - - - - - - - - - - - - - - - - 5,660 Ac.Ft.

Although the 1902 filing made for the Croke Canal contemplated a capacity of 2,000 sec. ft. and the canal superintendent says that it was built to an actual capacity of 650 sec. ft., it doesn't appear to divert much of the ordinary surplus of May, June or July as Standley

Lake, which it feeds is usually near its storage limit by May 1st, as shown by the following table taken from records of the Water Commissioner of District No. 2:

TABLE NO. 14.

STANDLEY LAKE STORAGE - 1926-1928

Acre-ft. in storage on first of month.

Year	Jan.1	Feb.1	Mar.1	Apr.1	May 1	June 1	July 1	Aug.1	Sept.1	Oct.1	Nov.1	Reported Capacity
1926	1710	3600	13110	16350	18700	18700	18900	17320	9100	5620	5620	20900
1927	9000	12800	15500	16900	17300	15200	15800	10600	10000	2900	2100	20900
1928	6000	9100	9800	14100	16200	18500	12700	6600	2760	0	0	18500
						Capacity to original height dam						50,000

Standley Lake derives its storage from Coal Creek, Woman Creek, Leyden Creek, Ralston Creek and from Church Canal from Clear Creek as well as from the Croke Canal.

In the absence of Croke Canal records, an attempt was made to show its effect, if any, on the stream flow during the months of surplus water (May, June and July) in 1928 when good flow records at the mouth of Clear Creek are available. The sum of the 1928 daily diversions of all canals below the Golden gaging station, except the Croke Canal, was taken by mean daily flows, from the discharge at the Golden station, increased by Ralston Creek and seepage return flows, and the results summarized as follows:

TABLE NO. 15.

May, 1928 Acre-Feet.				June, 1928 Acre-Feet			
Total Supply	1928 Diversions	Surplus	Flow at Mouth Clear Cr.	Total Supply	1928 Diversions	Surplus	Flow at mouth Clear Cr.
42,200	18,300	23,900	26,100	57,000	26,700	30,300	32,300

TABLE NO. 15 (cont'd.)

July, 1928
Acre-Feet.

Total Supply	1928 Diversions	Surplus	Flow at Mouth Clear Cr.
38,500	37,900	4,580	5,560

For each month shown above, the recorded flow at the mouth of Clear Creek is a little larger than the surplus obtained by subtracting the sum of all the daily diversions below the Golden gaging station, without the Croke Canal, from the total supply. This indicates that the Croke Canal was not diverting much, if any, water during the three months examined.

The "maximum diversion" table (No. 12) shown above, is considered the outside limit for the maximum demand in District No. 7.

A more reasonable method for a determination of a safe demand would be to take a good water year when the supply was well sustained throughout the irrigation season, with few rains to interrupt the demand, with all irrigators apparently satisfied throughout the season.

The year of 1926 comes very close to meeting these requirements. Therefore, the 1926 diversions were tabulated and used to show the demand against the water supply for the district, as another method for determining surplus waters.

TABLE NO. 16.

TOTAL DIVERSIONS FROM CLEAR CREEK BELOW GOLDEN - in 1926
(Without Croke Canal)
(Ralston Creek Diversions Included)

Total Daily Diversions - 1926 - Sec.Ft.

Day	April	May	June	July	Aug.	Sept.	Oct.
1	0	347	714	928	484	205	132
2	0	329	688	928	431	206	170
3	0	337	759	759	398	134	191
4	0	337	785	560	453	167	148
5	0	337	820	645	468	219	150
6	0	387	826	555	497	221	117
7	0	368	843	555	635	232	151
8	0	369	848	535	632	231	151
9	0	379	833	554	646	215	151
10	0	379	835	428	646	183	135
11	0	318*	794	410	598	183	148
12	50	299*	794	410	564	183	148
13	85	331*	784	410	482	178	148
14	95	274*	784	470	462	176	148
15	117	342	640	453	447	181	148
16	117	350	622	656	363	181	143
17	117	350	640	666	275	110	141
18	95	343	640	695	305	110	141
19	95	403	635	705	294	129	136
20	228	409	625	784	271	119	136
21	225	404	625	737	233	146	136
22	205	409	625	740	254	146	136
23	225	410	625	718	272	149	136
24	240	611	625	670	314	154	127
25	240	624	638	559	314	142	125
26	288	649	793	523	257	163	125
27	282	649	829	507	224	163	125
28	320	497	829	461	224	150	125
29	329	646	889	471	224	139	127
30	347	646	899	484	228	139	141
31	--	646	--	484	203	--	141
Total	3700	13179	22286	18460	12098	5054	4377
A.Ft.	7340	26100	44200	36600	24000	10000	8680
% Total	4.7	16.6	28.2	23.3	15.3	6.4	5.5

Total, A. F. - 156,920

* Refers to 1928 records as it rained in 1926 on these days.

Total Ralston Creek diversions included in above table for 1926 - 8,100 A.F.

5. Temperature and Precipitation at Denver.

Weather records have been kept at Denver, at the east edge of District No. 7, by the U. S. Weather Bureau, since 1872.

Records for the period 1921 to 1928 with averages for the period of record, 1872-1928, are given below:

TABLE NO. 17.

MONTHLY AVERAGE TEMPERATURE, DEGREES FAHRENHEIT AT DENVER

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	33.8	37.0	45.0	45.2	57.5	67.2	72.4	71.2	63.9	56.0	43.7	35.4	52.4
1922	27.7	31.4	40.3	45.2	57.7	70.4	71.8	74.2	65.8	52.8	37.2	35.1	50.8
1923	37.9	28.2	33.9	46.6	56.1	65.4	72.6	68.4	60.6	44.3	41.8	30.5	48.9
1924	29.6	37.6	28.0	46.0	52.6	68.4	71.8	73.2	60.4	54.4	44.4	25.6	49.3
1925	31.4	41.0	44.5	52.8	60.2	67.2	73.4	69.6	63.8	43.3	41.0	32.0	51.7
1926	31.2	39.0	37.6	47.6	58.6	66.6	70.8	73.0	61.6	53.6	42.8	29.8	51.0
1927	35.2	36.7	36.0	47.7	59.6	64.6	71.2	66.6	62.0	54.6	45.9	25.9	50.5
1928	36.6	33.2	42.0	45.8	57.7	61.0	71.0	70.6	62.6	50.8	39.6	31.2	50.2
Avg. 57 yrs.	29.8	32.7	39.3	47.1	56.2	66.3	72.2	70.7	62.9	51.2	39.8	32.3	50.1

TABLE NO. 18

INCHES OF RAINFALL AT DENVER

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	0.77	0.27	0.48	2.31	0.60	3.26	1.27	3.49	0.02	0.66	0.57	0.85	14.55
1922	0.30	0.40	0.48	3.65	1.14	0.19	1.87	1.50	0.54	0.30	1.95	0.63	12.95
1923	0.13	1.09	2.17	0.60	1.83	3.55	2.74	3.87	0.75	3.50	0.24	0.95	21.42
1924	0.52	0.27	1.29	1.60	2.62	0.46	0.33	0.02	1.44	0.96	0.14	1.42	11.07
1925	0.13	0.04	0.42	0.40	0.43	1.48	0.74	1.68	0.99	1.87	0.67	0.93	9.78
1926	0.77	0.40	1.98	2.31	1.41	0.86	1.00	0.80	1.48	0.69	0.31	1.04	13.05
1927	0.18	0.32	2.29	1.53	1.40	2.76	2.36	2.75	1.06	0.19	0.81	0.23	15.88
1928	0.24	0.59	1.40	1.36	3.06	2.42	1.01	0.85	0.07	1.97	1.58	0.06	14.61
Avg. 57 yrs.	0.40	0.56	1.04	2.06	2.21	1.38	1.68	1.43	0.99	1.05	0.55	0.73	14.08

6. Reservoirs in District No. 7.

There are a number of small reservoirs in the district (about 57) with a reported aggregate capacity of 21,550 acre-feet. About three-fourths of these reservoirs are without separate decrees but feed from decreed ditches, the principal of which are the Farmer's Highline, Agricultural, Church and Fisher Ditches. All are in natural depressions away from the creek, and mostly fill from winter or non-irrigation season flow, getting little benefit from the usual May, June or July excess run-off.

Standley Lake although situated in District No. 2, derives its water supply from District No. 7. Its present reported safe capacity is 18,500 acre-feet, and this figure added to the aggregate reservoir capacity for District No. 7, proper as given above (21,550 acre-feet), makes the total present available storage capacity for the District's waters, 40,050 acre-feet.

7. Surplus Available for Additional Storage, at Golden Gaging Station with Maximum Daily Diversions and South Platte Demands Supplied.

The maximum daily diversions, shown in Table No. 12, above, were subtracted day by day, for the months of May, June and July, from the daily flows of Clear Creek at the Golden Station, increased by Ralston Creek flows and estimated available seepage and return flows, for the 8 year period 1921 to 1928, inclusive. From the surplus flows thus obtained, were subtracted the combined reported shortages on the South Platte in Districts 1, 2 and 64, on parallel dates. The final remainders were considered as representing water available for additional storage at the Golden gaging station.

The period 1921-1928 shows an average run-off approximating the time of record average, includes one year (1925) approaching the driest year, and the year 1921 with the highest flood flow of record (July 31, 1921) and with next to the largest annual run-off for the past 20 years.

It also contains critical periods (1924-1928) and (1921-1925) with unusually low average annual run-offs.

An examination of monthly creek flows and canal diversions shows that the only opportunities for additional storage in this district occur during the annual excess flows of May, June or July, and accordingly the computations for surplus waters have been confined to these months.

The following table gives a summary of surplus available for storage at the Golden gaging station, based upon maximum canal demands, for the period 1921 to 1928, inclusive:

TABLE NO. 19.

SURPLUS AT GOLDEN IN ACRE-FEET, AVAILABLE FOR

ADDITIONAL STORAGE, MAXIMUM DIVERSIONS AND PLATTE SHORTAGES SUPPLIED

Year	May	June	July	Total
1921	11,800	70,900	920	83,620
1922	0	0	0	0
1923	0	10,740	1,280	12,020
1924	2,510	26,100	0	28,610
1925	0	0	0	0
1926	18,100	29,800	340	48,240
1927	0	0	0	0
1928	6,400	6,260	0	12,660
Avg.	4,851	17,975	318	23,144

8. Surplus at Golden Available for Additional Storage, after Supplying 1926 Diversions and Platte River Shortages

This method of estimating available surplus is recommended as more nearly representing the water that could be stored than the extra conservative scheme used for the results given in Paragraph 7 above.

The surplus flows given in the table below as available at the Golden gaging station, were also available at any other point on the stream, to the extent of the flow at such point at the time when the Golden surplus occurred.

TABLE NO. 20.

SUMMARY OF SURPLUS IN ACRE FEET AVAILABLE AT GOLDEN BASED ON 1926 DIVERSIONS.

	Surplus - Acre-feet Platte Shortages Disregarded				Surplus - Acre-feet Platte Shortages Supplied			
Year	May	June	July	Total	May	June	July	Total
1917	2,450	24,100	13,620	40,170	2,450	24,100	5,550	32,100
1918	5,320	38,500	10,050	53,870	0	17,650	1,325	18,975
1919	9,310	367	187	9,864	662	0	0	662
1920	12,480	19,090	4,320	35,890	11,410	3,097	0	14,507
1921	25,600	78,200	12,800	116,600	25,600	78,200	4,360	108,160
1922	220	5,520	0	5,740	0	0	0	0
1923	1,790	15,050	17,200	34,040	1,540	14,650	3,060	19,250
1924	18,200	36,300	4,390	58,890	8,130	30,700	0	38,830
1925	0	160	0	160	0	0	0	0
1926	31,900	37,300	7,920	77,120	31,900	36,800	5,260	73,960
1927	5,360	4,450	2,160	11,970	408	2,010	0	2,418
1928	16,750	12,800	4,940	34,490	13,050	10,700	0	23,750
1921-1928 Avg.	12,480	23,720	6,180	42,380	10,080	21,630	1,590	33,300
Average 1921 to 1925								33,250
Average 1924 to 1928								27,800
Average 1917 to 1928					7,929	18,159	1,630	27,718
Average 1918 to 1928					8,427	17,619	1,273	27,319

9. Allowable Annual Delivery for Reservoirs of Various Capacities.

The allowable annual delivery, for reservoirs storing surplus waters, as shown in the last column of the table above, for the low average period of 1924 to 1928, with various capacities, is as follows:

TABLE NO. 21
ANNUAL DRAFT ON CLEAR CREEK AT GOLDEN

(Seepage and Evaporation Disregarded)
Reservoir Capacity - Acre-Feet

Year	20,000	40,000	50,000	60,000	73,960
1924	20,000	38,830	38,830	38,830	38,830
1925	0	0	0	0	0
1926	20,000	40,000	50,000	60,000	73,960
1927	2,418	2,418	2,418	2,418	2,418
1928	20,000	23,750	23,750	23,750	23,750
Annual Draft	12,480	21,000	23,000	25,000	27,800

Additional storage reservoirs should preferably be located in the channel of Clear Creek, to obtain the full benefit of flashy surplus flows in the summer, avoid the necessity of large inlet canals and allow reservoir seepage losses to return directly to the creeks for use by canals below.

The maximum recorded momentary flow of Clear Creek at Golden is 4,420 second-feet, or 12 second-feet per square mile of drainage area. Some observed maximum mean daily surplus flows are:

June 13, 1921	-	2,341 sec. ft.
June 16, 1923	-	1,363 sec. ft.
June 13, 1924	-	1,451 sec. ft.
June 7, 1926	-	1,157 sec. ft.
May 31, 1928	-	854 sec. ft.
	Average	1,433 sec. ft.

As a preliminary estimate, it appears that if the Croke Canal were enlarged to carry about 1,500 sec. ft. and the capacity of Standley Lake were increased 40,000 or 50,000 acre-feet above its present safe capacity of 18,500 acre-feet, the greater portion of the additional surplus in Clear Creek could be taken care of, but water thus stored would be made available for lands in District No. 2.

CHAPTER VIII.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

SOUTH PLATTE AND TRIBS. - WATER DISTRICT NO. 8 - WATER SUPPLY

Contents

CHAPTER VIII.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

SOUTH PLATTE AND TRIBS. - WATER DISTRICT NO. 8 - WATER SUPPLY

1. Water Supply Records.

Water for this district is diverted from the South Platte River augmented by surplus flows from Bear Creek, Plum Creek, Deer Creek, from Castlewood Reservoir on Upper Cherry Creek and from many small intermittent creeks which furnish water for but a short time during the irrigation season.

Records are available for the flow of the South Platte River into the District, at South Platte From Mar. 28, 1902 to date. The gaging station is above all diversions for domestic use, irrigation and power, in the district, and records the river flow as regulated by Antero and Cheesman reservoirs of the City of Denver Water Works.

The South Platte River gaging station at Denver, showing the flow out of the district, has been operated since May 7, 1895. Releases from Antero Reservoir have affected flows since 1909 and from Lake Cheesman since 1901, inclusive.

Records of the flow of Bear Creek at the mouth are available from Apr. 1 to Nov. 30, 1914, and from Feb. 27, 1927 to date.

Plum Creek and Deer Creek inflows were estimated by the Water Commissioner of District 8.

The yield of Castlewood reservoir is the same as the record of diversions of the Arapahoe Canal.

TABLE NO. 1

RUN-OFF SOUTH PLATTE RIVER AT SOUTH PLATTE IN MEAN DAILY SEC. FT.

Drainage Area = 2,550 sq. mi. Elev. = 6,097
(Not corrected for storage)

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Ac.-Ft.
1902	-	-	-	-	-	-	261	181	128	85	81	82	--
1903	62	(50)	(70)	(80)	(80)	(95)	144	212	858	353	216	211	145,630
1904	113	163	97	155	129	60	196	470	541	421	633	366	202,690
1905	301	49	(80)	(105)	(120)	(175)	(560)	1321	1226	345	285	253	291,560
1906	167	169	(110)	(85)	(90)	(125)	468	887	722	515	350	477	251,150
1907	492	378	(200)	(130)	148	218	299	637	1200	1195	708	355	361,200
1908	230	163	(170)	(120)	(90)	(130)	173	191	255	276	391	236	146,960
1909	175	(100)	(120)	54	50	85	156	424	1032	925	886	1704	345,040
1910	607	316	206	209	172	437	415	602	464	312	404	171	261,660
1911	167	131	77	103	95	84	188	361	492	864	373	242	192,550
1912	144	94	109	(95)	(75)	(75)	98	451	1300	1250	749	393	293,250
1913	246	219	(150)	108	83	90	397	572	943	761	544	426	274,500
1914	324	212	171	179	143	211	950	2220	2120	1850	1690	642	649,640
1915	514	311	(170)	173	128	112	540	966	1180	707	458	420	343,900
1916	395	207	156	(118)	(124)	147	220	505	734	619	668	231	250,420
1917	152	(132)	(138)	(144)	(114)	(101)	189	696	1450	1070	739	338	318,680
1918	148	88	(118)	(116)	(123)	98	388	792	1340	917	442	357	297,870
1919	230	194	(140)	(160)	(150)	(160)	636	1170	1070	884	821	468	368,310
1920	160	118	151	134	108	104	225	840	1050	919	832	500	311,990
1921	274	108	(125)	(119)	(119)	147	415	1110	3050	1740	1350	747	562,180
1922	415	201	125	153	185	(181)	316	812	931	532	589	342	289,400
1923	190	131	139	134	129	124	192	433	844	1090	1190	696	320,870
1924	588	407	255	182	154	134	624	986	1540	813	476	260	388,500
1925	228	158	155	168	148	106	219	384	437	358	438	396	193,070
1926	305	140	77	66	75	111	401	1180	1520	875	641	240	341,310
1927	167	196	94	95	118	146	258	515	634	655	448	308	220,050
1928	277	170	68	105	106	135	168	783	950	615	450	214	244,940
Avg.	272	175	134	127	118	138	337	730	1037	776	624	410	302,590
Avg. 1919-1928	283	182	133	132	129	135	345	821	1203	848	724	417	324,060= 127 A.-Ft. per sq. mi.
Avg. A.Ft. 1919-28	17400	10800	8170	8120	7160	8300	20500	50400	71800	52110	44500	24800	

Avg.1909-1928 - 323,400 A.F.

Avg.1918 1928 - 321,700 "

Note: 82% of the average flow for the last 10 years occurred during the irrigation season, or from April to September, inclusive.

Figures enclosed thus ( ) are partly estimated from incomplete records.

Avg. 1917-1928, incl. = 321,430 A.-Ft.

TABLE NO. 2.

RUN-OFF SOUTH PLATTE RIVER AT DENVER IN MEAN DAILY SEC. FT.

Drainage Area = 3,840 sq. mi. Altitude = 5,240

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Ac-Ft.
1909	(125)	(110)	(120)	(80)	(75)	(100)	(140)	(325)	(830)	(750)	775	1787	320,710
1910	564	324	194	268	190	501	372	492	304	187	374	120	235,790
1911	110	90	90	123	96	81	123	207	343	595	270	132	137,050
1912	104	89	98	70	63	89	79	379	874	971	756	274	233,560
1913	222	256	(180)	(120)	(90)	(95)	(400)	457	690	407	274	235	207,010
1914	(251)	(225)	(244)	342	358	510	1920	2880	1960	1500	2305	434	784,120
1915	370	330	252	(188)	189	247	1480	1170	1210	353	427	383	398,000
1916	400	255	229	183	177	182	145	430	509	397	445	228	217,330
1917	205	162	148	138	119	132	176	1070	1770	603	470	248	316,650
1918	162	123	138	106	120	112	319	529	1000	818	356	320	248,030
1919	251	231	189	164	133	161	597	1200	876	683	841	393	346,590
1920	149	144	156	146	116	98	234	1340	523	740	606	314	277,870
1921	162	149	147	101	115	135	717	1270	3850	1120	1130	406	561,170
1922	197	220	196	169	166	160	362	514	556	376	451	211	216,360
1923	165	147	189	144	151	143	145	321	800	1060	1600	636	333,810
1924	836	673	379	324	414	293	848	1320	1530	532	246	187	458,000
1925	194	149	171	185	150	80	65	167	206	221	322	263	131,410
1926	151	165	122	94	119	182	989	1470	1220	783	379	208	355,810
1927	101	164	112	116	118	150	183	353	395	472	390	247	169,560
1928	124	122	121	103	97	120	130	787	733	379	285	150	191,070
Avg.	242	206	174	158	153	179	471	834	1009	647	635	359	307,000
Avg. 1919-1928	233	216	178	155	158	152	427	874	1069	637	625	302	304,170
Avg. A. Ft. 1919-28	14300	12850	10940	9530	8770	9340	25400	53700	63600	39100	38400	17950	

Avg. 1918-28 = 299,100 A.F.

Note: Figures enclosed thus ( ) have been estimated by comparison with record at South Platte.
79% of the average flow for the past 11 years occurred during the irrigation season or from April to September, inclusive.

TABLE NO. 3

RUN-OFF BEAR CREEK AT MOUTH IN DAILY MEAN SEC. FT.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1914							366	571	175	105	239	17	
1915	38	54	-	-	-	-	-	-	-	-	-	-	
1927	-	-	-	-	-	11.0	19.5	19.0	12.8	11.8	38.7	23.	
1928	25.4	17.8	18.2	13.7	11.4	7.7	17.3	251.0	66.4	7.6	6.7	5.6	27,304

TABLE NO. 4.

RUN-OFF PLUM CREEK AS ESTIMATED BY COMMISSIONER OF DISTRICT 8.
Mean Daily Sec. Ft.

Year Ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.	Diverted A.Ft.	For Ac.
1923	2	12	(10)	(8)	(6)	10	11	17	39	36	33	11	11820	3984	1308
1924	31	38	(30)	(11)	(12)	37	74	108	107	17	5	4	28631	2386	1176
1925	5	5	(5)	(4)	(4)	18	6	4	5	10	16	7	5319	1273	851
1926	10	11	14	(8)	(6)	53	117	97	24	21	5	3	22339	2370	1292
Avg.	12	14	15	8	7	30	52	57	44	21	15	6	17027	2503	1157

Total reported capacities Plum Cr. ditches (1926) = 87.4 s.f. (active ditches)

TABLE NO. 5.

RUN-OFF DEER CREEK AS ESTIMATED BY COMMISSIONER OF DISTRICT 8.
Mean Daily Sec. Ft.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.	Diverted A.Ft.	For Ac.
1923	2	3	(2)	(2)	(2)	3	5	10	14	11	40	5	6020	1370	583
1924	9	10	(6)	(3)	(4)	13	65	59	55	7	1	2	14110	2946	625
1925	3	3	(2)	(2)	(2)	3	1	1	3	5	14	13	3143	342	540
1926	4	3	3	(2)	(2)	10	66	62	5	6	3	2	10166	3450	665
Avg.	5	5	3	2	3	7	34	33	19	7	15	6	8360	2027	603

Total reported capacities Deer Cr. ditches = 71.28 s.f.

Note: Figures enclosed thus ( ) have been estimated by comparisons with Bear Creek flows.

The average run-off for the period 1923 to 1926, incl. is near the 10 year average for South Platte River at South Platte.

2. Temperature and Precipitation

For temperature and precipitation at Denver, in the district, see Chapter on District No. 9, Water Supply.

The normal annual temperature is 50.1° Fahrenheit and the normal annual rainfall is 14.08 inches, which conditions indicate the necessity for irrigation in District 8 for raising any kinds of satisfactory crops.

3. Seepage and Return-flow in District No.8.

TABLE NO. 6

SOUTH PLATTE R. SEEPAGE - CANON TO DENVER.
(FROM PROF. CARPENTER'S BULLETIN NO. 180)

Year	Month	Seepage Return Sec.-Feet	Year	Month	Seepage Return Sec.-Feet
1889	Oct.	71.31	1899	Oct.	144.06
1890	Oct.	67.79	1900	Oct.	94.53
1891	Oct.	95.71	1901	Oct.	68.34
1892	Mar.	138.60	1902	Oct.	45.69
1893	Oct.	94.85	1903	Oct.	55.90
1894	Oct.	216.01	1904	Oct.	120.92
1895	Nov.	191.54	1905	Oct.	111.16
1896	Nov.	58.89	1906	Oct.	139.21
1897	Nov.	27.82	1907	Oct.	92.50
1898	Oct.	89.29	1908	Oct.	101.69
			Avg.1899-1908 - Oct.		97.40

TABLE NO. 7.

SOUTH PLATTE R. SEEPAGE - CANON TO DENVER
(FROM STATE ENGINEER'S REPORTS)

Year	Month	Seepage Return Sec. Ft.
1913	Nov.	69.6
1926	Dec.	76.6
1927	Oct.	122.1
1929	July	93.2
Avg.		90.4

The Water Commissioner, in his weekly reports for 1928 estimated 80 sec. ft. as the average seepage return for Dist. 8 for each month from Mar. to Nov., incl.

Practically all of the seepage return can be diverted in the district, but most of the ditches extend out of the district and irrigate lands in District 2 as well as in District 8.

About 90 sec. ft. seems to be a reasonable allowance for the average available seepage return in District No. 8.

4. Diversions and Use of Water in District No.8.

TABLE NO. 8

PRINCIPAL CANALS WHICH DIVERT IN DISTRICT NO. 8

Name of Canal	Years of Priority	Total Decreed Rts. Sec.Ft.	Canal Cap Sec.Ft.	Acres (a) Irrigated in 1928
	South Platte River Canals			
Brown	1862	16.50	16.	156
Nevada	1861-1865	48.80	60.	1,690
No. Colo. Irr. Co.	1879	600.00	600.	32,250
Petersburg	1861	7.00	8.	265
Platte Canyon	1861-1868	52.27	52.	2,025
Platte Valley	1862	6.00	7.	200
Platte Water Co. (City)	1860-1882	85.95	50.	1,721
Smith Can. or Ditch Co.	1874-1878	(57.57)	(55)	Power only
Town of Littleton	1861-1865	(2.73)	(3)	Town use
	Deer Creek Ditches			
Deer Creek Canyon	1867-1887	5.28 (b)	3.5	125
Fairview	1871-1886	52.00	50.	300
Glenn Plynn No. 2	1881	12.00	7	35
Hayland	1862	2.52	3.	90
McLeod	1872	3.90	4.	65
Selzell	1868	2.18	2.	65
	Plum Creek Ditches (Principal)			
Lower Plum Creek	1870	11.00	11.	200
East Plum Creek	1890	3.55	4.	100
The Highline	1871	3.52	3.5	375
Huntsville	1880	9.12	9.	60
Snyder	1879	3.00	3.	110
Stevens	1879	7.56	7.5	150
	Castlewood Reservoir (Cherry Cr.)			
Arapahoe	1889	50.00	50.	3,000
Total		982.15	950.5	42,982

(a) See ARTICLE X covering land cruise 1930.
(b) Includes Glen Plynn Canal No. 1

In addition to the above listed canals there are a number of small ditches which divert, mostly from intermittent creeks and partially irrigate between 4,000 and 5,000 acres of land.

The City of Denver also diverts about 64,000 acre-feet per year for domestic use from the South Platte River in this district.

The following tabulation of areas irrigated and water used in Dist. No. 8 has been taken from annual reports of the Division Engineer for Div. No. 1, and the Water Commissioner's reports.

TABLE NO. 9

DIST. 8 - AREAS AND USE OF WATER 1921 to 1928, INCL.

Year	Acres Irrigable	Divtd. from Nat. flow Acre-Ft.	Res. Water used Acre-Ft.	Total water Diverted Acre-Ft.	Acres Irri-gated	Acre-Ft. per acre Irrigated
1921	139,713	181,300	7,622	188,922	58,755	3.22
1922	139,645	83,476	27,786	111,262	55,544	2.00
1923	135,437	147,946	8,484	156,430	48,377	3.23
1924	137,044	117,070	30,354	147,424	50,076	2.94
1925	135,570	68,166	5,235	73,401	46,711	1.57
1926	135,808	125,716*	11,556	137,272	49,077	2.80
1927	119,816	103,291	11,747	115,038	47,621	2.42
1928	118,931	126,845	13,233	140,078	47,760	2.95
Avg.	132,746	119,226	14,502	133,728	50,490	2.64

* Corrected.

The distribution of the irrigated areas and water used in 1926 was about as follows:

TABLE NO. 10

DIST. 8 - AREAS AND USE OF WATER IN 1926

Canal System	Divtd. from Nat. flow Acre-ft.	Res. Water used Acre-Ft.	Total water Diverted Acre-ft.	Acres Irri-gated	Acre-Ft. per acre Irrigated
Highline Canal					
from So. Platte	70,300	7,520	77,820	34,450	2.26
Other Diversions					
from So. Platte	40,217		40,217	6,086	6.60
Deer Cr. Ditches	3,450)	360		(665)	
	)	360	6,180	( )	3.16
Plum Cr. Ditches	2,370)			(1,292)	
Castlewood Res.					
(Arapahoe Canal)		3,676	3,676	2,846	1.29
Intermittent Crs.	9,379		9,379	3,738	2.51
Total	125,716	11,556	137,272	49,077	2.80

The last columns in the two tables above indicate the gross head-gate duty in the district. The average diversion duty, disregarding the extremely dry year of 1925, is about 2.8 acre-feet per acre. This figure seems rather large when compared with the estimated diversion duty in the Poudre Valley of 1.4 acre-feet per acre, but is in line with irrigation practice on other lands irrigating directly from the South Platte River. Mr. Parshall in Agricultural Experiment Station Bulletin 279 of Dec. 1922, determined the average gross duty for canals in District 1 to be 3.20 acre-feet per acre and 2.15 acre-feet per acre for District 64.

The average consumptive use of irrigation water on South Platte tributaries has been little more than 1 acre-foot per acre.

Records are available for the seasonal year ending Sept. 30, 1928, for an approximate determination of the consumptive use of irrigation water in District 8. Records of inflow and outflow in the South Platte River and inflow from Bear Creek are considered good. Other records are from weekly estimates by the Water Commissioner and are probably fair approximations:

TABLE NO. 11

APPROXIMATE CONSUMPTIVE USE OF WATER IN DISTRICT NO. 8 FOR SOUTH PLATTE, PLUM AND DEER CREEK LANDS FOR YEAR ENDING SEPT. 30, 1928.

Stream	Inflow Acre-Ft.	Outflow Acre-Ft.	Consumpt. use A. Ft.	Consumpt. Use A.-Ft. per A. Irrigated
South Platte at So. Platte	244,940			
Bear Cr. at Mouth	27,300			
Plum Creek	14,200			
Deer Creek	7,130			
South Platte at Denver		191,070		
Domestic Use		64,200		
Total	293,570	255,270	38,300	0.94

Note: The run-off of the South Platte River at South Platte for 1928 is 77% of the average.

While the above consumptive use as shown in Table No. 11 is probably somewhat low on account of incomplete inflow data, it is indicated that, although the canals in District 8 divert at an average rate about twice that of the canals diverting from the mountain tributaries of the South Platte, the consumptive use of irrigation water is about the same.

The practice of the irrigation canals in the South Platte Valley of diverting a great deal more water than required for irrigation, accounts, in part, for the unusual amount of return flow to the South Platte River. Diversions are excessive during the early part of the irrigation season, when water is plentiful, but shortages are frequently experienced later in the summer.

5. Reservoirs in District 8.

The Highline Canal of the Northern Colorado Irrig. Co., now controlled by the City of Denver, derives a portion of its water for late irrigation from its 1/3 right in Antero Reservoir situated on the South Platte River in District 23. This canal also has 7 small reservoirs under it for temporary storage.

There are several small reservoirs fed from Deer and Plum Creek, the largest of which is Fairview of 218 acre-feet capacity.

The only reservoir of any material size in the district, is Castlewood Reservoir on Cherry Creek with a decreed capacity of 5,260 acre-feet. This reservoir fills from flood flows in Upper Cherry Creek and supplies water for about 3,000 acres of land under the Arapahoe Canal.

6. Future Development in District No. 8

There doesn't appear to be much opportunity for any great increase in the water supply for irrigation in this district.

Plum Creek, with an average annual runoff of about 17,000 acre-feet supplies its ditches with about 2,500 acre-feet annually. In 1928 1,462 acres were reported as irrigated and 2,189 acres as capable of being irrigated from existing diversions. It is probable that a channel reservoir in Upper Plum Creek would store enough flood waters to irrigate the 727 acres now without water.

The difference between the area irrigated and irrigable from Deer Creek in 1928 was only 270 acres. The average annual run-off is about 8,000 acre-feet and average diversions 2,000 acre-feet. Channel storage would be necessary to increase the area irrigated by this creek. Small channel reservoirs on both these creeks would allow a small expansion of the area irrigated and also regulate the flow so that a more dependable supply for late irrigation would be available. It would be, however, from the nature of the storage works required, much more expensive water than that now being used.

The Highline Canal, owned by the City of Denver, irrigated

32,250 acres in 1928 out of a total of 100,000 acres commanded by the canal. Diversions are ordinarily excessive during the early part of the irrigation season up until the latter part of June, after which the supply is deficient and erratic until about October 1st. It appears to be the custom to irrigate throughout October and store water in the soil for next season's use. The total amount of water diverted in a season is usually considerably more than enough to supply the needs of the lands served by this canal, but on account of lack of uniform distribution of stream flow, the canal is peroneially short of water during the latter part of the irrigation season. Frequently, during late June and July, the only available supply is reservoir water from Antero Reservoir. The highline has rights to 1/3 of the water, stored in this reservoir, the present capacity of which is estimated at 28,000 acre-feet.

The obvious remedy would be additional storage on the upper South Platte, but the remaining surplus is now appropriated for use in Denver. It is probable that storage works contemplated by the City of Denver to increase its domestic water supply will tend to provide more water for use under the Highline Canal and with the bringing of trans-mountain water to Denver, a considerable quantity of additional water will be passed thru the sewer system of Denver for use of canals below Denver, thereby releasing for use under the Highline Canal, water which now is forced past that canal to satisfy rights below Denver.

7. Two Forks Power Project.

There is quite an attractive power project in the Platte Canyon below the junction of the North and South Forks of South Platte River, and above the head of the Highline Canal.

The available head is over 400 feet, without a storage dam and with a little regulation with present reservoirs, the stream flow from

November 1st to March 31 incl., could be regulated to 150 sec. feet, while the summer flow from Apr. 1st to Oct. 31st, incl., would be 400 sec. feet.

The theoretical available power would be:

Firm or all year power -----	6,800 h.p.
Excess summer power (7 mos.)	11,200 h.p.
Probable capacity of plant	18,000 h.p.

Power filings have been made on this site as follows:

Year	Name of Company	Capacity Conduit	Approx. head	Approx. theo.h.p.	Estimated Cost	Filing No.
1893	Denver Water Power Pipe Lines	200 s.f.	400 ft.	9,000	---	60
1907	Mill Gulch Ditch & Pipe Lines	400 s.f.	400 ft.	18,000	$400,000	3,922
1907	*Two Forks Power Tunnel	350 s.f.	350 ft.	14,000	$425,000	4,007

* This filing claimed by City of Denver in Filing No. 14,615, filed 1926.

The construction of Eleven Mile Canyon Reservoir and the future increase in water consumption by the City of Denver, will increase the flow available for power development. If Two Forks Reservoir dam is built to the contemplated height of 360 ft. and the power conduit connected with it, the average power head would be increased about 200 feet.

The annual surplus revenues from a power plant at this site even under present conditions would be considerable, and the project appears well worth while from the standpoint of private investment or as a municipal enterprise.

CHAPTER IX

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

BEAR CREEK, WATER DISTRICT NO. 9 - WATER SUPPLY

Contents

CHAPTER IX

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

BEAR CREEK, WATER DISTRICT NO. 9 - WATER SUPPLY

1. Discharge Records and Run-off.

The water supply of this district is all furnished by Bear and Turkey Creeks.

Fairly complete records of the run-off of Bear Creek at Starbuck since October 1, 1919, have been kept by the State Engineer.

The supply from Turkey Creek is reported weekly by the Water Commissioner of District No. 9.

Bear Creek Run-off Records.

The gaging station is at Starbuck, above all diversions for irrigation.

TABLE NO. 1

RUNOFF BEAR CREEK AT STARBUCK IN MEAN DAILY SEC. FT.

Drainage Area = 111 sq. miles - Elev. = 6400 ft.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1920	31.0	20.9	15.4	15.0	16.8	19.2	28.4	236	153	78.5	78.6	67.5	46135
1921	31.2	21.0	18.7	15.4	20.8	16.9	89.9	285	332	(195)	169.	86.7	77677
1922	31.3	20.5	22.2	16.1	16.7	23.0	44.6	97.3	86.3	53.3	91.1	50.9	33508
1923	31.5	32.0	(25)	(18)	(17)	(33)	53.1	140	239.	(191)	307	173.	76334
1924	95.9	86.7	(57)	(34)	(36)	33.0	102	227	265	91.6	28.5	25.6	65490
1925	33.9	22.9	(18)	(14)	(15)	14.6	16.4	16.3	24.7	25.9	42.2	78.7	19448
1926	86.8	56.4	33.0	(20)	(18)	32.5	226	352.	260.	178.	98.4	40.5	84820
1927	32.3	26.3	(20)	(18)	(16)	21.5	48.8	84.6	66.0	57.3	87.5	48.1	31889
1928	32.5	23.6	(20)	(15)	(7.5)	18.8	40.8	195.	154.	76.7	49.6	23.1	39873
Avg.	45.2	34.5	25.5	18.4	18.2	23.6	72.2	181.5	175.5	105.2	105.7	66.0	52800
Avg. 1924-1928 =													48300 A.Ft.

Figures enclosed thus ( ) are partly estimated.

The maximum recorded mean daily flow was 678 sec. ft. in June, 1921 - Estimated possible max. momentary flow = 2,500 sec. ft.

Available records of run-off at the mouth of Bear Creek where a state gaging station is being maintained, are as follows:

TABLE NO. 2

RUN-OFF BEAR CREEK AT MOUTH IN MEAN DAILY SEC. FT.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1914	--	--	--	--	--	--	366	571	175	105	23.9	17.3	---
1915	37.7	54.3	--	--	--	--	--	--	--	--	--	--	---
1927	--	--	--	(10)	(9)	11.0	19.5	19.0	12.8	11.8	38.7	23.0	---
1928	25.4	17.8	18.2	13.7	11.4	7.7	17.3	251	66.4	7.6	6.7	5.6	27304

Total run-off for calendar year 1927 = 13,098 acre-ft.

TABLE NO. 3.

TURKEY CREEK RUN-OFF IN MEAN DAILY SEC. FT.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Ft.
1924	8.7	12.3	(8.5)	(7.8)	(9.0)	11.0	55.7	92.8	51.2	7.1	1.3	0	16046
1925	1.0	2.2	(2.7)	(2.8)	(3.8)	3.3	2.9	1.8	1.0	0.2	3.1	4.8	1773
1926	6.0	6.0	5.4	(4.0)	(4.5)	13.6	80.2	107	18.3	10.5	5.1	0.7	15835
1927	1.3	2.0	(3.0)	(3.6)	(4.0)	5.2	20.0	18.2	5.3	2.5	4.2	3.1	3291
1928	2.7	2.2	(3.0)	(3.0)	(1.9)	(5.6)	13.3	57.8	21.1	4.0	2.3	0	7129
Avg.	4.0	4.9	4.5	4.2	4.6	7.7	34.4	55.5	19.4	4.8	3.2	1.7	
Avg.A.F.	242	294	277	261	262	475	1834	3416	1153	300	200	101	8815

Figures enclosed thus ( ) have been estimated from Bear Cr. flows.
Other figures are from Water Commissioner's weekly reports.

2. Temperature and Precipitation at Denver.

Denver, near the east edge of District No. 9, is the nearest weather bureau station with continuous climatic records, and is thought to represent approximately average conditions in the district.

Temperature and precipitation records at Denver, for the period 1921 to 1928, inclusive, with averages for the period of record, 1872 to 1928, inclusive, are given below:

TABLE NO. 4.

MONTHLY AVERAGE TEMPERATURE, DEGREES FAHRENHEIT AT DENVER.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	33.8	37.0	45.0	45.2	57.5	67.2	72.4	71.2	63.9	56.0	43.7	35.4	52.4
1922	27.7	31.4	40.3	45.2	57.7	70.4	71.8	74.2	65.8	52.3	37.2	35.1	50.8
1923	37.9	28.2	33.9	46.6	56.1	65.4	72.6	68.4	60.6	44.3	41.8	30.5	48.9
1924	29.6	37.6	28.0	46.0	52.6	68.4	71.8	73.2	60.4	54.4	44.4	25.6	49.3
1925	31.4	41.0	44.5	52.8	60.2	67.2	73.4	69.6	63.8	43.4	41.0	32.0	51.7
1926	31.2	39.0	37.6	47.6	58.6	66.6	70.8	73.0	61.6	53.6	42.8	29.8	51.0
1927	35.2	36.7	36.0	47.7	59.6	64.6	71.2	66.6	62.0	54.6	45.9	25.9	50.5
1928	36.6	33.2	42.0	45.8	57.7	61.0	71.0	70.6	62.6	50.8	39.6	31.2	50.2
Avg. 57 yrs.	29.8	32.7	39.3	47.1	56.2	66.3	72.2	70.7	62.9	51.2	39.8	32.3	50.1

TABLE NO. 5

INCHES OF RAINFALL - AT DENVER

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1921	0.77	0.27	0.48	2.31	0.60	3.26	1.27	3.49	0.02	0.66	0.57	0.85	14.55
1922	0.30	0.40	0.48	3.65	1.14	0.19	1.87	1.50	0.54	0.30	1.95	0.63	12.95
1923	0.13	1.09	2.17	0.60	1.83	3.55	2.74	3.87	0.75	3.50	0.24	0.95	21.42
1924	0.52	0.27	1.29	1.60	2.62	0.46	0.33	0.02	1.44	0.96	0.14	1.42	11.07
1925	0.13	0.04	0.42	0.40	0.43	1.48	0.74	1.68	0.99	1.87	0.67	0.93	9.78
1926	0.77	0.40	1.98	2.31	1.41	0.86	1.00	0.80	1.48	0.69	0.31	1.04	13.05
1927	0.18	0.32	2.29	1.53	1.40	2.76	2.36	2.75	1.06	0,19	0.81	0.23	15.88
1928	0.24	0.59	1.40	1.36	3.06	2.42	1.01	0.85	0.07	1.97	1.58	0.06	14.61
Avg. 57 yrs.	0.40	0.56	1.04	2.06	2.21	1,38	1.68	1.43	0.99	1.05	0.55	0.73	14.08

3. Seepage and Return Flow in District No. 9.

TABLE NO. 6

BEAR CREEK, SEEPAGE RETURN

From Prof. L. G. Carpenter - Bulletin No. 180

Year	Date	Inflow S.F.
1900	Oct. 27	15.71
1901	Sept. 11	18.70
1902	Sept. 3	4.15
1903	Oct. 23	11.19
1904	Oct. 22	13.51
1905	--	12.27
1907	Oct, 26	22.42
1908	Nov. 1	11.73
1909	Nov. 1	17.60
1910	Nov. 29	10.88
Avg.		13.82

TABLE NO. 7

BEAR CREEK SEEPAGE RETURN - SEC. FT.
(From State Engineer's Reports.)

Year	Date	Inflow s.f.
1906	Oct.	13.04
1907	Sept.	21.80
1908	Sept.	14.00
1913	Oct.	16.30
1914	Oct.	21.50 on account of large water supply
Avg.		17.33

TABLE NO. 8

PROPOSED SEEPAGE AND RETURN FLOW TABLE FOR BEAR CREEK.

Month	Avg. Inflow Sec.-Ft.	Month	Avg. Inflow Sec.-Ft.
Jan.	10	July	22
Feb.	12	Aug.	20
Mar.	14	Sept.	18
Apr.	16	Oct.	16
May	18	Nov.	14
June	20	Dec.	12

Practically all of the return flow is divertible in the district.

4. Use of Water for Irrigation in District No. 9.

The average total seasonal water supply for this district is as follows:

9 yrs. Avg. from Bear Creek	5 yrs. Avg. from Turkey Creek	Estimated return flow	Total Avg. Annual supply Dist. 9
52,800	8,815	11,680	73,295 A.Ft.

The total area irrigated in this district in 1928 was reported as 18,345 acres and the total irrigable as 19,775 acres. Therefore, the water supply of District No. 9 would yield 4.0 acre-feet per acre irrigated, and 3.7 acre-feet per acre irrigable, if it were all conserved and used.

The following table was compiled from data given in the State Engineer's reports and represents gross headgate diversions plus water released from storage:

TABLE NO. 9

USED BY CANALS FOR IRRIGATION IN DISTRICT NO. 9

Year Ending Sept. 30	Acre-ft. Run-off Bear Cr. at Star-buck	Acre-ft. Diverted by ditches from nat. flow	Acre-ft. used from storage	Total used for irrigation	Total acres irrigated	Acre-ft. per acre irrigated
1921	77,677	40,619	13,946	54,565	17,085	3.19
1922	33,508	45,841	4,751	50,592	20,348	2.48
1923	76,334	50,414	4,474	54,888	19,870	2.76
1924	65,490	42,498	9,253	51,751	16,773	3.09
1925	19,448	27,511	712	28,223	16,158	1.75
1926	84,820	42,201	10,831	53,032	19,265	2.75
1927	31,889	29,892	9,056	38,948	22,497	1.73
1928	39,873	33,494	12,407	45,901	18,345	2.50
Avg.	53,630	39,060	8,180	47,240	18,793	2.53

On the basis of 1.5 acre-feet per acre, which is considered a fair headgate duty in other districts in Division No. 1, it appears that the Bear Creek District is not subject to serious water shortages for irrigation.

Consumptive Use of Water in District No. 9.

Parallel records of flow into and out of the district for the calendar year of 1927 make it possible to compute the consumptive use of water for this year as follows:

TABLE NO. 10

CONSUMPTIVE USE IN DIST. NO. 9 FOR 1927 - ACRE-FT.

Bear Cr. at Star-buck	Turkey Creek	Total Inflow	Outflow Bear Cr. at mouth	In storage Jan. 1, 1927	In storage Dec. 31 1927	Cons. use 1927	Acres irri-gated 1927	Consump- Use A.Ft. per acre
31,739	3,393	35,132	13,098	14,460	12,709	23,785	22,497	1.06

5. Canal Diversions in District No. 9.

A list of decreed canals, which divert from Bear and Turkey Creeks in the district, is given below, in alphabetical order:

TABLE NO. 11

DECREED CANALS DIVERTING FROM BEAR AND TURKEY CREEKS

Identi-fication No.	Name of Canal	Years of Priority	Total Decreed Rights Sec.Ft.	Capacity Sec.Ft.	Acres Irrigated in 1928
1.	Arnett Canal	1869-84	57.10	132	2,369
2.	Dergen Ditch	1874	12.00	65	1,829
3.	Churn Ditch	1870	1.49	2	10
4.	Hindry Ditch	1862-67	12.88	5	292
5.	Hodgson Ditch	1861-62	10.32	8	180
6.	Independent Highline Canal	1862-81	33.69	8	160
7.	Robert Lewis (trans.to Arnett)	1865	17.00	18	487.5
8.	Lewis & Strouse Ditch	1863	28.26	8	30
9.	McBroom Ditch	1859	11.58	14	198
10.	Olson & Bell Ditch	1862	6.30	6	273.5
11.	Pioneer-Union Ditch	1861-65	45.67	36	998.5
12.	Simonton Ditch	1860	35.76	36	759.5
13.	Spickerman Ditch	1862	7.61	6	70
14.	Strouse Ditch	1865	4.80	5	27
15.	Ward Canal	1862-82	70.81	50	2,030.5
16.	Warrior	1861-65	52.15	52	1,766
	Irrigated direct from Res's.				6,864
	Totals		407.42	451	18,344.5

The sum of the diversions of the above canals each day for the good water season of 1926 was tabulated for use as a reasonable demand against the district water supply in past years. This table follows:

TABLE NO. 12

SUM OF DAILY CANAL DIVERSIONS FROM BEAR AND TURKEY CREEKS-1926-SEC. FT.

(From Water Commissioner's Field Books)

Day	April	May	June	July	August	September	October
1	0	67	264	220	145	93	72
2	0	62	276	198	142	96	81
3	0	47	283	191	140	114	66
4	0	47	272	197	116	119	64
5	0	47	269	201	116	112	60
6	0	63	297	198	129	106	54
7	0	73	284	273	135	70	52
8	0	68	286	228	137	98	54
9	0	68	254	220	137	72	54
10	0	65	256	236	115	76	61
11	0	65	253	187	111	77	47
12	0	56	278	193	150	76	50
13	0	48	235	186	150	81	50
14	0	45	221	185	144	82	47
15	0	52	202	201	145	81	60
16	0	54	199	198	142	89	49
17	0	55	165	186	124	80	46
18	5	54	161	179	142	85	46
19	5	54	182	195	148	77	45
20	5	57	184	201	138	76	44
21	25	83	185	201	138	65	44
22	25	112	177	128	138	61	49
23	29	128	180	128	131	49	49
24	19	183	206	133	131	69	41
25	15	220	222	142	129	69	43
26	20	256	213	147	123	78	44
27	62	265	218	148	104	72	42
28	57	245	211	150	113	59	30
29	69	279	213	138	95	59	31
30	81	256	207	144	3	64	16
31	xxx	256	xxx	145	3	xxx	16
Total	417	3430	6853	5677	3814	2405	1507
Acre-Ft.	830	6800	13600	11250	7560	4770	2990

Total for season = 47,800 Acre-Ft.

In a similar manner as above, the sums of the canal diversions from Bear and Turkey Creeks were compiled for the years 1924 to 1928, inclusive, and plotted to scale. From those plottings, a table of total maximum daily diversions for the 5 year period was made. This table follows:

TABLE NO. 13.

SUM OF MAXIMUM DAILY CANAL DIVERSIONS FROM BEAR AND TURKEY CREEKS, IN SEC. FT. FOR THE PERIOD 1924 to 1928, INCLUSIVE.

Day	April	May	June	July	August	Sept.	Oct.	Nov.
1	60	147	264	220	145	109	114	74
2	64	162	276	200	142	138	126	74
3	69	162	283	203	140	132	124	36
4	80	200	272	200	116	126	124	67
5	92	180	269	201	116	138	117	50
6	92	158	297	198	129	157	116	55
7	102	131	284	273	135	154	116	53
8	102	119	286	228	137	160	96	53
9	107	116	254	220	182	164	113	45
10	80	110	256	236	141	145	82	50
11	80	114	253	187	127	133	64	38
12	80	120	278	193	150	134	64	0
13	90	182	235	186	150	150	51	0
14	88	182	220	185	144	150	51	0
15	90	180	220	201	145	101	64	0
16	94	182	239	198	142	164	66	0
17	97	200	252	186	124	153	66	0
18	95	200	258	179	142	143	61	0
19	105	182	264	195	148	138	58	0
20	108	163	263	201	138	94	50	0
21	107	180	257	201	138	91	50	0
22	106	193	253	155	138	93	45	0
23	106	186	251	130	131	127	50	0
24	107	204	235	145	131	112	56	0
25	97	220	221	140	129	132	64	0
26	115	256	213	147	123	105	48	0
27	145	265	218	148	104	117	50	0
28	145	245	211	150	113	116	44	0
29	145	279	213	147	95	114	55	0
30	145	256	207	144	80	108	55	0
31	xxx	256	xxx	145	59	xxx	67	xx
Total	2993	5730	7502	5742	4034	3898	2307	595
Acre-ft.	5940	11350	14870	11400	8000	7730	4575	1180

Total = 65,045 acre-foot.

In the above table, the sum of diversions for each day is the maximum for that day during the past 5 years.

This table is considered extra conservative for use as a basis to determine irrigation demand, since the total acre-ft. diverted as shown above, is 30% greater than the total acre-ft. actually diverted in any one year during the past 8 years and the peaks of the canal diversions come at different dates in different years according to the manner in which the stream run-off occurs.

However, the surplus over the maximum daily diversions was computed to show the outside minimum available for additional storage.

6. Surplus Available for Additional Storage Using Maximum Daily Canal Diversions for the Period, 1924-1928, inclusive.

TABLE NO. 14.

SURPLUS FOR STORAGE, DIST. 9 - MAXIMUM DIVERSIONS 1924-28.

	Surplus-Acre-ft. Platte Shortages Disregarded				Surplus-Acre-ft. Platte Shortages Supplied			
Year	May	June	July	Total	May	June	July	Total
1920	11,230	6	0	11,236	11,230	0	0	11,230
1921	11,420	11,560	2,677	25,657	11,420	11,560	299	23,279
1922	347	0	0	347	131	0	0	131
1923	1,770	4,619	3,230	9,619	214	4,572	1,192	5,978
1924	9,400	5,385	0	14,785	7,410	5,164	0	12,574
1925	0	0	0	0	0	0	0	0
1926	17,970	3,492	1,830	23,292	17,970	3,492	625	22,087
1927	204	0	0	204	200	0	0	200
1928	5,584	317	0	5,901	3,410	317	0	3,727
Avg.	6,436	2,820	860	10,116	5,776	2,790	235	8,801

The above table is a summary of results obtained by comparisons of daily supply and demand for the period covered.

TABLE NO. 15

7. SURPLUS AVAILABLE FOR ADDITIONAL STORAGE USING 1926 DAILY DIVERSIONS

	Surplus - Acre-Ft. Platte Shortages Disregarded				Surplus - Acre-Ft. Platte Shortages Supplied			
Year	May	June	July	Total	May	June	July	Total
1917	12,400	12,100	3,250	27,750	12,400	12,100	1,320	25,820
1918	4,270	3,140	7,500	14,910	982	2,400	4,530	7,912
1919	13,140	0	1,231	14,371	9,130	0	0	9,130
1920	15,780	107	0	15,887	15,780	0	0	15,780
1921	15,980	12,850	2,805	31,635	15,980	12,850	313	29,143
1922	3,285	0	0	3,285	1,470	0	0	1,470
1923	5,920	5,880	3,323	15,123	256	5,840	1,245	7,341
1924	13,850	6,420	0	20,270	10,995	6,248	0	17,243
1925	0	0	0	0	0	0	0	0
1926	22,750	4,440	1,925	29,115	22,750	4,440	625	27,815
1927	3,153	0	0	3,153	1,770	0	0	1,770
1928	9,635	343	2	9,980	4,963	343	0	5,306
1920-28 Avg.	10,039	3,338	895	14,272	8,218	3,302	243	11,763
1917-28 Avg.	10,013	3,773	1,670	15,456	8,040	3,685	669	12,394
1918-28 Avg.	9,797	3,016	1,526	14,339	7,643	2,920	610	11,173

This table indicates that there is an annual average of about 12,000 acre-ft. available for additional storage on Bear Creek during May, June and July, without interfering with present irrigation needs or customs in District No. 9 and Districts 1, 2 and 64 on the South Platte River. The 12,000 acre-feet average represents surplus waters above irrigation needs, which occur during the late spring or early summer floods. It is probable that during good years some water could be stored in the winter after all other present reservoirs are filled, but this source has been disregarded as it would not be needed to fill a reservoir of reasonable size during good years and would not be available in lean years. The amount available could be stored at any point on Bear Creek to the extent of the flow at such point, at the time the water was available.

8. Present Reservoirs in District No. 9.

The district court handed down decrees for six reservoirs in this District in 1884. No other reservoir decrees have been entered since that time, although eleven additional reservoirs have been constructed and operated for a number of years.

All of the reservoirs are in natural depressions away from the creek, fed by irrigation canals, except the Evergreen Reservoir which is in the channel of Bear Creek, just above the town of Evergreen.

TABLE NO. 16

SUMMARY DIST. NO. 9 RESERVOIRS FROM WATER COMM'S. REPORTS

Reservoir	Number	Capacity A.Ft.	Remarks
Decreed Irrig. Reservoirs	6	4,250	Decreed in 1884
Not " " "	9	6,980	
(19,800) (670) Domestic (Marston & Evergreen)	2	20,470	Denver City Water Supply
Totals	17	31,700	(11,230 A. Ft. for irr. Res's.)

Marston Lake has an amended decree (of 1930) for 31,186 acre-feet for water diverted from So. Platte R. in Dist. 8, and a pending from Bear Creek in Dist. 9. It usually stores about 5,000 acre-ft. annually from Bear Cr. through the Arnet Ditch.

Except in extremely dry years, practically all of the irrigation reservoirs fill during the winter or early in the spring, and are mostly emptied during the irrigation season.

Evergreen Reservoir (670 A.Ft.) which was begun late in 1926 and completed in 1927, is owned by the City of Denver and was designed principally as a beauty spot in the park district, although it supplies the small town of Evergreen with domestic water and might yield a little stored water for use in Denver. It is probable that the only effect of this dam on Bear Creek run-off, after it was once filled, is the small loss of water due to evaporation from the reservoir water surface.

According to the report of the Water Commissioner, about 7,000 acres are irrigated directly from the reservoirs in the district.

There are no decrees for power purposes in this district.

9. Allowable Annual Draft for a Reservoir on Bear Creek.

Approximate average annual yields for a reservoir on Bear Creek near Starbuck, for various capacities (disregarding evaporation and seepage losses) are as follows:

TABLE NO. 17
(Based on 1926 Canal Diversions)

Reservoir Capacity A. Ft.	Avg. Ann. Yield A.-Ft. 1920 to 1928, incl.
10,000	6,200
15,000	8,400
20,000	9,900
25,000	11,000
30,000	11,760

It is evident from the above table that a reservoir of from 20,000 to 25,000 acre-feet capacity on Bear Creek, to yield annually 10,000 to 11,000 acre-feet of water for irrigation, would be feasible if an economical site exists on the stream where the excess water is available.

Such a reservoir ordinarily would not be needed for irrigation in District 9, where the supply is usually ample, but the stored water could be used to good advantage for summer irrigation in lower districts, or such a reservoir might be operated to increase the winter flow for power purposes by holding the early summer flood surplus until the following winter. The increased winter flow would not be needed to fill District 9 reservoirs but could be handled by lower reservoirs which take their supply from the South Platte River.

This is a case where a reservoir could be operated to good advantage both for power and irrigation purposes.

10. Channel Reservoir Sites on Bear Creek.

A preliminary field examination was made of Bear Creek Canyon from the mouth at Morrison to above Bendemeer Lodge, and three possible dam and reservoir sites were noted, as follows:

TABLE NO. 18.

No.	Location Dam	Remarks	Drainage Area above Dam
1.	Sec. 36, T. 4 S., R. 71 W.	Below Kittredge	96 sq. mi.
2.	Sec. 10, T. 5 S., R. 71 W.	In Evergreen, below Evergreen Lake	82 " "
3.	Sec. 12, T 5 S., R. 72 W.	1 mi. below Bendemeer	46 " "

Preliminary surveys and filings were made at or near each of the three sites, by the Mt. Evans Power and Reservoir Company in 1905, but these filings are considered to have lapsed as no work has been done on them since 1905 and no supplementary statements have been filed in the office of State Engineer in compliance with notices sent the Company in 1919.

Filing (No. 2013) for Reservoir No. 1, near Kittredge, contemplated a dam only 70 ft. high, above the Creek bed, to store 1,319 acre-feet of water. By plotting the capacity curve to 70 ft. height on logarithmic scale paper and extending same, a capacity of 24,000 acre-feet was arrived at for a dam of a height of 160 ft. These figures are not very reliable on account of the distance the curve was extended.

Filing No. 3831 for Reservoir No. 2 shows a survey for a dam 150 ft. high, to store 22,100 acre-feet. This site is about 400 yds. below the present Evergreen Dam and partly in the town of Evergreen. It would entirely submerge the Evergreen Dam and reservoir, which was built at a cost of about $200,000.

Filing No. 2274 for Reservoir No. 3 was for a dam of a height of 90 ft. above creek bed, to provide a capacity of 5,140 acre-feet. By curve extension, a capacity of 23,800 acre-feet is indicated for a dam 160 ft. in height.

A 160 foot dam at any of the three sites would store about the same amount of water (24,000 acre - ft.) or enough to take care of the average surplus at Starbuck.

No. 3 site has too small a water shed(46 sq. mile) in comparison with the area above Starbuck (111 sq. mi.) to insure satisfactory operation of a large storage reservoir at this point.

No. 2 site is probably not practical on account of its interference with the town site of Evergreen and Evergreen Lake.

No. 1 site at Kittredge, about 3 miles upstream from Starbuck, could store practically all the estimated available surplus on Bear Creek. If the cost of the dam and right of way doesn't prove excessive, this is probably the most favorable site for storage on Bear Creek. (See Chapter XIII for cost estimate for dam at this site.)

Cykler Reservoir Site. A preliminary filing was made in 1906 for the Cykler Reservoir, situated north of the channel of Bear Creek, near Morrison, which would require a feeder canal from Bear Creek.

The Van Sant-Houghten Co. made a survey and estimate of this site for the City of Denver with results as follows:

Height of dam - 95 feet.
Area submerged at high water - 240 acres.
Capacity of reservoir - 12,000 acre-feet.
Estimated cost - $1,156,000 (not including relocation of narrow gauge R. R., and canal from South Park).
This site is not an attractive one for storing flood waters for irrigation uses.

CHAPTER X.

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

SOUTH PLATTE RIVER - WATER DISTRICT NO. 23 - WATER SUPPLY

Contents

CHAPTER X

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

SOUTH PLATTE RIVER - DISTRICT NO. 23 - WATER SUPPLY

1. General Description of District No. 23.

This district comprises about 2,550 square miles of area, from 8,000 to 14,000 feet in elevation, drained by the North and South Forks of the South Platte River, above Platte Canyon.

It differs from the other mountain districts of the South Platte Basin, in the character and elevation of its irrigated area and in the location of the irrigated lands, which lie at altitudes of from 8,500 to 10,000 feet above sea level. The crop raised consists almost entirely of native hay.

In the other mountain districts, the lands irrigated are located on the plains, or adjacent to the mountains below points where the streams leave the mountains, but in District 23 the irrigated areas are above most of the run-off which originates in the district.

Only about 3% of the area included in District 23 is irrigated, and the water supplies of the district are used more as a source of domestic supply for the City of Denver and for irrigation in the vicinity of Denver, than for irrigating lands in water district No. 23.

2. Irrigated Area and Use of Water in District No. 23.

The topographic map, Plate 5, shows the approximate location of the hay lands as determined by Bull and Witham, Consulting Engineers in 1920. Mr. Bull, in a report, gives the area of hay land irrigated in South Park as follows:

Along Tarryall Creek and its branches-------	24,000 acres
On the main South Fork and its branches-----	24,000 "
Total hay land irrigated	48,000 "

The U. S. Census for 1919 estimates the total irrigated area in South Park as 50,000 acres.

There are decrees on record for 409 ditches in District 23, dating from 1861 to the 1920's. Most of the ditches in this District are small. The greatest number ever reported by the Water Commissioner is 74 in 1924.

These 74 ditches were reported to have diverted a total of 105,000 acre-feet to irrigate 30,430 acres of native hay, or at the rate of 3.45 acre-feet per acre irrigated,

The irrigation season commences in May and ends in August. Large quantities of water are applied to the hay lands during the short period of irrigation and on account of the shallow soil, under-laid with gravel, the major part of this water returns directly to the streams.

The Van Sant-Houghton Co. made an investigation of the consumptive use of water on South Park hay and pasture lands, for the City of Denver in 1916. Records were kept on the diversions for, and returns from, about 3,300 acres of land along the South Fork of the river and Tarryall Creek. Their conclusion was that an average of about 1.7 acre-feet per acre were consumed in evaporation and plant growth each season.

George M. Bull, Engineer, has estimated that not less than 1 acre-foot per acre is consumed, and cites investigations made by R. I. Meeker on the consumptive use by native hay on the Laramie River in Wyoming, in which it was found that approximately 1 acre-foot per acre was used.

The consumptive use by irrigation in the South Park area probably amounts to about 50,000 acre-feet each season.

The City of Denver, at one time, contemplated the purchase of the South Park hay lands, so as to receive the benefit of the increased water supply for domestic use. It was decided, however, that as many of the South Park water rights are junior to irrigation decrees in the lower

South Platte Valley, the bulk of the water released by the non-irrigation of South Park hay lands would go to satisfy early rights in the South Platte Valley and, hence, the City would not greatly benefit therefrom.

3. Reservoirs in District No. 23.

The principal reservoirs of 1,000 acre-feet capacity and over, which have decreed rights to store water in District No. 23, are as follows:

TABLE NO. 1

Name Reservoir	Total Decrees Acre Feet	Capacity Acre-Feet	Av'g. Ann. Yield	Remarks
Lake Cheesman	79,000-1889-93	79,000	24,000 (a)	Denver, domestic.
Antero	85,600-1907	33,000*	12,500	Denver 2/3, Hiline 1/3.
Lost Park (b)	45,000-1907	0	0	Not successfully built.
Jefferson Lake	4,200-1888	4,200	2,440	Cut from Natural Lake.
Wellington	2,750-1892	2,750	-	For Burlington Ditch.
Tarryall (c)	Not decreed	3,280	0	For Fish Purposes.

(a) 50,000 A. ft. held for reserve - could yield 54,000 acre-feet.

(b) The dam for this reservoir was to consist of a concrete diaphram in a boulder slide which fills the Canyon of Goose Creek. The decree is temporary and was granted, conditionally, before the work on the dam was finished. This work was a failure and the decree evidently is of no force unless the dam is made to hold water. Mr. Bull estimates that if this reservoir proved feasible of construction, it would hold about 35,000 acre-feet. However, the available water supply makes this development infeasible.

(c) Has filing for 13,150 acre-feet but is being constructed (1930) to hold 3,280 acre-feet, for fish cultural purposes, a non-consumptive use.

* Capacity limited due to condition of dam.

There are a few other small reservoirs in the district, some with conditional decrees, such as the Como, Dry Lake, Geneva Creek, Altura and Baker.

4. Surplus for Storage in District No. 23.

Mr. George M. Bull, engineer for the Denver Board of Water Commissioners, has estimated that the total annual average surplus for storage on the South Platte River at South Platte, under present conditions of stream flow, is 106,500 acre-feet. He also estimates that present reservoirs in the vicinity and above South Platte are storing on the average about 63,500 acre-feet per year, which leaves a balance of 43,000 acre-feet in District No. 23, uncontrolled by present reservoirs, under present methods of operation.

Lake Cheesman has a total capacity of 79,000 acre-feet but 50,000 acre-feet of this capacity is held as a reserve to protect Denver's water supply. If other reservoir capacity were provided to hold this reserve, it is estimated that the annual yield of Lake Cheesman could be increased from 30,000 to 35,000 acre-feet.

5. Principal Reservoir Sites in District No. 23.

There have been a number of filings on the North and South Forks of the South Platte River for domestic, irrigation and power uses, but those made by the City of Denver for municipal water supply seem to be the only ones which are alive at present.

The City has filings on the Eleven Mile Canyon Reservoir site and on the Two Forks Reservoir site which, if constructed, would provide storage capacity for all of the uncontrolled surplus originating in the district; would also provide storage for the proposed trans-mountain diversions from Blue River and, to a certain extent, control the river flow for generation of hydro-electric power.

The American Reservoir site, on the South Fork of the South Platte River, about six miles below Lake George, is also included in the City filings but is considered undesirable on account of the cost of construction.

The latest filing map and statements of claim by the City of Denver are numbered 14,894 as of January 19, 1928.

The Eleven Mile Canon Reservoir Site.

The Eleven Mile Canon Reservoir Site is located just above the head of Eleven Mile Canon on the South Fork of the South Platte River. In the filing for 80,250 acre-feet, it was estimated that the average annual supply at this point is 68,000 acre-feet. The site is considered economic of development up to 100,000 acre-feet.

The abandonment of the Colorado Midland Railroad, which passed through this site, has made it an attractive proposition for economically storing the City's reserve supply.

The estimated cost of the Eleven Mile Canon Reservoir is about $1,250,000 for a dam 120 ft. in height above stream bed, for storing about 80,000 acre-feet. It is considered the most feasible site above Lake Cheesman. Construction of this dam probably will be started in 1930.

Two Forks Reservoir Site.

The dam-site for Two Forks Reservoir is located just below the junction of the North and South Forks of the South Platte River. The original filing was for a dam 280 feet high to store 145,133 acre-feet, but a later filing is for a dam 360 feet in height, to store a total of 336,368 acre-feet.

This reservoir is to be supplied from the North and South Forks, but the principal supply will be from trans-mountain diversions from Blue River.

It is to be used not only as the Chief storage reservoir of the Denver Municipal water system, not only for surplus waters of the South Platte River and Blue River, but also, possibly in connection with a system of exchanges of water from other sources, such as the Williams Fork and Frazer River, to be brought into the South Platte water shed by trans-mountain tunnels.

The Narrow Gauge line, South Park branch of the Colorado and Southern Railroad traverses the dam-site and the North Fork branch of the reservoir site.

The total estimated cost of the Two Forks Reservoir, not including relocation of the railroad, is about $7,000,000 for the project as enlarged to store 336,368 acre-feet.

The construction of Two Forks reservoir to greater capacity than justified by the surplus waters available for storage, ultimately will serve to control the City Water supply from all sources, and to allow winter regulation of flow from upper reservoirs released for hydro-electric development by re-impounding it in Two Forks Reservoir. It is a project for the future, the construction of which probably will not be undertaken for a number of years.

6. Proposed Trans-mountain Diversions to District No. 23.

There is, at present, a small diversion over Boreos Pass from the headwaters of Blue River to upper Tarryall Creek. This is operated in connection with the Como Reservoirs and diverts about 600 acre-feet annually.

The City of Denver has made surveys of several schemes to bring Blue River water into the South Platte drainage area by means of trans-mountain tunnels, varying in length from 3 miles to 22.8 miles, with estimated annual average diversions varying from about 30,000 acre-feet to 200,000 acre-feet.

The average season for trans-mountain diversion is taken as from April 1 to Sept. 30, during which period about 80% of the run-off from the drainage area commanded, may be diverted.

Filing No. 14894, made by the City of Denver in 1928, contemplates the maximum practical diversion, amounting to about 200,000 acre-feet. The cost is estimated to be about $14,000,000.

The following summary gives three of the proposed plans investigated by the City of Denver and includes minimum average and maximum possibilities:

TABLE NO. 2

PROPOSED TRANS-MOUNTAIN DIVERSIONS FROM BLUE RIVER

Diversions		Diversion Elev. Feet	Length Tunnel Miles	Length Ditch Miles	Drainage Area Sq.Mi.	Mean Annual Diversion Acre-Ft.
From	To					
Snake R.	W. Geneva Cr.	10,300	3.0	26	56	28,000
Swan R.	Hall's Gulch	9,500	12.9	26	181	96,000
*Blue R.	N.F. So.Pl.R.	8,842	22.8	1	328	197,000

* From Dillon, on Blue River to near Grant, on North Fork of South Platte River. Includes run-off from Blue River, Ten Mile Cr. and Snake River.

7. Power Possibilities in District No. 23.

Numerous filings for power projects have been made on the North and South Forks of the South Platte River in District No. 23, but little has been done towards their development. Plentiful and cheap coal for steam power in the vicinity tends to operate against hydro-electric developments. Also the probability of conflict between present irrigation uses of stream flow, and proposed stream regulation for power development, reduces the attractiveness of hydro-electric projects.

With the construction of Two Forks Reservoir, however, the City of Denver expects to be able to develop considerable power for City consumption, as a by-product of storage for municipal water supply. Few of the power opportunities in the upper South Platte area are considered attractive under present conditions and probably any extensive development will wait until the growth of Denver justifies building Two Forks Reservoir.

Studies for the City's scheme of power development are not yet completed, but in general, they contemplate, first, a power plant below Lake Cheesman for use during the winter months when natural flow will be increased by upstream storage release, to be re-impounded in Two Forks Reservoir; and, second, another power plant below Two Forks Reservoir for use of the water required to be passed for irrigation uses.

Steam standby plants of 60 to 75% capacity are considered necessary to stabilize the output from hydro-electric plants.

The report of The Engineering Board of Review, to the Denver Board of Water Commissioners in 1922, mentions a number of ultimate possibilities for power development in connection with the City water supply, with aggregate installed capacities of 134,000 horse power.

The two plants now being considered by the City are listed in the report as follows:

TABLE NO. 3

Location	Cap. Conduit Sec.-Ft.	Available Head	Installed Capacity Horse Power
Below Cheesman	500	200	9,000
Below Two Forks	1,000	250	22,500
Total -			31,500

There will also be opportunities for power development between Eleven Mile Canon Reservoir and Cheesman Lake, and also between Two Forks Reservoir and Marston Lake, about as follows:

TABLE NO. 4.

Location	Capacity of Conduit Sec.-Ft.	Available Head Ft.	Installed Capacity Horse Power
Between Eleven Mile & Cheesman	200	1,500	27,000
Between Two Forks & Marston	1,000	450	40,000
Total -			67,000

The above possibilities are all on the South Fork, except that below Two Forks Reservoir which will utilize North Fork water as well as water from South Fork.

On the North Fork, there is a fall of over 2,500 feet in about 25 miles, from Geneva Reservoir site to Two Forks site, but storage for stream regulation on this branch would have to be for power only, and independent of the City water supply and would be in conflict with lower domestic and irrigation water rights.

The Engineering Board of Review, mentioned above, considered that less than 1/3 of the installed plant capacities would be for primary power.

The total possibility for power in the district is about 100,000 installed horse-power, of which about 33,000 horse-power is primary. A large part of such power would result as a by-product in the final development of Denver's plans for a municipal water supply.

CHAPTER XI

SOUTH PLATTE RIVER SYSTEM - IRRIGATION DIVISION NO. 1

SOUTH PLATTE AND TRIBUTARIES - WATER DISTRICT NO. 64 - WATER SUPPLY

Contents

CHAPTER XI.

SOUTH PLATTE RIVER SYSTEM - DIVISION NO. 1

SOUTH PLATTE RIVER AND TRIBUTARIES - DISTRICT NO. 64, WATER SUPPLY

1. Water Supply Records.

The water supply for District No. 64 comes from the South Platte River at Balzac, from Pawnee Creek and other small intermittent streams, and from seepage return which amounts to between 40 and 50% of the total water supply of the District.

TABLE NO. 1

RUN-OFF SOUTH PLATTE RIVER AT BALZAC - MEAN DAILY SEC.-FEET

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-feet
1917	(90)	(100)	(70)	(40)	(460)	(130)	115	2,200	3,780	279	160	311	464,110
1918	365	179	191	291	371	158	54	128	793	478	238	83	200,250
1919	79	114	(100)	478	834	74	170	107	142	184	261	249	165,280
1920	275	373	261	59	24	20	186	1,050	273	237	250	256	198,390
1921	305	172	88	82	40	28	295	475	12,200	930	468	297	919,890
1922	336	123	353	332	414	412	62	94	185	158	234	192	174,370
1923	123	77	22	23	22	37	30	44	4,880	463	282	588	393,650
1924	1,070	2,020	1,010	(1,040)	1,170	1,350	1,960	1,500	5,230	194	102	267	1,016,370
1925	34	22	29	168	247	39	99	134	125	140	156	126	78,820
1926	80	15	26	25	143	28	785	1,230	2,270	741	108	138	336,220
1927	113	22	27	130	144	306	905	156	127	259	248	191	158,220
1928	81	13	37	108	359	164	136	365	1,400	921	215	151	237,390
AV'G.	246	269	185	231	352	229	400	624	2,617	415	227	237	361,910
1918-28	260	285	195	249	343	238	426	480	2,511	428	233	231	352,620

Note: Figures enclosed thus ( ) have been estimated.

Record at Balzac was started January, 1917.

2. Temperature and Precipitation.

The Weather Bureau records at Sterling are fairly representative of the mean temperature and precipitation conditions for District No. 64. Nineteen years' temperature and precipitation records, including 1928, are available at this station.

In the tables below, the last 8 years, prior to 1928, are given in detail, followed by the normals for the whole period of record:

TABLE NO. 2

AVERAGE TEMPERATURES, DEGREES FAHRENHEIT, AT STERLING

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual
1921	28.8	31.9	40.3	45.8	57.2	69.0	76.1	69.7	61.4	53.0	38.9	26.9	49.9
1922	19.2	25.6	36.7	44.6	56.2	68.0	69.6	72.5	62.8	50.7	34.7	28.4	47.4
1923	33.8	23.4	30.2	44.7	54.0	65.5	71.6	67.9	59.9	44.8	38.0	23.5	46.4
1924	17.0	32.6	26.5	45.6	50.8	63.6	68.8	70.5	58.0	50.2	37.5	15.4	44.7
1925	17.1	35.1	38.4	50.2	58.2	68.2	72.9	70.1	62.8	43.5	37.6	27.6	48.5
1926	25.8	36.6	37.0	47.0	58.6	65.8	71.5	72.3	60.0	50.8	37.0	23.8	48.8
1927	28.8	35.6	35.4	47.2	59.2	64.2	65.4	66.3	60.8	52.4	40.6	20.8	48.1
1928	30.4	30.5	39.4	45.4	59.0	60.0	70.9	69.6	60.0	48.6	34.8	24.5	47.8
Avg. 19 yrs.	24.1	28.9	38.0	46.9	56.6	67.2	72.2	70.2	62.2	49.8	37.0	24.2	48.2

TABLE NO. 3.

INCHES OF PRECIPITATION AT STERLING

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual
1921	1.01	0.42	1.15	2.04	0.82	3.96	1.02	1.42	1.03	1.12	0.06	1.03	15.08
1922	0.20	0.44	0.03	5.48	2.25	1.41	2.44	2.30	0.11	0	2.61	0.14	17.41
1923	0.02	0.20	2.42	1.45	4.76	3.10	4.63	1.45	0.42	1.81	0.23	0.60	21.09
1924	0.06	0.50	1.00	0.63	3.02	0.68	0.69	0.69	4.24	0.46	T	1.06	13.03
1925	T	0	0.50	0.84	2.22	1.98	1.18	2.75	0.67	1.97	0.37	1.37	13.85
1926	0.30	0.09	1.09	0.51	2.79	2.77	3.55	1.77	0.63	1.04	1.27	0.72	16.53
1927	0.10	0.39	2.02	3.37	1.00	3.71	2.21	2.50	1.65	0.22	0.84	0.25	18.26
1928	0.18	0.18	0.34	0.74	4.76	4.07	2.98	1.18	0.18	1.73	0.49	0	16.83
Avg. 19 yrs.	0.36	0.39	0.51	2.16	2.36	1.99	1.47	2.37	1.23	1.07	0.43	0.57	14.91

3. Seepage and Return Flow in District No. 64.

Parshall's continuous seepage records as given in Bulletin No. 279 and as adjusted, to include several drainage streams as return flow, are shown below:

TABLE NO. 4

SUMMARY OF RETURN FLOW - DIST. NO. 64 - BALZAC TO JULESBURG-DISTANCE 83 MILES
(From Parshall's Bulletin No. 279 - Mean Sec.-Ft.)

1919	Return Flow from Parshall's Table 12 (Sec. Ft.)	Parshall's Results Adjusted to Include Several Drainage Streams
Month		
July	289	346
Aug.	280	329
Sept.	251	302
Oct.	263	290
1920		
Jan.	219	302
Feb.	251	349
Mar.	269	364
Apr.	365	520
May	378	513
June	539	680
July	354	441
Aug.	252	374
Sept.	325	449
Oct.	266	336
Mean	308	400
Av'g. Apr.-Sept.	337	439
Av'g. Winter Mos.	254	328

TABLE NO. 5

R. G. HOSEA'S SERIES OF MEASUREMENTS

BALZAC TO JULESBURG - SECOND-FEET - (83 Miles)

Year	Mean s.f. for Storage Season	Mean s.f. for Irrigation Season	Mean s.f. For Year
1916	336	283	310
1917	395	398	396
1918	405	398	402
Avg.	379	360	369

TABLE NO. 6

SEEPAGE MEASUREMENTS FROM STATE ENGINEER'S REPORTS

BALZAC TO JULESBURG - 83 MILES

Year	Month	Return Flow Second-Feet
1907	Oct.-Nov.	206.20
1908	" "	300.99
1925	Nov.	370.70
1926	Nov.-Dec.	429.00
1927	Oct.-Nov.	386.80
Mean	-	338.74
Mean less 1907		371.87

TABLE NO. 7

LATE YEAR, MEAN ANNUAL SEEPAGE RETURN, DISTRICT NO. 64

Date of Measurement	Authority	Return Flow Sec.-Ft.	Remarks
Annual - 1918	R. G. Hosea	402.00	See Table No. 5 above
14 mos.-1919-20	R. L. Parshall	400.00	" " " 4 "
Nov. 1925	State Engineer	370.70	" " " 6 "
" 1926	" "	429.00	" " " 6 "
" 1927	" "	386.80	" " " 6 "
Av'g.		397.70	

The present annual average return flow in District No. 64 is probably about 400 second feet or 290,000 acre-feet per year. The distance by river from Balzac to Julesburg is 83 miles, which makes the average return for this district amount to 4.8 second feet per mile.

4. Use of Water for Irrigation in District No. 64.

Disregarding the run-off of small intermittent streams, for which no records are kept, the main water supply for this district is as follows:

TABLE NO. 8

ANNUAL AVERAGE WATER SUPPLY ENTERING DISTRICT 64

Origin of Supply	Av'g. Annual Run-off A.-Ft.	Remarks
So. Platte River at Balzac	352,620	Avg. 1918 to 1928, incl.
Av'g. Annual Seepage Return	290,000	400 Sec.-Ft. Ann. Av'g.
Total Main Av'g. Ann. Supply	642,620	A.-Ft. per year.

The 1928 report of the Division Engineer for Division No. 1 gives 224,234 acres irrigable in Dist. No. 64, of which 160,037* acres were irrigated.

The total average annual supply is, therefore, 2.86 acre-feet per irrigable acre and 4.01 acre-feet per acre irrigated in 1928. The supply is subject to allowances for needs in Nebraska in accordance with the South Platte River Compact.

* The cruise of Irrigated Area in 1930, showed 140,703 acres.

TABLE NO. 9

GROSS USE OF WATER BY CANALS FOR IRRIGATION IN DIST. NO. 64
ACRE-FEET

Year Ending Sept. 30	Run-off So. Platte R. at Balzac	Diverted by Ditches from Natural Flow	Diverted from Storage	Total Diverted For Irrig.	Total Acres Irrig. in Dist. No. 64*	Total A.Ft. Diverted per Acre Irrigated
1921	918,890	232,394	77,566	309,960	129,968	2.39
1922	174,370	190,005	*68,922	258,927	125,758	2.06
1923	393,650	193,584	*70,992	264,576	146,265	1.81
1924	1,016,370	191,665	*109,253	300,918	148,479	2.03
1925	78,820	199,136	109,296	308,432	151,133	2.04
1926	336,218	277,934	110,148	388,082	154,038	2.52
1927	158,220	171,369	130,533	301,902	157,063	1.92
1928	237,387	261,225	149,991	411,216	160,037	2.57
Av'g.	414,240	214,664	103,338	318,000	146,593*	2.17

* Not given in Div. Engineer's reports - taken from W. C.'s reports.

Mr. Parshall's Bulletin 279 (Page 67) provides a table showing the gross duty for each canal in District No. 64 for the year 1920. The average diversion for all canals for that year was 2.15 acre-feet per acre irrigated, but the duty varies from a minimum of 0.10 acre-feet per acre for the Harmony No. 2 Ditch to 9.32 acre-feet per acre for the Batten Ditch. The next lowest duty after the Batten Ditch, the record for which probably is in error, is for the Chambers Ditch, which diverted 8.87 acre-feet per acre for 225 acres of land.

The larger ditches with senior rights usually divert a little more than the average and several smaller junior ditches are perennially short of water.

Additional storage and more careful distribution of water are needed in this district.

5. Canal Diversions in District No. 64.

TABLE NO. 10

LIST OF CANALS DIVERTING FROM THE SOUTH PLATTE RIVER IN DIST. No. 64, IN THE GEOGRAPHICAL ORDER IN WHICH THEY TAKE OUT FROM THE RIVER.

Ident. No.	Name of Ditch	Years of Priority	Amount of Decrees(s.f.)	Maximum Capacity	Area Under	Area Reported Irrig. 1928
1.	So. Platte and Ext.	1872-96	137.50	150	6,500	6,000
2.	Farmers' Pawnee	1873-82	140.40	290	18,135	18,060
3.	Davis Bros.	1874-1903	139.93	140	2,700	2,269
4.	Schneider	1873-80	45.03	120	3,000	2,950
5.	Springdale	1886	62.50	88	5,000	4,879
6.	Batten	1894	25.00	25	400	290
7.	Sterling Irrigation Co.	1873	113.90	150	10,000	9,170
8.	Sterling Hereford	1894	21.00	Not operating		
9.	Sterling No. 2	1884	50.00	50	3,000	2,260
10.	Henderson & Smith	1880	12.50	25	1,600	1,570
	Cole Ext.(So.Side storage)	1902	24.00	60	2,000	750
11.	Low Line	1882	39.90	62	3,035	3,035
12.	Bravo	1893-06	60.00	100	4,000	2,941
13.	Farmers'	1895	16.00	20	1,600	1,151
14.	Iliff & Platte Valley	1883	150.00	175	10,700	10,662
15.	J. B. Ditch	1895	10.00	30	1,300	1,190
16.	Lone Tree (& Huston Tr.)	1894-5	92.00	90	2,700	1,758
17.	Powell & Dillon	1893	45.00	40	2,500	600
18.	Powell (& Blair)	1895	40.00	40	3,000	2,800
19.	S. B. Rice	1904	35.00	20	1,100	942
20.	Harmony No. 2	1897-00	212.00	150	2,900	2,583
21.	Ramsey	1894	12.00	22	2,500	900

TABLE NO. 10 (Cont.)

Ident. No.	Name of Ditch	Years of Priority	Amount of Decrees (s.f.)	Maximum Capacity	Area Under	Area Reported Irrig. 1928
22.	Chambers	1895	30.00	30	2,000	1,750
23.	Harmony No. 1	1895	252.00	250	7,000	6,540
	(Julesburg Highline)	1904	450.00	450	For Julesburg res.	
	Harmony No. 3	1903	219.00		in Harmony No. 1	
24.	Tamarack	1902	134.00	134	2,500	1,904
25.	Settlers'	1897-8	377.00	200	6,900	6,900
26.	Long Island	1897-1906	34.50	17	1,500	1,330
27.	Red Lion Supply	1895	52.00	52	4,000	1,840
28.	Peterson	1895-7	534.00	90	10,003	10,003
29.	So. Reservation	1892	25.00	35	2,000	1,606
30.	Liddle (& R & S)	1890-1	19.00	30	1,400	1,137
31.	Carlson	1894	16.00	16	2,000	1,500
32.	Cox Irrigation	1907	42.50	45	1,400	1,000
	Totals		3,668.66	3,196	128,373	112,270

TABLE NO. 11

LIST OF DECREED DITCHES NOT DIVERTING FROM SOUTH PLATTE RIVER - DIST. NO. 64

Name of Ditch	Years of Priority	Amount of Decree (S.F.)	Maximum Capacity	Area Under	Area Reported Irrig. 1928
From Simpson Draw					
Byers	1904	2.00	2	125	117
Seepage					
H. L. Greve	1907	19.94	30	380	200
Knowles - (Springs)	1895-8	60.00	6	800	85
Eaton - (Heaton Draw)	1916	3.00	2	140	140
Pawnee Creek					
Corbin No. 1	1914	6.00	2	800	225
Short Line	1920	6.00	2	320	100
Louis Creek					
Dubbs (& Spring Canon)	1921	2.00	3	160	130
Cedar Creek					
Buchanan Nos. 3 & 4	1913	8.00	5	600	415(1926)
Reagan	1926	4.00	3	150	150
Reagan & Collier	1926	2.00	2	80	80
Farley-(Farley Draw)	1914	7.00	5	320	200
Shackley-(So Platte D.)	1893	2.25	7	240	231
Crain T.D.-(Two Mi.)	1895-06	38.00	18	600	600
McWilliams-(Cottonwood)	1894	8.00	8	300	220
King-(McConley Draw)	1917	10.00	3	200	200
Tew (Res. & Ditch)	1915	1.00	3	57	57
Safford-(Ramsey Creek)	1916	2.00	2	60	57
Johnson-(Wild Duck)	1887-1906	5.50	5	566	566
Miller (Res. & Ditch)	1916	6.00	8	315	315
McRoberts-(George Ck.)	1913	5.00	4	340	250
Totals		197.69	120	6,553	4,338

6. Reservoirs in District No. 64.

There is only one reservoir of material size which diverts water in District 64. This is the Julesburg Reservoir. The Point of Rocks and Prewitt Reservoirs divert in District No. 1 but irrigate lands mainly in District No. 64 and are reported by the Water Commissioner of the latter district. There are also a few small seepage and flood water reservoirs in the district.

TABLE NO. 12

PRINCIPAL RESERVOIRS IN DISTRICT NO. 64.

Name of Reservoir	Acre-Feet Decreed	Reported Capacity
* Prewitt	32,300	32,150
** Point of Rocks	84,000	81,300
Julesburg	28,178	27,210
Totals	144,478	140,660

* The Prewitt Reservoir is decreed in District No. 1

** The Point of Rocks or North Sterling Reservoir has a decree of 73,920 acre-feet from the South Platte River in District No. 1; 2,000 acre-feet from Cedar Creek in District No. 64, and an undetermined amount from Pawnee Creek, the total storage from all sources not to exceed 84,000 acre-feet, or a storage of 49 ft. in depth over the outlet.

7. South Platte River Compact.

The rights to the use of the waters of South Platte River in District No. 64, and in Nebraska are defined in the South Platte River Compact, which was ratified by Congress and became effective in 1926.

The distribution of water for irrigation in District No. 64 under the compact, is subject to demands of the Western Irrigation Canal in Nebraska, under its priority date of June 14, 1897, during the irrigation season, and to the future preferred right for Colorado to store an additional

35,000 acre-feet during the non-irrigation season and to the right of the Perkins County canal to divert in the future up to 500 sec. feet during the non-irrigation period, for storage and use in Nebraska.

The Compact Allowance for the Western Irrigation Canal.

The Western Irrigation Canal in Nebraska is entitled to divert, between April 1st and October 15th, as great a part of 120 sec.-feet as can be put to beneficial use, with date of priority as of June 14, 1897. This demand is to be met, when necessary, at the expense of junior appropriators in District 64, of which there are 9 with decrees totaling 1856.5 second-feet. These junior appropriators may in turn call upon upper districts where water is being diverted by rights junior to them, to replace reductions made in favor of the Western Canal.

The Water Commissioner of District 64 states that he distributes the river flow to the Western Canal in the order of its priority, the same as if it were a Colorado Canal.

The Compact Allowance for Storage.

The compact first recognizes the preferred right of Colorado to divert an additional 35,000 acre-feet of water for storage in District No. 64 between October 15th and April 1st of the succeeding year and then allows the proposed Perkins County canal to divert, for storage in Nebraska, all of the remaining river flow up to 500 sec.-feet during the non-irrigation season.

8. Surplus for Storage at Julesburg.

That portion of the South Platte River flow at Julesburg, which could be diverted upstream in Colorado after the Interstate Compact obligations are met, was computed for the representative period, 1918 to 1928, inclusive.

The undivertable flow available for Colorado at Julesburg was taken as the excess of the seepage return to the river, below the point of minimum flow, over the average canal diversions below that point. The average point of minimum flow on the river was found to be at Sedgwick, for the period May 1st to October 15th, and at Balzac from October 16th to April 30th of the succeeding year.

The average annual flow at Julesburg that is undivertable upstream in Colorado was found to be 86,809 acre-feet, but the greater part of this flow is divertable for Nebraska's needs.

TABLE NO. 13.

RUN-OFF SOUTH PLATTE RIVER AT JULESBURG - MEAN DAILY SEC.-FEET

DIST. No. 64

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-Feet
1902	-	-	-	-	-	-	30	27	22	18	2	160	-
1903	133	39	(600)	-	-	-	296	32	13	2	36	4	-
1904	5	46	(340)	(280)	(260)	70	18	124	1,705	270	103	64	197,900
1905	128	151	(280)	(300)	(320)	514	1,590	6,090	5,620	248	744	52	969,030
1906	90	369	(450)	(600)	(900)	(1,800)	645	322	61	52	44	66	324,700
1907	695	(1,600)	-	-	-	-	-	-	-	-	-	-	-
1908	-	-	-	-	-	-	-	(65)	39	46	53	52	-
1909	(65)	(142)	(180)	(240)	(300)	(650)	1,080	456	2,740	1,360	155	1,720	545,500
1910	1,070	(1,100)	(800)	(850)	(1,000)	910	276	45	11	6	16	17	366,500
1911	21	17	194	689	344	140	27	27	17	9	48	15	Min.93,000
1912	23	26	19	112	279	345	282	111	25	57	565	437	137,700
1913	366	342	-	-	-	-	960	213	11	15	21	23	-
1914	21	53	-	-	-	-	2,070	5,910	4,460	190	234	446	-
1915	336	783	-	-	-	-	1,240	3,080	2,370	115	247	148	-
1916	781	982	979	-	-	403	61	75	50	26	29	36	-
1917	111	198	(195)	298	660	515	432	1,780	4,720	521	34	76	571,590
1918	541	393	486	520	(600)	(436)	143	112	130	353	286	210	253,640
1919	482	443	506	407	(540)	522	516	307	48	22	20	148	238,060
1920	519	(450)	299	274	248	342	707	1,450	321	91	68	363	310,830
1921	346	287	293	218	181	199	256	283	10,600	352	53	118	787,590
1922	521	528	486	502	712	688	233	213	27	20	12	12	237,280
1923*	18	116	158	317	312	259	213	313	6,160	445	351	320	537,340
1924*	1,170	2,330	1,610	1,350	1,670	1,440	2,070	1,480	5,150	45	19	173	1,111,770 Max.
1925	280	380	329	(340)	(580)	383	114	34	45	24	25	34	153,280
1926	117	336	391	499	478	270	419	1,250	1,910	669	111	105	394,960
1927	400	394	364	422	455	693	1,310	350	166	31	218	75	293,320
1928	357	365	343	386	425	414	65	243	1,520	820	270	28	316,260
Avg. s.f.	344	475	443	453	540	550	602	938	1,843	223	145	189	
Avg.A.F.	21150	28240	27230	27850	30000	33800	35820	57650	109700	13700	8900	11210	405,300
1917-28 s.f.	405	518	455	461	572	513	540	651	2,566	283	122	138	433,500
1918-28	432	548	479	476	564	513	550	549	2,371	261	130	144	
A.F.1918-28	26600	32600	29500	29300	31300	31600	32700	33800	141000	16100	8000	8580	421,000

* Record kept at Ovid instead of Julesburg for these years.
Figures enclosed thus ( ) indicate estimated record.

The following table gives summaries in acre-feet of the distributions that could have been made of the Julesburg flow from 1918 to 1928, inclusive.

TABLE NO. 14

ANNUAL SUMMARIES - DISTRIBUTION OF FLOW AT JULESBURG
ACRE-FEET

Year Ending Sept. 30	Run-off So. Platte R. at Julesburg	Western Canal could have Diverted	Dist. 64 could have Diverted Additional for Storage	Perkins Canal could have Diverted	Upstream Surplus for Colo.	Surplus not Divertable (for Colo. or Nebr.)
1918	253,640	28,942	35,000	116,380	72,235	1,083
1919	238,060	21,680	35,000	111,160	65,309	4,911
1920	310,830	28,678	35,000	81,190	160,570	5,392
1921	787,590	32,110	35,000	46,870	669,100	4,510
1922	237,280	14,012	35,000	129,490	54,770	4,008
1923	537,340	34,672	33,830	36,130	427,390	5,318
1924	1,111,770	25,960	35,000	166,460	879,200	5,150
1925	153,280	14,840	35,000	90,260	9,730	3,450
1926	394,960	33,780	35,000	84,280	238,120	3,780
1927	293,320	26,830	35,000	102,760	123,690	5,040
1928	316,260	29,570	35,000	90,130	160,720	840
Avg.	421,303	*26,460	34,894	95,919	260,075	*3,954

* All of the undivertable surplus occurred early in April each year and could have been diverted by the Western Canal, above normal irrigation requirements. This addition would bring the possible diversions of the Western Canal up to an annual average of 30,414 acre-feet.

District 64 was allowed to divert up to 350 sec.-feet during the storage season, between Iliff and Crook, until 35,000 acre-feet had been diverted.

9. Reservoir Sites for Additional Storage in Dist. No. 64.

The South Platte River Compact gives District No. 64 the preferred right to divert 35,000 acre-feet for storage in addition to present uses.

The Julesburg Reservoir with a decreed capacity of 28,178 acre-feet is the only one which diverts from the river in the district. Its practical capacity is limited to between 23,000 and 24,000 acre-feet on account of danger to the dam from wind action and there seems little likelihood of its being enlarged.

TABLE NO. 15

PRINCIPAL RESERVOIR FILINGS IN DISTRICT NO. 64

No.	Reservoir	Filing Number	Fills From	Capacity Acre-Ft.	Remarks
1.	Pawnee	4077	Pawnee Creek & So.Pl.R.	31,000	Under No.Sterling Inlet
2.	Springdale	4077	Spr'dale " " "	3,800	" " "
3.	South Side	4936	So. Platte River	10,000	Same loc.as Sedgwick Res.
4.	Pawnee Buttes	5440A	Pawnee & Igo Creeks	15,250	8500A. Carey Act. Project
5.	Ogallalah	6086	So. Platte River	23,000	Diverts below Perkins Co. Canal
6.	Sedgwick Irr. Sys.	7850	" " "	17,600	9 Reservoirs
7.	" " "	8399	" " "	3,200	Reservoir No. 9
8.	" " "	9291	" " "	1,500	" No. 10

Note: In addition to the above, there are two old filings on Upper Pawnee Creek, which have lapsed.

Projects Nos. 1 and 2, of the above table are for additional storage under the North Sterling Inlet Canal which feeds the Point of Rocks Reservoir, and would take water from District No. 1. These filings have lapsed and there is not much probability of the reservoirs being constructed in the near future.

Project No. 3 for the South Side Reservoir has lapsed and has evidently been superseded by the later Sedgwick filings.

Project No. 4, The Pawnee Buttes, was to have been supplied from flood and "underflow" from North Pawnee and Igo Creeks and would have little effect on the water supply of District No. 64. No supplemental statement has been filed with the State Engineer.

Project No. 5, the Ogallalah filing, would divert about four miles downstream from the proposed heading for the proposed Perkins County Interstate Canal. The inlet canal would extend for 45 miles to the reservoir site, south of the town of Ogallalah in Nebraska. This filing has evidently been superseded by the Perkins County proposition. It is considered to have lapsed as no supplemental statement has been filed with the State Engineer.

Filings for Nos. 6, 7 and 8, constituting the Sedgwick Irrigation system, have lapsed, but appear to contain the elements of the most feasible scheme for additional storage in District No. 64.

The proposed heading for the inlet canal is located on the South side of the South Platte River about 1½ miles southeast of Iliff, Colo. This proposed system would consist of eleven small reservoirs, the largest being of 13,000 acre-feet capacity.

A summary of the three related filings is as follows:

Inlet Canal - Capacity 280 sec.ft., 30 miles long.
11 Reservoirs, total capacity 22,300 acre-feet.
Irrigable area - 19,000 acres of land in Logan and Sedgwick Counties, Colorado.
Total estimated cost - $595,000.

See Chapter XIII for new plans and estimate of cost for this proposed Sedgwick Storage system.

CHAPTER XII.

POSSIBILITIES FOR TRANS-MOUNTAIN DIVERSIONS FROM UPPER COLORADO RIVER INTO SOUTH PLATTE BASIN

Contents

CHAPTER XII.

POSSIBILITIES FOR TRANS-MOUNTAIN DIVERSIONS UPPER COLORADO RIVER INTO SOUTH PLATTE RIVER BASIN

1. Present Diversions.

Three comparatively small diversions are now operating to bring water from the Upper Colorado River watershed to the South Platte River Basin during the period May to September, inclusive.

These diversions are summarized as follows:

TABLE NO. 1

PRESENT DIVERSIONS FROM UPPER COLORADO TO SOUTH PLATTE BASIN

Diversion	From	To	Avg. Ann. Diversions Acre-Feet
Grand River	Colorado River	Cache la Poudre R.	12,300*
Berthoud Pass	Fraser "	Clear Creek	685
Boreas Pass	Blue "	So. Platte River	600

* Average 1909-1928, incl.

The three ditches discharge across the continental divide in open cuts. There appears little likelihood of material increase over past diversions, except in the case of the Grand River Ditch where improvements are proposed or under way, which should practically double the annual yield of the collection ditches.

2. Grand River Ditch Extension.

Stream records of the run-off from the drainage area commanded by the Grand River collection ditches are lacking, but comparison with the yields from similarly situated areas indicates that the ditches are diverting but a portion of the water available. This condition has been due to leaky ditches and to lack of storage facilities for storing the run-off until needed for irrigation.

The Water Supply and Storage Co., owners of the Grand River diversion works, have constructed a reservoir in Long Draw to hold between 5,000 and 6,000 acre-feet of water and are contemplating some improvements and extensions to their collection ditches.

In the U. S. Bureau of Reclamation Report on Cache la Poudre Investigations of May, 1928, it was estimated (Page 145) that the yield of the area above the two collection ditches for the months of May to September, inclusive, should average 36,000 acre-feet. It was evidently assumed that the main ditch had been extended to Baker Gulch. Late year actual diversions were taken at 13,000 acre-feet, which is the average for the period 1918 to 1928, inclusive. At 80% efficiency and with adequate storage the diversions could be made to total 28,800 acre-feet, or an increase of 15,800 acre-feet over present diversions. With a short extension of the South Side Feeder, the total annual diversions could be increased to 30,000 acre-feet.

Robert Follansbee in U.S.G.S. Water Supply Paper 617 estimates that the extension of the main ditch for 7 miles to Baker Gulch will intercept 12,000 acre-feet in addition to present diversions.

A conservative assumption seems to be that the Grand River Ditch will eventually at least double its past average diversions, which, for the period 1917 to 1928, inclusive, were as follows:

TABLE NO. 2

MEAN GRAND RIVER DITCH DIVERSIONS - 1917-1928 - ACRE-FEET

1917-1928	May	June	July	Aug.	Sept.	TOTAL
Av'g. A.Ft.	1,230	4,760	4,980	1,410	180	12,560

3. Grand Lake Project.

There is a considerable surplus of water originating in the

Upper Colorado or Grand River water shed, above Grand Lake, that could be diverted to the eastern slope for irrigation and power uses.

The most extensive scheme proposed is to carry the run-off from the Upper Colorado and from the area above Monarch, into Grand Lake by means of canals and to connect the latter lake by tunnel, with either the headwaters of the Big Thompson River or St. Vrain Creeks. The tunnel to the Big Thompson would be about 11 miles long and that to the St. Vrain 14 miles.

Grand Lake has a surface area of 530 acres and it may be possible to secure control of this surface for a depth of 20 or 30 ft. by diking, without much damage to the town of Grand Lake and adjacent summer resorts. This control would permit Western slope storage of from 10,000 to 15,000 acre-feet for regulating the flow into the tunnel at times of excess run-off.

The Shoshone Power Plant of the Public Service Co., on the Colorado River, 6 miles above Glenwood Springs, has a decree for 1250 second feet. The record at Glenwood Springs shows that there is available for the plant 700 second feet 90% of the time and 1260 second feet 50% of the time, and that the average run-off exceeds 1250 second feet ordinarily only during the months of April to September, inclusive.

There will be available for the Grand Lake trans-mountain diversion the run-off from the Colorado River above Grand Lake with a drainage area of 101 square miles, from Grand Lake water shed of 79 square miles, and from the Monarch Lake area of 76 square miles in excess of requirements to meet the demands of the Shoshone power development and present decreed rights for other uses above same.

Stream flow records have been kept for the Colorado River at Glenwood Springs for the 29 year period from 1900 to 1928, inclusive. A summary of those records in mean daily second-feet is given below.

TABLE NO. 3

RUN-OFF COLORADO (GRAND) RIVER AT GLENWOOD SPRINGS

IN MEAN DAILY SECOND-FEET

Drainage Area = 4,560 sq. mi., - Elev. = 5,747.

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual A.-Ft.	% Mean	
1900	(1,293)	(1,009)	(759)	825	816	1,150	1,760	9,970	13,300	3,110	1,250	826	2,176,000	95	
1901	830	839	688	693	765	878	1,850	11,800	10,400	4,470	2,030	1,130	2,200,000	96	
1902	979	932	817	721	775	803	1,430	8,390	6,330	1,780	1,000	1,000	1,510,000	66	Min.
1903	1,270	700	646	534	547	738	1,690	5,910	12,600	5,020	1,600	1,420	1,970,000	86	
1904	1,340	958	595	583	619	911	2,470	7,980	10,900	4,860	2,380	1,820	2,140,000	93	
1905	1,290	854	599	674	591	843	1,600	7,070	14,900	3,770	1,690	1,300	2,120,000	92	
1906	1,090	1,010	603	610	685	1,050	2,800	9,750	13,100	6,390	2,800	3,460	2,620,000	114	
1907	1,720	1,090	801	686	902	1,570	3,300	6,960	16,400	11,100	3,420	1,800	3,010,000	131	Max.
1908	1,460	1,000	750	858	703	1,020	2,150	3,880	8,420	3,360	2,050	984	1,610,000	70	
1909	889	777	678	797	685	894	1,490	6,740	20,400	8,690	3,010	2,440	2,860,000	124	
1910	1,460	1,110	772	841	730	1,860	3,190	6,760	7,690	2,230	1,330	1,370	1,720,000	75	
1911	988	903	665	701	749	942	1,790	7,910	11,700	5,020	1,930	1,280	2,090,000	91	
1912	1,440	915	653	768	754	805	1,410	7,510	19,100	9,490	3,240	1,660	2,890,000	126	
1913	1,470	1,090	745	725	674	705	2,980	7,020	7,120	3,220	1,430	1,390	1,720,000	75	
1914	1,410	1,060	682	733	754	1,010	2,600	12,530	18,700	5,830	2,710	1,700	3,000,000	130	
1915	1,640	979	618	627	668	744	2,290	4,620	9,530	4,440	1,550	1,020	1,730,000	75	
1916	1,120	806	694	722	686	1,250	2,400	7,390	11,800	4,870	2,960	1,770	2,210,000	96	
1917	1,570	1,050	785	694	736	783	2,900	6,870	19,900	9,490	2,520	1,520	2,940,000	128	
1918	1,180	1,160	965	826	882	1,280	2,120	9,210	19,600	5,330	1,820	1,680	2,780,000	121	
1919	1,450	1,140	846	764	723	1,030	2,630	7,420	5,370	2,340	1,490	1,150	1,600,000	70	
1920	1,030	1,010	840	725	691	764	1,260	11,800	16,600	5,850	2,520	1,620	2,710,000	118	
1921	1,330	1,140	825	806	700	1,250	1,730	10,200	19,400	5,550	2,980	1,910	2,880,000	125	
1922	1,140	1,060	1,060	814	844	1,230	1,720	7,460	11,200	3,090	1,800	1,250	1,970,000	86	
1923	912	864	796	762	739	764	1,560	8,230	15,100	6,780	3,030	1,700	2,490,000	108	
1924	1,800	1,280	856	850	844	840	2,510	7,970	13,200	3,630	1,260	1,030	2,180,000	95	
1925	1,370	1,140	734	735	735	1,270	2,760	6,450	7,390	3,330	1,700	1,700	1,770,000	77	
1926	1,480	1,090	790	739	702	890	3,310	9,650	14,400	6,260	2,240	983	2,570,000	112	
1927	1,020	957	745	706	700	860	2,280	11,400	11,600	4,820	2,750	1,620	2,390,000	104	
1928	1,520	1,330	1,010	954	815	1,190	2,180	13,700	13,300	6,800	2,200	1,450	2,816,000	122	
Av'g.	1,293	1,009	759	740	732	1,011	2,212	8,363	13,085	5,204	2,162	1,517	2,299,000	Mean	

Apr.-Sept., Incl. Run-off = 1,967,200 A.Ft. = 86% Annual.

Note: Figures enclosed thus ( ) indicate estimated quantities.

Available run-off records for the Colorado River near Grand Lake and for Grand Lake outlet are as follows:

TABLE NO. 4

RUN-OFF COLORADO (GRAND) RIVER NEAR GRAND LAKE
MEAN SECOND-FEET

Drainage Area = 101 sq. mi., - Elev. = 8,400

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual Acre-feet
1905	42.3	(35)	(25)	(20)	(18)	(18)	35.8	291	816	254	67.5	35.7	100,000
1906	34.2	31.1	(22)	(20)	(20)	(20)	76.8	388	612	278	101.	83.8	102,000
1907	62.9	42.5	30.3	22.8	19.1	31.1	104.	235	764	603	132.	52.3	127,000
1908	46.6	24.4	13.9	16.8	18.9	24.3	87.7	145.	319	162	96.3	36.5	60,000
1909	24.6	16.4	15.2	15.6	13.7	16.0	19.7	280	944	465	104	74.3	120,000
1911	(35)	(25)	(25)	(30)	(28)	(30)	68.	560	890	200	82	50	122,000
1912	(55)	(45)	(30)	(20)	(20)	(20)	31.8	273	770	397	132	61.6	112,000
1913	(50)	(40)	(30)	(25)	(25)	(25)	82.2	329	389	149	61.8	74.5	77,300
1914	68.0	50.0	(35)	(25)	(25)	26.	82.2	563	908	265	94.0	73.0	134,000
1915	65.0	40.	(25)	(18)	(18)	20.	123.	200.	350.	188	78.8	58.4	71,000
1916	54.6	46.1	36.8	36.4	34.3	39.5	122.	285	443.	171.	95.0	74.9	87,000
1917	66.0	51.4	40.8	31.9	28.4	27.6	71.7	220.	930.	436.	91.0	56.1	124,000
1918	41.4	39.9	31.6	19.4	13.5	21.1	61.9	407.	943.	178	65.3	50.2	113,000
Av'g.	49.7	37.4	27.7	23.1	21.7	24.5	74.4	321.	698.	288.	92.4	60.1	103,800
(a) % Normal	103	97	94	98	100	98	103	90	112	120	111	112	
Normal Av'g.	48.3	38.6	29.5	23.6	21.7	25.0	72.2	357	624	240	83.2	536	
Normal A.Ft.	2970	2300	1810	1450	1200	1540	4300	22000	37200	14800	5120	3180	97,900

Normal A. Ft. April 1 - Sept. 30 - - - - - - - 86,600 = 88½% Annual.

(a) Based upon 29 year record at Glenwood Springs.

TABLE NO. 5

RUN-OFF GRAND LAKE OUTLET AT GRAND LAKE
MEAN DAILY SEC.-FT. PER MONTH

Drainage Area = 79 sq. mi. - Elev. = 8,369

Year Ending Sept.30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual Acre-feet
1905	36.3	13.4	(10)	(9)	(9)	(10)	22.7	168	785	267	76.2	23.7	86,100
1906	14.7	(11)	(10)	(8)	(7)	(6)	40.6	296	628	402	107.	79.2	97,400
1907	48.5	21.0	11.2	8.3	9.4	13.3	42.9	147	685	698	175.	41.3	115,000
1908	34.9	10.4	3.4	6.9	6.6	6.2	47.3	119	424	231	174.	44.0	67,000
1909	21.5	13.9	12.0	10.7	9.9	7.3	11.0	92.7	805	491	127	79.8	102,000
1911	(38)	(20)	(17)	(12)	(12)	11.5	35.4	282	632	268	79.3	39.6	87,400
1912	56.3	19.6	(12)	(10)	(11)	(11)	(13)	140	830	520	183.	42.3	112,000
1913	28.7	15.6	(10)	(9)	(8)	(7)	32.3	281	398	183	56.6	45.0	65,100
Av'g.	34.9	15.6	10.7	9.2	9.1	9.0	30.7	191	648	383	122.	49.4	91,500
(a) % Normal	100	95	91	98	98	97	99	85	106	123	113	118	
Normal Av'g.	34.9	16.4	11.8	9.4	9.3	9.3	31.0	225	611	311	108	41.9	
Normal A.Ft.	2150	976	726	578	516	572	1840	13800	36300	19100	6640	2490	85,700

Normal A. Ft. April 1- Sept. 30 - - - - - - - - 80,200 =
94% Annual.

Note: ( ) indicates estimated quantities.

(a) Based upon 29 year record at Glenwood Springs.

The normal run-off from the total 180 square miles tributary to the Colorado River above Grand Lake and to Grand Lake, for the months April to September, inclusive, has been estimated by comparison with the 29 year record at Glenwood Springs, and by adding the means of the Grand River Ditch diversions for these months:

TABLE NO. 6

SUMMARY - NORMAL RUN-OFF FROM 180 SQ. MILES
COLORADO RIVER NEAR GRAND LAKE AND GRAND LAKE OUTLET

Mean Second-Feet

Normal Run-off From	Apr.	May	June	July	Aug.	Sept.	Run-off Acre-feet
Colo.R. near Grand L.	72	357	624	240	83	54	86,600
Grand L. Outlet	31	225	611	311	108	42	80,200
Grand R. Diversion	0	20	80	81	23	3	12,560
Total	103	602	1,315	632	214	99	
Total Acre-Ft.	6140	37030	78230	38880	13170	5850	179,360
% Total	3	21	44	22	7	3	100

Total April-Sept. run-off per sq. mile = 996 acre-feet.

The Monarch Lake area will require a collection ditch about 26 miles long. It will intercept the drainage from an area comprising 76 square miles and similarly situated to the drainage area above Grand Lake in exposure and altitude. The normal April - September run-off above Monarch Lake is estimated at 1,000 acre-feet per square mile or 76,000 acre-feet distributed as for the Grand Lake area as follows:

TABLE NO. 7

ESTIMATED APRIL-SEPTEMBER RUN-OFF MONARCH LAKE AREA

Monarch Lake Area	April	May	June	July	Aug.	Sept.	Total
Av'g. Acre-Ft.	2,280	15,960	33,440	16,720	5,320	2,280	76,000
Av'g. Sec.-Ft.	38	260	562	272	87	38	

TABLE NO. 8

SUMMARY OF NORMAL FLOWS FROM AREAS TRIBUTARY TO PROPOSED GRAND LAKE TRANS-MOUNTAIN DIVERSION, AND BALANCE FOR GRAND LAKE DIVERSION

Acre-Feet

Av'g. Run-off From	April	May	June	July	Aug.	Sept.	Total
Colo.R. near Grand L.	4,300	22,000	37,200	14,800	5,120	3,180	86,600
Grand R. Ditch	0	1,230	4,760	4,980	1,410	180	12,560
Grand Lake Outlet	1,840	13,800	36,300	19,100	6,640	2,490	80,170
Monarch Lake Area	2,280	15,960	33,440	16,720	5,320	2,280	76,000
Total - - - - - -	8,420	52,990	111,700	55,600	18,490	8,130	255,330
Less for prior irrig. rts. and pres. and future Grand R. Ditch diversions	460	3,750	11,570	11,940	4,190	820	32,730
Bal. for Grand Lake Trans-Mtn. diversions	7,960	49,240	100,130	43,660	14,300	7,310	222,600
Bal. at 80% Efficiency	6,370	39,390	80,100	34,930	11,440	5,850	178,080

The proposed Grand Lake trans-mountain diversion considered without regard to other future trans-mountain diversions (except the Grand River Ditch) and future irrigation requirements in the upper Colorado River drainage area, would provide an average water supply during the months of April to September, inclusive, each year of about 178,000 acre-feet with 80% efficiency in the diversion system.

It probably will not be feasible to construct a diversion tunnel large enough to take care of the available peak flows which occasionally reach as high as 3,000 second-feet in June so that considerable storage will be required on the western slope to regulate the run-off to a feasible tunnel capacity.

For a 1,000 second-feet tunnel the required storage for years of which there are detail records of run-off, would be as follows:

TABLE NO. 9

GRAND LAKE STORAGE REQUIRED ON WESTERN SLOPE WITH 1,000 SEC.-FT. TUNNEL

Year	Total Acre-Feet storage required
1905	44,900
1906	26,900
1907	63,200
1908	1,200
1909	73,700
1910	No record
1911	24,000
1912	53,600
1913	8,600
Avg.	37,000

The average May, June, July run-off of the Colorado River at Glenwood Springs for the above period is 105% of that for the period of record or from 1900 to 1926, inclusive.

With only 15,000 acre-feet storage in Grand Lake, the average amount of water divertable to the western slope through a 1,000 second-feet tunnel would be reduced by 24,500 acre-feet.

Channel storage on the eastern slope will also be required for proper control of such trans-mountain diversions.

4. Frasor River Project.

The proposed Frasor River trans-mountain diversion is covered by a filing by the City of Denver. The proposed plan would bring the run-off from 107 square miles tributary to the Fraser River, to the source of South Boulder Creek by means of about 36 miles of collection ditches and the six mile Moffat pilot tunnel, which parallels the railroad tunnel at a distance of 75 feet.

Continuous records are available for the run-off of the Fraser River at the west portal of the tunnel, from 1911 to 1928, inclusive. The drainage area above the gaging station is 28 square miles from 9,100 to 13,300 feet in elevation.

At 80% efficiency, the average annual yield from the 107 square miles commanded, is estimated at about 90,400 acre-feet for the months of April to September inclusive.

About 10,000 acre-feet storage capacity would be required on the western slope, for a tunnel capacity of 1,000 second-feet. With a tunnel capacity of 1500 sec. ft., as proposed by the City of Denver, very little western slope storage would be required.

5. Williams River Project.

This project has been surveyed by the City of Denver and is an integral part of the plans for future water supplies for the city.

This proposed trans-mountain development will require 22 miles of collection ditches to bring the run-off from 29 square miles of the drainage area tributary to the Williams River, to the west end of the proposed tunnel on Bobtail Creek at an elevation of 10,300 feet. The tunnel will be three miles long and will terminate in upper west Clear Creek.

There are no stream flow records for the upper Williams River, but a comparison with the recorded flow from the Fraser River at West Portal, indicates that the average yield from the Williams River area, for the months of April to September will be about 32,000 acre-feet annually. At 80% efficiency, the average annual yield available for trans-mountain diversion would be 25,600 acre-feet.

6. Blue River Project.

The proposed Blue River diversion is the third scheme covered by appropriations by the City of Denver of Colorado River water, and is the most extensive one contemplated.

The required tunnel would be 22.8 miles in length, from the confluence of Blue River, Snake River and Ten Mile Creek near Dillon, to Geneva Creek, near Grant on the North Fork of the South Platte. The drainage area intercepted by the three tributaries is 328 square miles.

Records of the Blue River at Dillon have been kept from Oct. 1, 1910 to Sept. 30, 1919.

At 80% efficiency, the average annual combined yield of the three streams for the months of April to September, inclusive, is 185,200 acre-feet.

The average distribution by months would be as follows:

TABLE NO. 10

AVERAGE MONTHLY BLUE RIVER TRANS-MOUNTAIN DIVERSIONS POSSIBLE
Acre-Feet

Possible trans-Mt'n diversions of Blue River at	April	May	June	July	Aug.	Sept.	Total
Dillon	6,900	41,800	76,800	37,000	15,000	7,700	185,200

TABLE NO. 11

YEARLY VARIATION OF APRIL-SEPTEMBER RUN-OFF - 1911-1919

(80% combined Blue River, 10 Mile Creek & Snake River at Dillon)

Year	Acre-ft. Diversion	Year	Acre-ft. Diversion
1911	187,500	1916	164,000
1912	232,000	1917	196,000
1913	153,500	1918	235,000
1914	266,000	1919	120,000
		Avg.	189,000

An examination of the records of daily flow at Dillon shows that occasionally the combined run-off of the three streams reaches over 3,000 second-feet in June. For a tunnel of 1,200 second-feet capacity, some storage would be required on the western slope above Dillon.

For the average year of 1911 only about 7,000 acre-feet storage was required. In the wettest year of record, 1914, 69,000 acre-foot of storage would have been required, and for the extremely dry year of 1919 no storage would have been needed.

7. Summary of Proposed Trans-Mountain Diversions from Upper Colorado River into South Platte River Basin.

TABLE NO. 12.

SUMMARY MEAN MONTHLY POSSIBLE TRANS-MOUNTAIN DIVERSIONS FROM UPPER COLORADO RIVER INTO SOUTH PLATTE RIVER BASIN - ACRE-FEET

Proposed Diversion	April	May	June	July	Aug.	Sept.	Total
Grand R.Ditch Extension*	0	1,230	4,760	4,980	1,410	180	12,560
Grand Lake	6,370	39,390	80,100	34,930	11,440	5,850	178,080
Fraser River	2,710	17,200	40,700	18,100	7,220	4,520	90,450
Williams River	1,020	4,850	11,000	5,370	2,050	1,280	25,570
Blue River	6,900	41,800	76,800	37,000	15,000	7,700	185,200
Total	17,000	104,470	213,360	100,380	37,120	19,530	491,860

* Estimated increase over present average diversions.

Trans-mountain diversions ordinarily are limited to the April-September period on account of the right of the Shoshone Power Plant above Glenwood Springs to a flow of 1,250 second-feet, and also due to the high altitudes and, consequently, low temperatures.

The above average diversions could be made without infringing on vested irrigation rights in Colorado, and without reducing the supply at the Shoshone Power Plant below its decree, except to the extent of about 3,700 acre-feet in September.

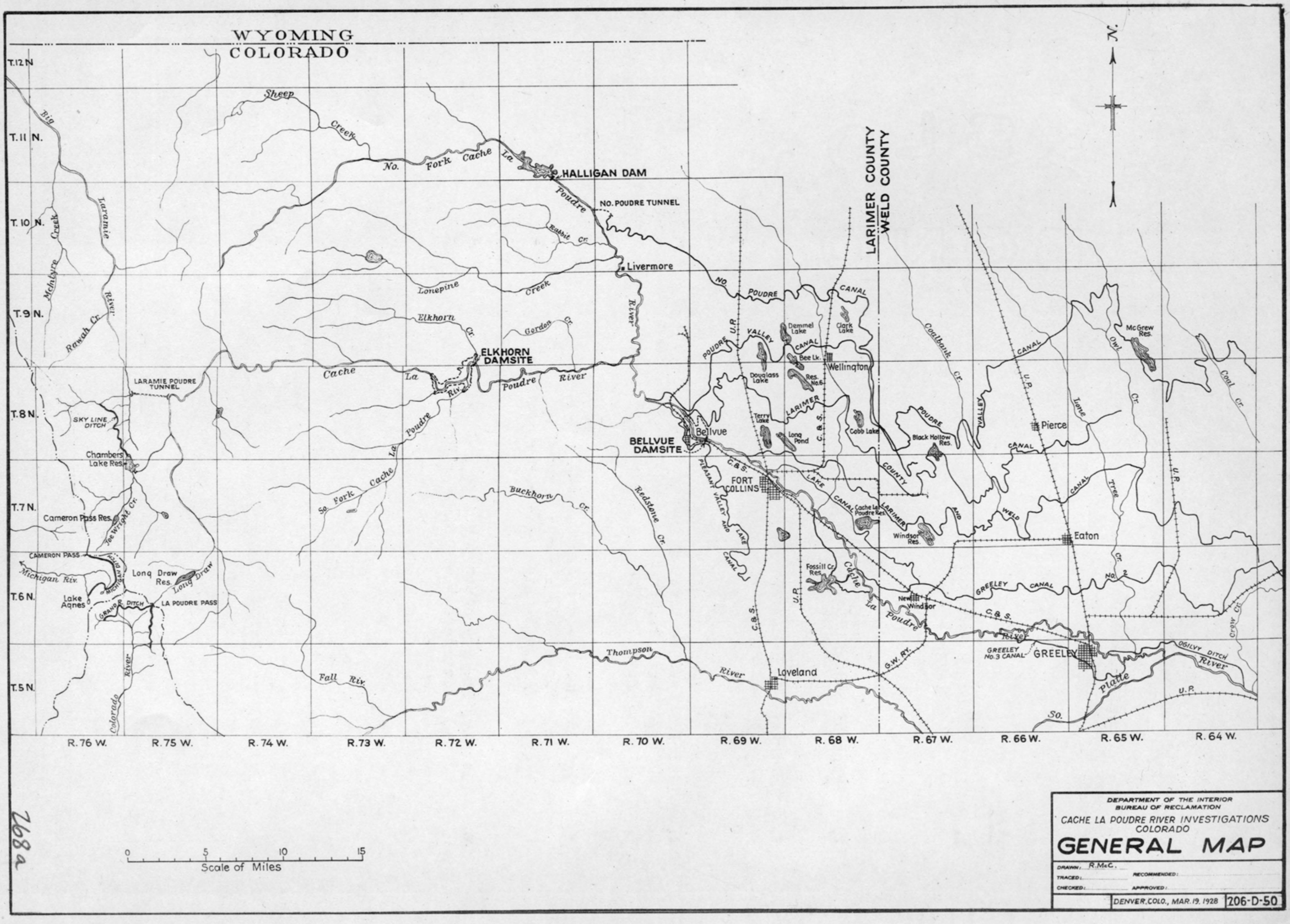
A report by the State Engineer's Office on Present and Proposed Utilization of the Colorado River in Colorado, October, 1929, gives in Table 17 the future irrigation possibilities on the Colorado River above Glenwood Springs as approximately 120,000 acres.

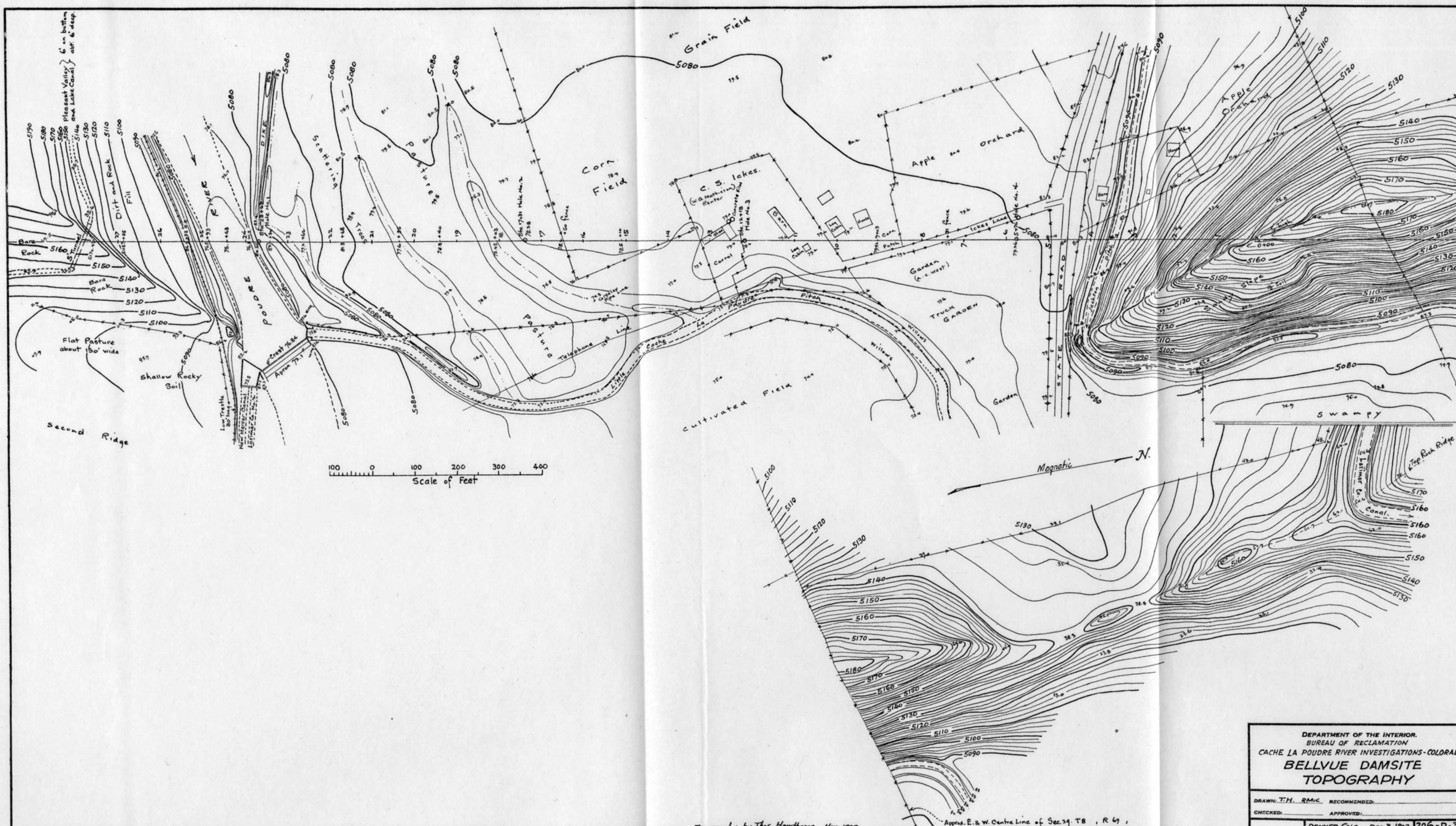
With this area under irrigation and with assumed prior rights over diversions to the South Platte Basin, the total average trans-mountain diversions shown in Table 12 above would be reduced by 13,400 acre-feet in August and by 14,500 acre-feet in September.

CHAPTER XIII.

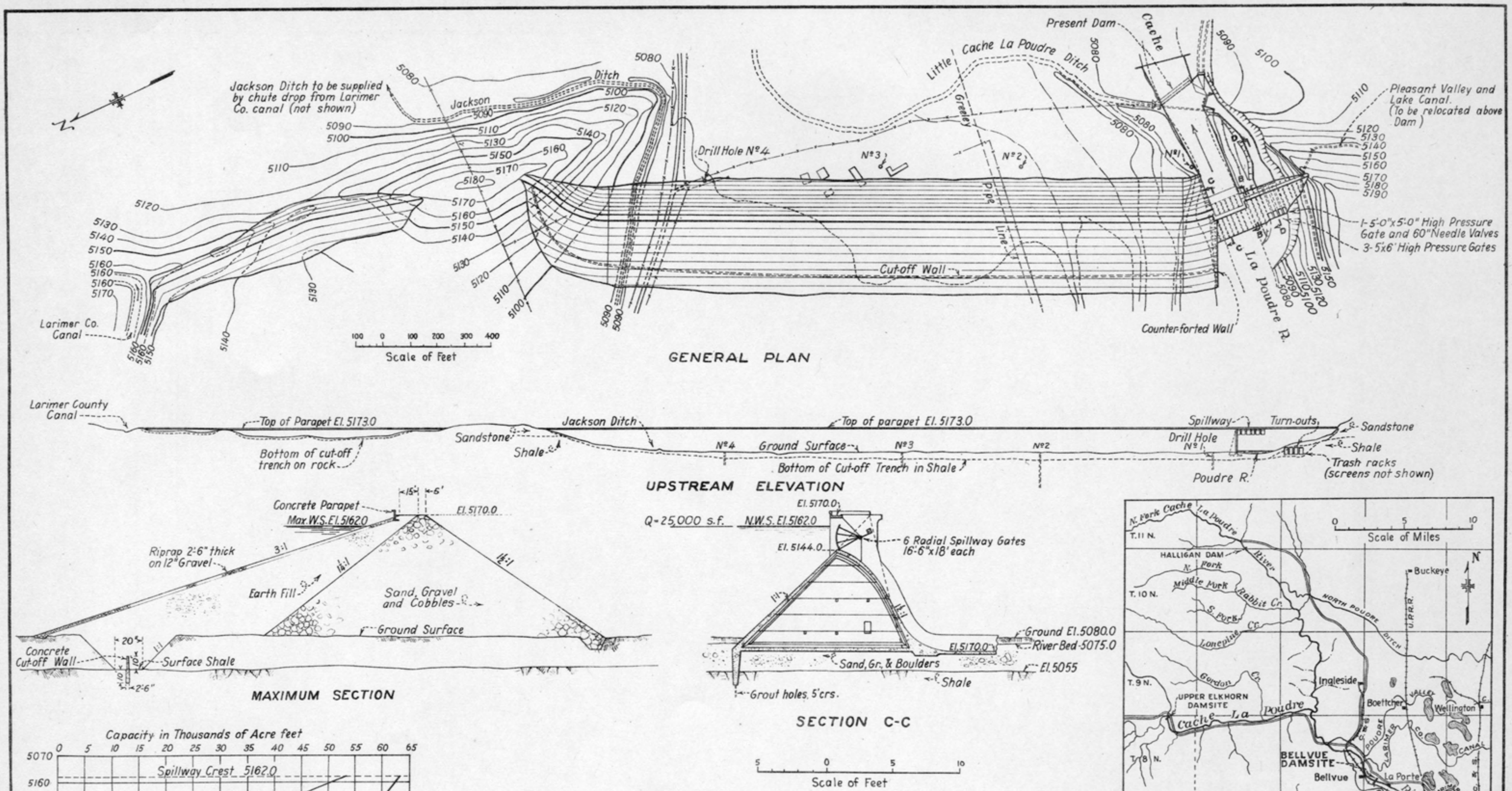
RESERVOIRS FOR ADDITIONAL STORAGE IN SOUTH PLATTE BASIN

Contents


WYOMING
COLORADO
T.12 N.
T.11 N.
T.10 N.
T.9 N.
T.8 N.
T.7 N.
T.6 N.
T.5 N.
R.76 W.
R.75 W.
R.74 W.
R.73 W.
R.72 W.
R.71 W.
R.70 W.
R.69 W.
R.68 W.
R.67 W.
R.66 W.
R.65 W.
R.64 W.
N.
LARIMER COUNTY
WELD COUNTY
HALLIGAN DAM
NO. POUDRE TUNNEL
Livermore
ELKHORN DAMSITE
BELLVUE DAMSITE
Bellvue
FORT COLLINS
Wellington
Pierce
Eaton
New Windsor
GREELEY
Loveland
Sheep Creek
No. Fork Cache La Poudre
Big Laramie River
McIntyre Creek
Rawah Cr.
Rabbit Cr.
Lonepine Creek
Elkhorn Cr.
Gordon Cr.
Cache La Poudre River
So. Fork Cache La Poudre
Buckhorn Cr.
Redstone Cr.
Thompson River
Fall Riv.
Coalbank Cr.
Lone Tree Cr.
Owl Cr.
Coal Cr.
Crow Cr.
So. Platte River
LARAMIE POUDRE TUNNEL
SKY LINE DITCH
Chambers Lake Res.
Cameron Pass Res.
Joe Wright Cr.
CAMERON PASS
Michigan Riv.
Lake Agnes
Long Draw Res.
Long Draw
GRAND R. DITCH
LA POUDRE PASS
Colorado River
NO. POUDRE CANAL
POUDRE VALLEY CANAL
LARIMER COUNTY CANAL
LARIMER AND WELD CANAL
LAKE CANAL
PLEASANT VALLEY AND LAKE CANAL
GREELEY CANAL No. 2
GREELEY No. 3 CANAL
OGILVY DITCH
Demmel Lake
Clark Lake
Bee Lk.
Douglass Lake
Res. No. 6
Terry Lake
Long Pond
Cobb Lake
Black Hollow Res.
Cache La Poudre Res.
Windsor Res.
Fossil Cr. Res.
McGrew Res.
U.P.
C.&S.
G.W. RY.
0 5 10 15
Scale of Miles
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS
COLORADO
GENERAL MAP
DRAWN: R.McC.
TRACED:
CHECKED:
RECOMMENDED:
APPROVED:
DENVER, COLO., MAR. 19, 1928
206-D-50
268a


Grain Field
Corn Field
C. S. Ickes.
Apple Orchard
Pasture
Scattering
POUDRE RIVER
Dirt and Rock Fill
Pleasant Valley and Lake Canal 6' on bottom av. 6' deep
Bare Rock
Flat Pasture about 150' wide
Shallow Rocky Soil
Second Ridge
Crest
Apron
Telephone Line
Little Cache La Poudre Ditch
Garden
Truck Garden
Cultivated Field
Willows
Ickes Lane
STATE ROAD
Swampy
Magnetic N.
Top Rock Ridge
Canal
100 0 100 200 300 400
Scale of Feet
Topography by Thos. Hawthorne - Nov. 1927
Approx. E. & W. Centre Line of Sec. 29. T8, R69,
DEPARTMENT OF THE INTERIOR.
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS-COLORADO
BELLVUE DAMSITE
TOPOGRAPHY
DRAWN: T.H. RMcC RECOMMENDED:
CHECKED: APPROVED:
DENVER COLO., Dec. 3. 1927
206-D-33

268b


GENERAL PLAN
Scale of Feet
Jackson Ditch to be supplied by chute drop from Larimer Co. canal (not shown)
Larimer Co. Canal
Drill Hole Nº4
Cut-off Wall
Little Cache La Poudre Ditch
Greeley Pipe Line
Present Dam
Cache La Poudre R.
Counterforted Wall
Pleasant Valley and Lake Canal. (To be relocated above Dam)
1-5'-0"x5'-0" High Pressure Gate and 60" Needle Valves
3-5'x6' High Pressure Gates
UPSTREAM ELEVATION
Larimer County Canal
Top of Parapet El. 5173.0
Bottom of cut-off trench on rock
Sandstone
Shale
Jackson Ditch
Ground Surface
Bottom of Cut-off Trench in Shale
Spillway
Turn-outs
Drill Hole Nº1
Poudre R.
Trash racks (screens not shown)
MAXIMUM SECTION
Concrete Parapet
Max.W.S.El.5162.0
El.5170.0
Riprap 2'-6" thick on 12" Gravel
Earth Fill
Sand, Gravel and Cobbles
Ground Surface
Concrete Cut-off Wall
Surface Shale
SECTION C-C
Q=25,000 s.f.
N.W.S. El.5162.0
El. 5170.0
El. 5144.0
6 Radial Spillway Gates 16'-6"x18' each
Ground El.5080.0
River Bed-5075.0
El.5170.0
El.5055
Sand, Gr. & Boulders
Shale
Grout holes, 5'crs.
Scale of Feet
CAPACITY AND DISCHARGE CURVE
Capacity in Thousands of Acre feet
Spillway Crest 5162.0
Capacity
Discharge
Discharge in Thousands of Second Feet
SECTION B-B
N.W.S. El.5162.0
El.5170.0
El.5070.0
El.5080.0
Sand, Gr. & Cobbles
El.5055.±
Grout Holes, 5'crs.
SECTION D-D
N.W.S. El. 5162.0
El.5170.0
5'x6' High Press. Gates
Trashrack
Top Shale El. 5095.0
Ground Surface
S.=.02
El.5077.0
LOCATION MAP
Scale of Miles
Halligan Dam
Upper Elkhorn Damsite
Bellvue Damsite
Bellvue
Ingleside
Boettcher
Wellington
La Porte
Fort Collins
Buckeye
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS-COLO.
BELLVUE DAM
STORAGE CAPACITY 54,000 A.F.
PRELIMINARY ESTIMATE DRAWING
DRAWN: T.N.
TRACED: L.C.N.
CHECKED:
RECOMMENDED:
APPROVED:
Denver, Colo., Feb. 9, 1928
206-D-49

2682

CHAPTER XIII

RESERVOIR SITES FOR ADDITIONAL STORAGE IN SOUTH PLATTE BASIN

1. DISTRICT NO. 3 - RESERVOIR SITES

Investigations of reservoir sites on the Cache la Poudre River have been carried on intermittently for many years and a number of sites have been filed upon under State laws.

The most attractive of these are: The Bellevue site, just below the mouth of the river canyon and about 8 miles west of Fort Collins; the Elkhorn site, located at the mouth of Elkhorn Creek, about 32 miles northwest of Fort Collins; and the enlargement of Halligan Reservoir, which is situated on the North Fork of the Cache la Poudre River, approximately 30 miles northwest of Fort Collins.

(a) Bellevue Reservoir Site.

The Bellevue dam site, on the Cache la Poudre River, is at a point where the river has cut through a sandstone and shale "hog back" or ridge, which parallels the foot-hills, usually at a distance of a mile or more from the latter. The site is about one mile east of the village of Bellevue. The reservoir basin comprises the major portion of Pleasant Valley and is all privately owned and mostly improved farming land. A branch of the Colorado and Southern Railroad and the state highway traverse the reservoir site.

Filing map (No. 12,642) by L. L. Stimson of Greeley, Colorado, is reproduced as Plate 6. Capacities and areas above Mr. Stimson's survey were obtained by extending curves.

Plate No. 7 is a reproduction of a detail survey of the dam-site, made on a scale of 1" = 100' by the Bureau of Reclamation in 1927.

Geology Of Bellevue Site

A geological examination of the dam and reservoir site was made by Prof. R. D. George, State Geologist, for the Bureau of Reclamation in 1927. His report is favorable for the construction of a reservoir at this location. It is quoted in part as follows:

"The site is wholly within the area of folded sedimentary rocks. The formations from the youngest to the oldest are:

Dakota

Morrison

Lykins

Lyons

Fountain

* * * * * * * *

"The reservoir floor is composed of soil, alluvial clays, sands and gravels in varying proportions and depths. Beneath this is the bedrock consisting of the eroded surfaces of the various rocks described, but the Lykins appear to occupy much the largest area and, except around the borders of the reservoir, is not highly tilted.

"The ground water level is nowhere far below the surface and, as a consequence, floor leakage will be small.

* * * * * * * *

"The proposed dam will extend across a partially filled valley between two ridges of the Dakota formation. The strata of the Dakota ridges dip downstream away from the reservoir and the water will rest against the broken outcropping edges of the strata. This attitude of the strata is less favorable than a dip towards the reservoir which would bring the weight of the water on the broad surfaces of the strata and not on the edges. The water will naturally follow the bedding planes and joints of the formation, and there will be a certain amount of leakage.

* * * * * * * *

"But the worst that can happen is a small leakage, since the upper part of the sandstone will be above the water level, This matter should receive attention, but it does not appear to present a problem of such importance as to justify any consideration of abandonment of the project."

Foundation Drilling

Four holes were put down with a well rig by the Bureau of Reclamation in 1927, along the proposed dam site, at the locations shown on Plate 3.

The logs of these holes are given below:

TABLE NO. 1

DRILL HOLES - BELLEVUE DAM SITE

Hole No. 1 - Ground Elevation, 5080.05.

0-3.5	feet	- silt and sand.
3.5-10	"	- cobblestones and sand, water below 3.5 ft.
10-20	"	- silt and gravel.
20-29	"	- yellow clay and sand.
29-46	"	- dry shale.
46-60	"	- porous shale, occasional hard streaks.

Hole No. 2 - Ground Elevation, 5078.28.

0-6	feet	- silt and sand, water below 3.3 ft.
6-23	"	- sand and cobblestones, water.
23-37	"	- shale, strong flow of water at 27 ft.
37-49	"	- hard shale.
49-59	"	- shale.
59-126	"	- hard shale.

Hole No. 3 - Ground Elevation, 5078.20.

0-1	feet	- silt and sand.
1-19	"	- cobblestones and sand, water below 6.5 feet
19-26.5	"	- sand and few cobblestones.
26.5-50.7	"	- hard shale, strong flow of water at 29.0 ft.

Hole No. 4 - Ground Elevation, 5079.5.

0-3.5	feet	- silt and sand.
3.5-20	"	- cobblestones and sand, water below 5.5 ft.
20-25	"	- soft shale, strong flow of water at 25.0 ft.
25-34	"	- shattered shale.
34-47	"	- shale.
47-52	"	- soft shale.

Reservoir Capacity

The practical maximum height to which a storage dam can be built at the Bellevue site is about to elevation 5170 or 95 feet above the bed of the river, with high water surface elevation at 5162. This elevation is 5 to 8 feet below the water surface in the Larimer County Canal. Raising the reservoir surface above 5162 would submerge this canal, and would increase the danger of leakage through the tilted strata at the dam site.

TABLE NO. 2
BELLEVUE RESERVOIR CAPACITIES AND SURFACE AREAS
(From Filing Map No. 12,642 and curve ext.)

Elev. water	Capacity Acre-Feet	Surface Area Acres	Available Capacity Acre-feet	Remarks
5162	54,000	1,350	52,000	Max. high water surface
5155	46,070	1,258	44,070	
5145	34,520	1,066	32,520	
5135	23,170	923	21,170	
5125	16,550	712	14,550	
5115	9,960	570	7,960	
5105	5,120	420	3,120	
5096.3	2,000	236	0	Surface of dead storage
5095	1,680	212		
5085	300	72		
5080	30	29		
5077	12	11		Bottom Outlet
5075	0	0		Bed of River

The 52,000 acre-feet above elevation 5096.3 is considered available for irrigation use, it being estimated that the lower 2,000 acre-feet storage space would be lost, eventually, through silting.

Proposed Bellevue Dam by the U. S. Bureau of Reclamation

Plate 8 shows a preliminary design for a dam at the Bellevue site, as prepared by the Bureau of Reclamation in 1928.

The main embankment is of the earth and gravel fill type, with a concrete cut-off wall carried to solid rock, and located near the upstream toe. Embankment materials and riprap can be obtained in the near vicinity of the dam site.

The dam embankment is connected with the right abutment by means of an Ambursen Type section located in the channel of the Cache la Poudre River, and provides the spillway and outlet works.

Spillway capacity of 25,000 second-feet is provided by means of six 16'-6" x 18'-0" radial gates. Three 5' x6' high pressure slide gates and one 60" balanced needle valve give an outlet capacity of 3,500 second-feet under a head of approximately 25 feet.

It is proposed to protect the lower bank of the Larimer County Canal, against reservoir wave action by riprap, and to supply the Dry Creek or Jackson Ditch from the Larimer County Canal. A portion of the Pleasant Valley and Lake Canal would be relocated around the right abutment of the dam and the New Mercer, Larimer County No. 2 and Little Cache la Poudre Canals would be directly connected with the dam.

TABLE NO. 3

ESTIMATE OF COST OF BELLEVUE DAM (FROM RECLAMATION REPORT, 1928)

Max. Height of Dam = 95 ft. Storage Cap. - 54,000 A.Ft. (52,000 usable)

Spillway Capacity - 25,000 s.f. Outlet Capacity - 3500 s.f.

Item	Quantity	Total Unit Cost	Total Cost
Care and diversion of river during constr. & unwatering foundations	Lump sum		$50,000
Clearing and grubbing dam-site	30 acres	$200	6,000
Stripping for embankment	46,000 c.y.	0.50	23,000
Excavation-earth & loose rock in cut-off	100,000 c.y.	0.75	75,000
Excavation solid rock for cut-off	2,600 "	6.00	15,600
" earth & loose rock for spillway & outlet works	25,000 "	1.00	25,000
Excavation-shale for outlet works	12,000 "	6.00	72,000
" sandstone " "	1,800 "	10.00	18,000
" Lar. Co. C. headgates	140 "	0.50	70
" T.O. to Jackson Ditch	1,200 "	0.30	360
" P.V. & Lake C. relocation	13,000 "	0.75	9,750
Embankment: Earth fill, 8" layers	627,000 "	0.50	313,500
" sand, gravel & cobbles	868,000 "	0.75	651,000
12" gravel under riprap	49,000 "	1.00	49,000
2'-6" riprap on upstream face	122,000 "	3.50	427,000
Fill Lar. Co. Canal bank	15,000 "	0.40	6,000
Riprap " " " "	18,000 "	3.50	63,000
Drilling, placing pipes and grouting	1,800 l.f.		4,230

TABLE NO. 3 (Cont'd.)

Item	Quantity		Total Unit Cost	Total Cost
Concrete-Parapets & walks	1,800	c.y.	$19.20	$34,560
" conterforted retaining wall	7,300	"	19.20	140,160
" turnout to Jackson Ditch	220	"	19.20	4,224
" cutoff & buttress footings	6,600	"	13.50	89,100
" stream bed protection and unreinforced portion spillway bucket	1,900	"	11.50	21,850
Concrete-Mass, around outlet gates	400	"	10.50	4,200
" Ambursen Buttresses	9,400	"	15.50	145,700
" " face slabs	5,100	"	18.20	92,820
" " struts	160	"	22.20	3,552
" Trash rack str., floors	100	"	24.20	2,420
" Conduits & outlet canal	700	"	23.50	16,450
" Radial headgate str.	60	"	21.50	1,290
" Cut-off in open trench	4,200	"	15.50	65,100
" P.V. & L. Canal Reloc.	1,100	"	15.50	17,050
Bending & placing reinf. steel	1,500,000	#	0.055	82,500
Placing & painting steel in trash racks	130,000	#	0.095	12,350
Placing & painting 14 radial gates and operating mechanisms	175,000	#	0.14	24,500
Installing & painting high pressure outlet slide gates	500,000	#	0.145	72,500
Placing & painting miscel. metal work	4,000	#	0.15	600

TABLE NO. 3 (Cont'd.)

Item	Quantity	Total Unit Cost	Total Cost
Tunnel for P.V.& Lake Canal Reloc.	Lump sum		$ 7,200
Drop " " " "	" "		5,000
60" Needle valve outlet	60,000 #	$ 0.20	12,000
Little C. La P. siphon	Lump sum		6,000
Installing electrical apparatus,etc.	" "		3,000
Permanent improvements	" "		5,000
Relaying & connecting Greeley P.L.	127,500	0.06	7,650
Relocation C.& S. R.R. branch	6.3 mi.	30,000.00	189,000
Relocation Shipps Bridge & 0.4 mi. road	Lump sum		15,000
Flooded R.O.W. Improved Land	1,200 Ac.	200.00	240,000
" " not improved	400 "	50.00	20,000
Town of Bellevue	Lump sum		40,000
Total estimated field cost			$ 3,189,286
Engineering and Inspection, 7½%			239,196
Contingencies, 10%			318,929
Total estimated cost			$ 3,747,411

Cost per acre-foot for 50,000 acre-feet usable capacity $75.00

Cost per acre-foot for 52,000 acre-feet usable capacity 72.00

Operation of Bellevue Reservoir, 1917 to 1928, incl.

Max. height dam = 95 ft. - Storage Capacity = 54,000 acre-ft. of which 52,000 acre-feet is considered usable.

Reservoir operated to supply irrigation shortages for all lands except the area irrigated by the North Poudre Canal.

Reservoir evaporation losses computed in accordance with following table by Robert Follansbee, in Engineers' Bulletin of March, 1927:

TABLE NO. 4.

EVAPORATION AT FORT COLLINS - 24 YEARS AVERAGES

Month	Observed Evaporation Inches	Reservoir Equivalent Inches	Reservoir Equivalent Feet
Jan.	1.30	1.01	.08
Feb.	1.59	1.24	.10 (Total, May-Sept. = 1.62 ft.)
Mar.	2.88	2.25	.19
Apr.	4.26	3.32	.28
May	4.62	3.60	.30 (Total, Oct.-Apr. = 1.04 ft.)
June	5.37	4.18	.35
July	5.58	4.36	.36
Aug.	5.00	3.90	.33
Sept.	4.30	3.35	.28
Oct.	3.32	2.59	.22
Nov.	1.54	1.20	.10
Dec.	1.14	0.89	.07
Annual	40.90	31.89	2.66

No deductions were made for seepage losses, as it was assumed that these losses would enter the river flow and be available for diversion.

TABLE NO. 5

IRRIGATION SHORTAGES FOR LANDS SERVED BY BELLEVUE RESERVOIR

(Irrigation requirement taken as 1.3 acre-ft. per acre irrigated.)

Year	Acre-Ft. per Acre Used Dist. No. 3 (Table 11)	Area Irrigated except lands under No. Poudre Canal	Shortage on basis of 1.3 A.Ft. per A. irrigated	Shortage on Area irrigated in 1928.
1917	1.31	224,310	0	0
1918	1.25	226,850	11,340	21,000
1919	0.69	228,090	139,140	147,100
1920	1.43	229,815	0	0
1921	1.40	229,840	0	0
1922	0.82	231,440	111,090	114,400
1923	1.43	232,440	0	0
1924	1.20	232,440	23,240	25,700
1925	0.99	233,130	72,270	74,700
1926	1.61	233,140	0	0
1927	1.29	233,140	2,330	2,340
1928	1.30	233,540	0	0
Avg.	1.23			

TABLE NO. 6

BELLEVUE RESERVOIR OPERATION 1917-1928, INCL.

Year	Ac.Ft. Avail- able for storage	Total stored Ac. Ft.	Evapo- ration Loss	Irriga- tion Draft	Total Outflow	In storage Sept.30	Res. Spill	Shortage Acre-feet
1917	178,700	53,560	1,560	0	1,560	52,000	125,140	0
1918	59,060	24,500	3,500	21,000	24,500	52,000	34,560	0
1919	1,950	1,950	2,960	50,990	53,950	0	0	96,110
1920	53,150	53,150	1,560	0	1,560	51,590	0	0
1921	75,400	3,810	3,400	0	3,400	52,000	71,590	0
1922	8,050	8,050	2,960	57,090	60,050	0	0	57,310
1923	127,880	53,560	1,560	0	1,560	52,000	74,320	0
1924	110,680	29,200	3,500	25,700	29,200	52,000	81,480	0
1925	9,480	9,480	2,960	58,520	61,480	0	0	15,180
1926	30,440	30,440	1,120	0	1,120	29,320	0	0
1927	16,110	16,110	2,770	2,340	5,110	40,320	0	0
1928	13,847	13,847	3,220	0	3,220	50,947	0	0
Avgs.	57,062	24,805	2,589	17,970	20,559	36,015	32,258	14,050
Avg. 1918-1928	46,004	22,184	2,683	19,604	22,287	34,562	23,814	15,330

In years when the reservoir would be full at the beginning of the irrigation season, enough water would be transferred to lower reservoirs, early in the season, to allow the storage of flood flows and the use of the same in the same year in which they occur, if needed, the transferred water to be repaid later in the season. There is usually a minimum of about 40,000 acre-feet unused capacity in present lower reservoirs on May 1st of a short year.

The above computation discloses that drafts would be made on the reservoir in only 6 years out of the 12 considered; that the reservoir would be full at the beginning of the 3 driest years and would be emptied in each instance, reducing shortages in two years by amounts greater than the full capacity of the reservoir. Preceding each of the 3 dry years was one or more years of spill sufficient to have taken care of the succeeding shortage, if such spill could have been stored.

All of the canals which divert from the Cache la Poudre River would receive benefit from the proposed Bellevue Reservoir, those below by direct diversion and those above thru exchange of water. The North Poudre Canal would not benefit as it is already using all of the natural flow of the North Fork, from which it diverts, by virtue of its direct flow decreed rights, and thru exchange on the river thru Fossil Creek Reservoir, and could make no further exchanges.

There are only about 5,000 acres being irrigated under the Poudre Valley Canal which commands an area of 125,000 acres. It was shown in the Bureau of Reclamation report of May, 1928, that if the Poudre Valley Canal were enlarged to carry 400 sec. ft. it could divert practically the entire yield of Bellevue Reservoir by exchange with lower canals and increase its average annual diversions by about 26,000 acre-feet.

Bellevue Power Development

The location of the Bellevue site, below the mouth of the canyon, limits the available power head to the depth of water in the reservoir. The desirability of holding the storage over the winter and drawing on it to supply irrigation shortages, and completely emptying it in dry years, would conflict with the operation of the reservoir to maintain a power head. The power possibilities in connection with this site, considered as an irrigation storage reservoir, are, therefore, not attractive.

(b) Elkhorn Reservoir Site.

Reference is made to reports by Mr. M. C. Hinderlider in 1922, and by the Bureau of Reclamation of May, 1928, on this subject.

The dam-site of the proposed Elkhorn reservoir is located just below the mouth of Elkhorn Creek, about 32 miles by road, northwest of Fort Collins. It is in a steep, narrow, granite canyon, with bed rock at or near the surface at most points. The reservoir basin is narrow and has considerable grade, which conditions make a high dam necessary for impounding any considerable amount of water. The basin is unimproved, with the exception of a small area near the upper end, occupied by the Fort Collins Park. A state highway traverses the full length of the site.

A survey of the Elkhorn site, to a height of 200 feet above the river bed and capacity of 34,285 acre-feet, by John R. Wortham, is reproduced in Plate 9. Larger capacities and surface areas were approximated by extending capacity and area curves.

A dam 265 feet in maximum height, 250 feet above river bed, will store 53,000 acre-feet, or about the same as at the Bellevue site with a dam 95 feet high, the cost estimate for the Elkhorn site being slightly larger than for the Bellevue site.

The highest dam that could be constructed at the Elkhorn site is 368 feet. A dam of this height would impound about 112,500 acre-feet and would cost about $9,800,000, according to the Bureau of Reclamation estimate for a concrete gravity type dam.

Although the total run-off at Bellevue is greater than at Elkhorn, the storable surplus is practically the same at both points, the increase in flow being divertable and not surplus. This was determined by comparing estimated surplus flows at the canyon gaging station with a few year's records of flows below Elkhorn on parallel dates.

Geology of the Site

A geological report on the Elkhorn site by State Geologist, R. D. George, is quoted in the Bureau of Reclamation report of May, 1928:

"The Upper or Elkhorn Creek reservoir site, is entirely a pre-Cambrian area. The rocks are the usual pre-Cambrian granites, gneisses and schists, locally intruded by later granites and related rocks in the form of dikes and irregular masses. In several places these intrusions have taken on the structure of the pre-Cambrian basement rocks.

* * * * * *

"Faulting is quite common, but most of the faults are of the compression type and appear to be of small displacement.

"In most of the faults the breaks are fairly clean cut and brecciated fault zones are rare. As a consequence of these conditions the faults blocks are closely appressed and tight. Only two of the observed faults are of any importance in consideration of the reservoir possibilities. One of these is just above the high water line on the Western branch of Elkhorn Creek. The fault strikes N. 70° West and dips 45 degrees to the north. The plane is closely squeezed, but in places there is considerable brecciation. Where it crosses the bottom of the creek valley there is little evidence of brecciation, and what is still more important it is in a mica schist in which as a rule faults do not form open zones.

"I do not think there is anything to fear from this break.

"The other fault or fault zone is on the saddle selected for spillway about 1500 feet below the dam site. The country here is broken by many small faulting or shearing planes, and there appear to be some displacements of considerable magnitude. The structural conditions have rendered the rocks more easily eroded and this fact is responsible for the development of the saddle.

* * * * * *

"In my judgment this is an extremely critical place, and great care should be used in the construction of the spillway, especially if the trenching should reveal conditions of weakness.

"The dam-site is excellent and no difficult engineering conditions exist."

A set of stream flow measurements was made at the upper and lower ends of the reservoir site, on Dec. 3, 1927, during the investigation of the site by the Bureau of Reclamation, to determine if there were any losses in the river channel, with results as follows:

Date	Stream	Point of Measurement	Discharge Inflow	Sec.Ft. Outflow
Dec. 3	Cache la Poudre R.	¼ mi. below mouth Little So.Fk.	67.38	
" 3	Elkhorn Creek	100 ft. above bridge	1.76	
" 3	Cache la Poudre R.	0.4 mi. below Elkhorn Dam-Site		71.14
	Totals		69.14	71.14
		Gain through reservoir site		2.00

The dam-site has not been drilled but trenching across the canyon in 1922 disclosed that bedrock of granite formation, with little overburden and but slightly disintegrated on the surface, is available and capable of supporting any type of dam that might be built. Leakage should be much less than at the Bellevue site and, owing to tighter and less soluble formations, the evaporation loss would be less than one-half that at Bellevue.

Reservoir Capacity

In the following capacity and area table, quantities for depths from 0 to 200 feet have been taken from John R. Wortham's survey. Values above 200 feet depth were obtained by curve extensions.

TABLE NO. 7

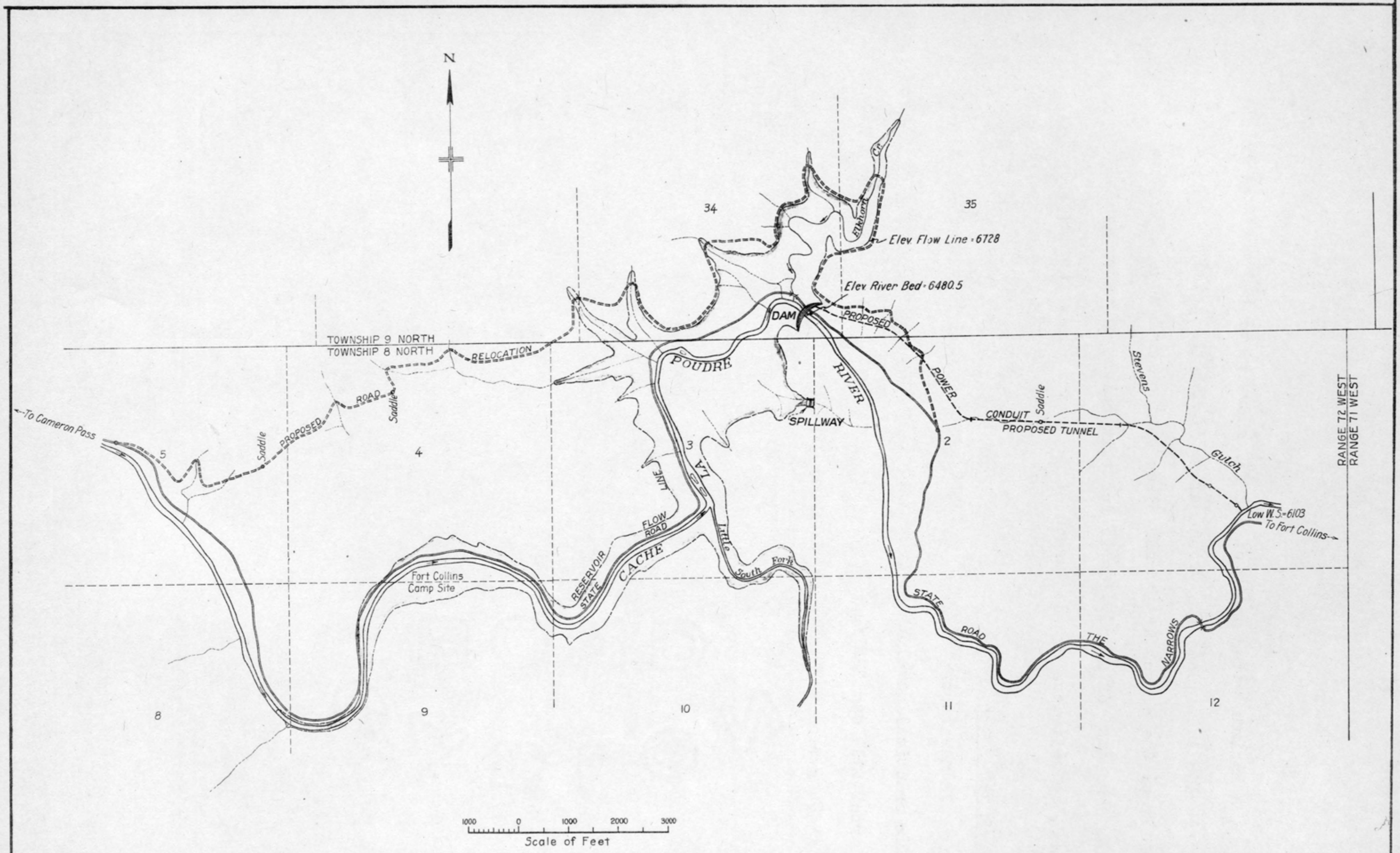
ELKHORN RESERVOIR, CAPACITIES AND SURFACE AREAS

Elev. Water	Depth above River bed Feet	Gross Capacity Acre-Ft.	Surface Area Acres	Available Capacity Acre-Ft.	
6828.5	348	112,500	1120	109,500	Max.Height reservoir surface
6780.5	300	86,200	862	83,200	
6728.5	248	53,000	610	50,000	H.W.S., dam by U.S.B.R.
6710.5	230	47,000	540	44,000	
6695.5	215	40,000	480	37,000	H.W.S., dam by M.C.Hinderlider
6680.5	200	34,350	422	31,350	
6670.5	190	30,300	389	27,300	
6660.5	180	26,590	353	23,590	
6650.5	170	23,210	316	20,210	
6640.5	160	20,210	287	17,210	
6630.5	150	17,470	263	14,470	
6620.5	140	14,950	242	11,950	
6610.6	130	12,620	222	9,620	
6600.5	120	10,510	202	7,510	
6590.5	110	8,580	184	5,580	
6580.5	100	6,825	168	3,825	
6570.5	90	5,226	151	2,226	
6560.5	80	3,805	134	805	
6553.5	73	3,000	113	0	Surface of Dead Storage
6550.5	70	2,612	104		
6540.5	60	1,712	78		
6530.5	50	1,053	54		
6520.5	40	592	38		
6510.5	30	285	24		
6505.5	25	182	17		(Note: Bottom of outlet for
6500.5	20	110	11		U.S.B.R. Dam = 6482)
6480.5	0	0	0		Bed of river at dam site.

A maximum water depth of 348 ft. above river bed would place the water surface 100 feet above the ground elevation at the spillway saddle and above the rim of the canyon at another place on the north side of Little South Fork. The cost of storage works for this height of water surface ($9,800,000, as estimated by the Bureau of Reclamation) is prohibitive.

Proposed Elkhorn Dams.

In the report of M. C. Hinderlider in 1922, previously mentioned, the maximum practical development recommended for the Elkhorn site was for an earth and rock fill dam 235 feet high above streambed, with high water surface 215 feet above stream bed and maximum gross capacity of 40,000 acre-feet.



DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS - COLO.
GENERAL MAP
ELKHORN RESERVOIR
AND POWER CONDUIT

DRAWN: T.H.
TRACED: J.E.V. RECOMMENDED:
CHECKED: APPROVED:
DENVER COLO. JAN. 10-1928 206-D-39

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TABLE NO. 8.

ESTIMATE OF COST FOR ELKHORN DAM BY M. C. HINDERLIDER, 1922

EARTH AND ROCK FILL TYPE

Max. height above stream-bed = 235'   Storage Capacity = 40,000 A.F. (37,000 A. F. usable)

Spillway capacity = 14,000 s.f.   Total outlet capacity = 4,500 s.f.

Upstream slope, 3:1 - Downstream slope, 1½:1.

Item	Quantity		Total Unit Cost	Total Cost
Clearing walls of canyon with giants	Lump sum			$10,000
Blasting down cliffs of decayed rock	" "			10,000
Moving loose rock strippings from floor of canyon to lower toe of dam	84,000	c.y.	$ 0.75	63,000
Excavating cut-off trenches & moving mat.	48,500	"	1.50	72,750
Placing hydraulic fill-ground sluiced	282,000	"	0.20	56,400
" " " " "	80,000	"	0.24	19,200
" " "pumped material	200,000	"	0.37	74,000
Steam shovel material	172,000	"	0.50	86,000
" " "	463,000	"	0.45	208,350
" " "	71,520	"	0.55	39,336
Loose rock fill	373,288	"	0.70	261,302
Dry rubble face wall	26,100	"	4.00	104,400
Sand diaphragm	46,300	"	1.00	46,300
Total Cost of dam				$ 1,052,038

TABLE NO. 8 (Cont'd.)

Item	Quantity	Total Unit Cost	Total Cost
Concrete conduit to divert Elkhorn Cr. during early stages of construction	Lump sum		$ 7,100
Temporary diversion at tunnel intake	" "		16,200
Pressure Tunnel & Regulators, complete	" "		448,900
Spillway excavation & structures	" "		61,740
Total			$ 1, 585,987
Engineering and supervision 5%			79,299
Contingencies 10%			166,529
Total estimated cost of dam - - - - - - - - - - - - - - - - - -			$ 1,831,815

Cost per acre-foot for 40,000 acre-feet gross capacity = $45.80

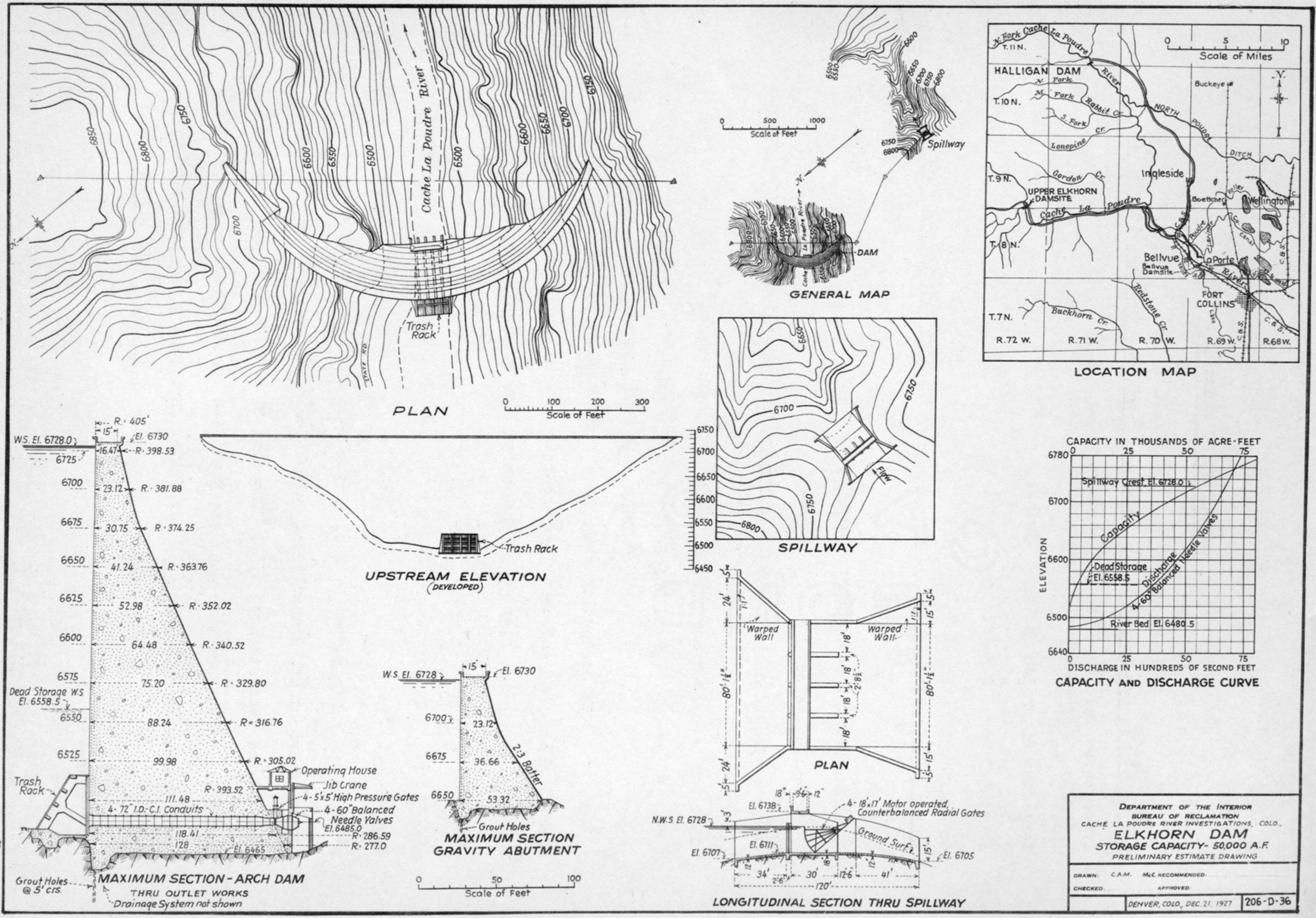
" " " " 37,000 " usable " = 49.50

In connection with the above estimate, Mr. Hinderlider's report states "That the cost per acre-foot for the development of this storage is well within the limits of value placed upon reservoir capacity in the Poudre River Valley."

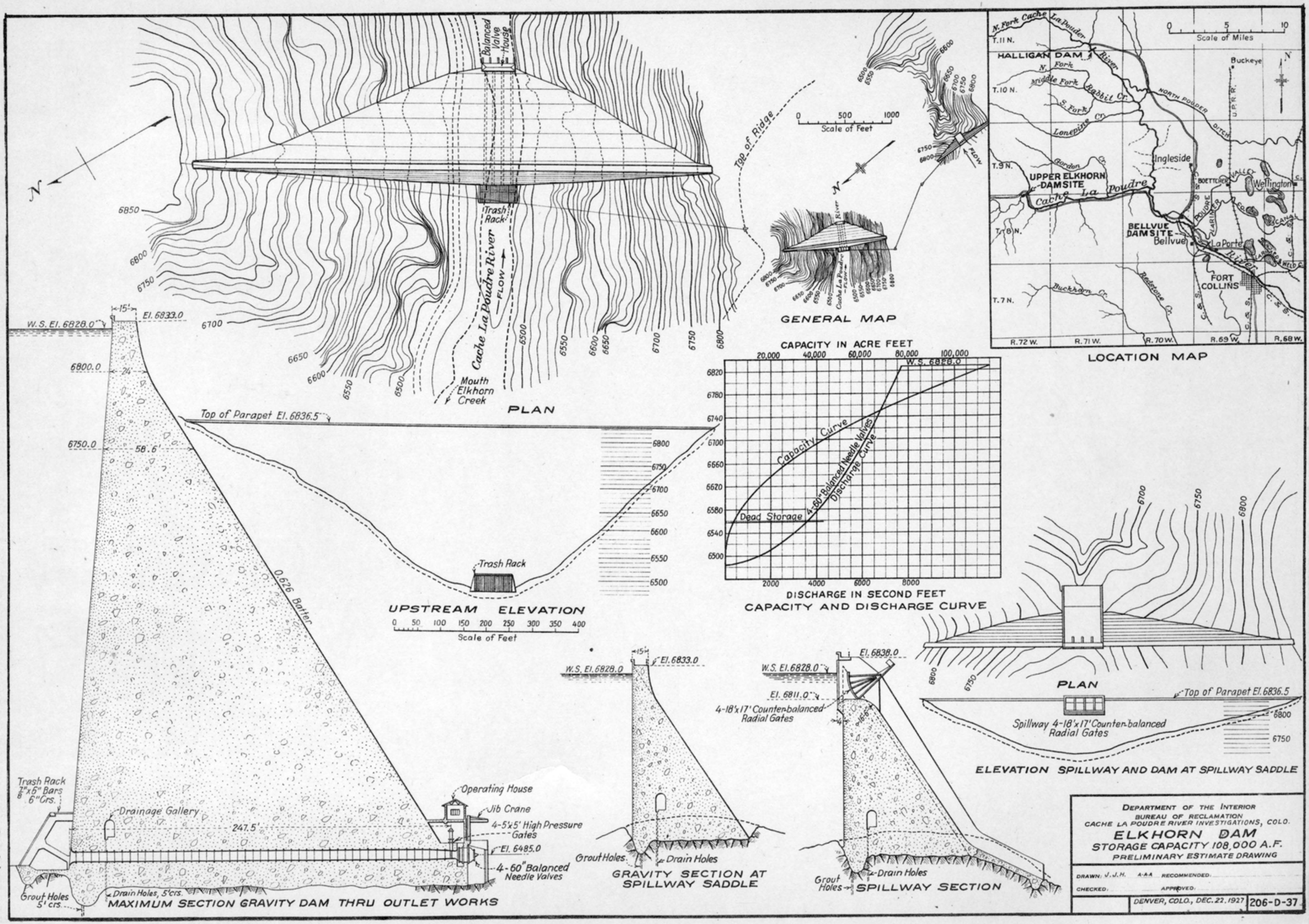
No consideration is given in this report to the development of power.

The Bureau of Reclamation made no estimate for a dam of the type recommended by Mr. Hinderlider, but proposed a higher and more expensive dam of the concrete arch type. The cost of storage under this scheme was admitted to be more than would be justified for irrigation purposes alone but the excess cost was to be met by the development and sale of power.

The estimate of the Bureau of Reclamation for this dam is given below:


PLAN
Cache La Poudre River
Trash Rack
Scale of Feet
UPSTREAM ELEVATION
(DEVELOPED)
Trash Rack
MAXIMUM SECTION - ARCH DAM
THRU OUTLET WORKS
Drainage System not shown
W.S. El. 6728.0
El. 6730
R. 405'
R. 398.53
R. 381.88
R. 374.25
R. 363.76
R. 352.02
R. 340.52
R. 329.80
R. 316.76
R. 305.02
R. 393.52
R. 286.59
R. 277.0
Dead Storage W.S. El. 6558.5
Operating House
Jib Crane
4 - 5'x5' High Pressure Gates
4 - 60" Balanced Needle Valves
El. 6485.0
4 - 72" I.D. C.I. Conduits
El. 6465
Grout Holes @ 5' crs.
MAXIMUM SECTION GRAVITY ABUTMENT
W.S. El. 6728
2:3 Batter
Grout Holes
GENERAL MAP
Spillway
DAM
SPILLWAY
Flow
PLAN
Warped Wall
LONGITUDINAL SECTION THRU SPILLWAY
N.W.S. El. 6728
El. 6738
El. 6711
El. 6707
El. 6705
4 - 18'x17' Motor operated, Counterbalanced Radial Gates
Ground Surf.
LOCATION MAP
Scale of Miles
HALLIGAN DAM
UPPER ELKHORN DAMSITE
Ingleside
Bellvue
Bellvue Damsite
LaPorte
Wellington
FORT COLLINS
N. Fork Cache La Poudre River
North Poudre Ditch
Buckeye
Rabbit Cr.
Lonepine Cr.
Gordon Cr.
Redstone Cr.
Buckhorn Cr.
T. 11 N.
T. 10 N.
T. 9 N.
T. 8 N.
T. 7 N.
R. 72 W.
R. 71 W.
R. 70 W.
R. 69 W.
R. 68 W.
CAPACITY IN THOUSANDS OF ACRE-FEET
ELEVATION
Spillway Crest El. 6728.0
Capacity
Dead Storage El. 6558.5
Discharge 4-60" Balanced Needle Valves
River Bed El. 6480.5
DISCHARGE IN HUNDREDS OF SECOND FEET
CAPACITY AND DISCHARGE CURVE
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS, COLO.
ELKHORN DAM
STORAGE CAPACITY - 50,000 A.F.
PRELIMINARY ESTIMATE DRAWING
DRAWN: C.A.M. McC. RECOMMENDED:
CHECKED: APPROVED:
DENVER, COLO., DEC. 21, 1927
206-D-36

288a


PLAN
Balanced Valve House
Trash Rack
Cache La Poudre River
FLOW
Mouth Elkhorn Creek
GENERAL MAP
Top of Ridge
Scale of Feet
LOCATION MAP
HALLIGAN DAM
UPPER ELKHORN DAMSITE
BELLVUE DAMSITE
Ingleside
Bellvue
La Porte
FORT COLLINS
Wellington
Buckeye
Scale of Miles
CAPACITY IN ACRE FEET
W.S. 6828.0
Capacity Curve
4-60" Balanced Needle Valves Discharge Curve
Dead Storage
DISCHARGE IN SECOND FEET
CAPACITY AND DISCHARGE CURVE
Top of Parapet El. 6836.5
UPSTREAM ELEVATION
Scale of Feet
W.S. El. 6828.0
El. 6833.0
0.626 Batter
Trash Rack 7"x6" Bars 6" Crs.
Drainage Gallery
247.5'
Operating House
Jib Crane
4-5'x5' High Pressure Gates
El. 6485.0
4-60" Balanced Needle Valves
Grout Holes 5' Crs.
Drain Holes, 5' Crs.
MAXIMUM SECTION GRAVITY DAM THRU OUTLET WORKS
Grout Holes
Drain Holes
GRAVITY SECTION AT SPILLWAY SADDLE
El. 6838.0
El. 6811.0
4-18'x17' Counter-balanced Radial Gates
SPILLWAY SECTION
PLAN
Spillway 4-18'x17' Counter-balanced Radial Gates
ELEVATION SPILLWAY AND DAM AT SPILLWAY SADDLE
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS, COLO.
ELKHORN DAM
STORAGE CAPACITY 108,000 A.F.
PRELIMINARY ESTIMATE DRAWING
DRAWN: J.J.H.
RECOMMENDED:
CHECKED:
APPROVED:
DENVER, COLO., DEC. 22, 1927
206-D-37

288b

ESTIMATE FOR ELKHORN DAM BY BUREAU OF RECLAMATION, 1928

CONCRETE ARCH TYPE

Max. Height of Dam = 265 ft. Storage capacity - 53,000 A.Ft.(50,000 A.F.usable)

Spillway capacity = 14,000 s.f. Outlet draft = 3,000 s.f.

Item	Quantity	Total Unit Cost	Total Cost
Care and diversion of river	Lump sum	x	$30,000
Excavation: earth and loose rock	45,000 c.y.	$ 1.50	67,500
" : solid rock in base of dam	13,000 "	3.50	45,500
" : solid rock in upstream cut-off	5,400 "	10.00	54,000
" : solid rock in spillway	2,500 "	2.50	6,250
Drilling grout holes	6,000 l.f.	1.50	9,000
" drain holes	6,000 "	2.00	12,000
Fitting & Placing grout pipe	240 holes	5.00	1,200
" " " drain pipe	105,300#	0.10	10,530
Pressure grouting	300 c.y.	45.00	13,500
Placing porous tile drains	28,000 l.f.	0.45	12,600
Concrete: Dam	294,100 c.y.	8.50	2,499,850
" : Trash rack floor & cut-off	220 "	11.50	2,530
" : Trash rock above floor	600 "	24.20	14,520
" : Valve house substructure	400 "	21.50	8,600
" : " " superstructure	50 "	27.70	1,385
" : Foot Walk	100 "	24.20	2,420
" : Parapets, pilasters & curbs	260 "	24.20	6,292
" : Spillway str. & transitions	750 "	20.50	15,375
Bending & placing reinforcing steel	230,000 #	0.05	11,500
Placing rail reinf. about outlet pipe	100,000 #	0.06	6,000
Placing copper seals	3,800 l.f.	1.00	3,800
Placing-painting steel in trash racks	138,000 #	0.10	13,800
Placing-painting outlet conduit lining	850,000 #	0.12	102,000
Placing-painting high press. gates & mechanism	350,000 #	0.15	52,500
Placing-painting needle valves & mechanism	340,000 #	0.20	68,000
Placing-painting valve crane & hoist	12,000 #	0.20	2,400
Construction of valve house(except concrete)	Lump sum		6,000
Placing-painting handrail & misc.metal work	35,000 #	0.15	5,250
Placing-painting radial gates & mechanism	90,000 #	0.14	12,600
Installing electrical apparatus & fittings	Lump sum		2,500
Selected backfill upstream cut-off	3,000 c.y.	1.00	3,000
Permanent improvements	Lump sum		5,000
Power Outlet - 72" conduit	133,000 #	0.12	15,960
" " 5' x 6' high pressure gates	66,000 #	0.15	9,900
Road relocation-excav., surfacing & struc.	Lump sum		67,313
Right of way and damages	Lump sum		25,000
Total estimated field cost			$ 3,225,575
Engineering and inspection 7½%			241,918
Contingencies 10%			322,558
Total estimated cost			$ 3,790,051

Cost per acre-foot for 50,000 acre-feet usable capacity = $75.80

Oporation of Elkhorn Reservoir - 1917-1928, incl.

Storage dam as proposed by M. C. Hinderlider in 1922.

Max. Hoight dam abovo stream bed = 235 ft.

Max. Depth water " " " = 215 ft.

Available storage capacity = 37,000 acre-foot.

Evaporation from reservoir surface assumed to be the same as at Fort Collins (see Table No. 4). Reservoir to be available for use by all Poudre Valley Canals except North Poudre. Canal shortages as given in Table No. 5. No deductions for losses by seepage.

TABLE NO. 10

ELKHORN RESERVOIR OPERATION, 1917-1928, incl. (M.C.HINDERLIDER'S DAM)

Year	Acre-Feet available for stor.	Total stored Acre-Ft.	Evaporation Loss	Irrigation Draft	Total Outflow	In storage Sept. 30	Reservoir Spill	Shortage A. Ft.
1917	178,700	37,490	490	0	490	37,000	141,210	0
1918	59,060	22,230	1,230	21,000	22,230	37,000	36,830	0
1919	1,950	1,950	990	37,960	38,950	0	0	109,140
1920	53,150	37,490	490	0	490	37,000	15,660	0
1921	75,400	1,240	1,240	0	1,240	37,000	74,160	0
1922	8,050	8,050	990	44,060	45,050	0	0	70,340
1923	127,880	37,490	490	0	490	37,000	90,390	0
1924	110,680	26,930	1,230	25,700	26,930	37,000	83,750	0
1925	9,480	9,480	990	45,490	46,480	0	0	29,210
1926	30,440	30,440	440	0	440	30,000	0	0
1927	16,110	10,490	1,150	2,340	3,490	37,000	5,620	0
1928	13,847	1,230	1,230	0	1,230	37,000	12,617	0
Avg.	57,062	18,710	913	14,713	15,626	27,170	38,350	17,390
Avg. 1918-28	46,004	17,003	952	16,050	17,002	26,276	29,000	18,971

Note: As in the computations for Table No. 6, it was assumed that there would be some exchange of water with lower reservoirs.

Storage Dam as Proposed by Bureau of Reclamation

Max. height dam above stream bed - 250 feet.

Max. depth water " " " - 248 feet.

Gross storage capacity - 53,000 acre-feet.

Available storage capacity - 50,000 acre-feet.

Evaporation and shortages, same as for Table No. 10 above.

TABLE NO. 11

ELKHORN RESERVOIR OPERATION - 1917-1928, incl. (Dam by U.S.B.R.)

Year	Acre-Feet available for stor.	Total stored Acre-Ft.	Evaporation Loss	Irrigation Draft	Total Outflow	In storage Sept. 30	Reservoir Spill	Shortage Acre-ft.
1917	178,700	50,590	590	0	590	50,000	128,110	0
1918	59,060	22,610	1,610	21,000	22,610	50,000	36,450	0
1919	1,950	1,950	1,210	50,740	51,950	0	0	96,360
1920	53,150	50,590	590	0	590	50,000	2,560	0
1921	75,400	1,610	1,610	0	1,610	50,000	73,790	0
1922	8,050	8,050	1,210	56,840	58,050	0	0	57,560
1923	127,880	50,590	590	0	590	50,000	77,290	0
1924	110,680	27,310	1,610	25,700	27,310	50,000	83,370	0
1925	9,480	9,480	1,210	58,270	59,480	0	0	16,430
1926	30,440	30,440	440	0	440	30,000	0	0
1927	16,110	16,110	1,200	2,340	3,540	42,570	0	0
1928	13,847	8,880	1,450	0	1,450	50,000	4,967	0
Avg.	57,062	23,184	1,110	17,908	19,018	35,214	33,878	14,196
Avg. 1918-28	46,004	20,693	1,157	19,536	20,693	33,870	25,311	15,486

TABLE NO. 12.

SIMULTANEOUS OPERATION OF BELLEVUE RESERVOIR WITH 52,000 ACRE-FEET USABLE CAPACITY AND ELKHORN RESERVOIR WITH 50,000 ACRE-FEET USABLE CAPACITY

Year	Acre-Feet available for Storage	Total stored Acre-Ft.	Evaporation Loss	Irrigation Draft	Total Out-flow	In storage Sept. 30	Res. Spill	Shortage Acre-Ft.
1917	178,700	104,170	2,170	0	2,170	102,000	74,530	0
1918	59,060	26,190	5,190	21,000	26,190	102,000	32,870	0
1919	1,950	1,950	4,200	99,750	103,950	0	0	47,350
1920	53,150	53,150	1,560	0	1,560	51,590	0	0
1921	75,400	54,480	4,070	0	4,070	102,000	20,920	0
1922	8,050	8,050	4,200	105,850	110,050	0	0	8,550
1923	127,880	104,170	2,170	0	2,170	102,000	23,710	0
1924	110,680	30,890	5,190	25,700	30,890	102,000	79,790	0
1925	9,480	9,480	4,500	74,700	79,200	32,280	0	0
1926	30,440	30,440	3,160	0	3,160	59,560	0	0
1927	16,110	16,110	3,930	2,340	6,270	69,400	0	0
1928	13,847	13,847	4,210	0	4,210	79,037	0	0
Avg.	57,062	37,740	3,710	27,445	31,160	66,820	19,320	4,660
Avg. 1918-28	46,004	31,705	3,850	29,940	33,790	63,620	14,300	5,080

Power Development at Elkhorn Dam.

A general map of the proposed Elkhorn Reservoir, with gross capacity of 53,000 acre-feet, and the Cache la Poudre River for some three miles below the dam site is shown in Plate No. 12. An excellent opportunity for power development is indicated by the location of a proposed power conduit extending from the dam to the river at the mouth of Stevens Gulch.

For the first 4000 feet below the dam, the conduit would be carried along the east hillside paralleling the river, after which it would enter a tunnel about 3000 feet long and cross a divide into Stevens Gulch. It would then continue along the west side of Stevens Gulch for about 3,000 feet farther to a final drop into the river at the mouth of the Gulch.

The only available stream flow records for the river which indicate the natural stream flow at Elkhorn dam site are those of 1909, 1910 and 1911 above the mouth of the North Fork. The averages of these flows are shown in Table 4, Chapter III. The November to March, incl., average flow for these 3 years is 54 sec. ft. and the Oct.-April, incl., average is 73 sec. ft.

The Bureau of Reclamation, in their report of May, 1928, estimated that 150 sec. ft. could be maintained for the 7 month period, October to April, inclusive, by exchange of water with Valley reservoirs and that a minimum of 300 second-feet would be available for the summer months, May to September, incl. The average static head was estimated at 560 feet during the winter months and 592 feet during the irrigation season, and average effective heads at 540 feet and 537 feet, respectively.

At 70% over-all efficiency, the power output would be:

October to April, inclusive,	6,440 h.p. or 4,800 k.w.
May to Sept., inclusive,	12,800 h.p. or 9,500 k.w.

The following table is a summary of the Bureau of Reclamation's estimate for the power development. The cost of the outlet through the dam into the power conduit was included in the cost for the dam.

TABLE NO. 13

ESTIMATE FOR ELKHORN POWER DEVELOPMENT (SUMMARY)

Two units of 7,500 h.p. water wheel capacity each

Item	Cost
Preparatory work	$ 5,000
Power House Building (60' x 110' concrete)	90,000
Machinery (installed)	340,000
Switchyard and transformers	75,000
Penstock (about 2 miles long - 78" steel pipe and concrete lined pressure tunnel)	520,000
Operators' Quarters (4 cottages, storehouse and garage and grounds)	16,000
Total field cost	$ 1,046,000
Contingencies 15%	157,000
Administration and engineering 15%	157,000
Total cost power plant	$ 1,360,000
Transmission line to Ft. Collins (26 mi.)	76,900
Contingencies and Engineering 30%	23,100
Total cost power plant & transmission line	$ 1,460,000
Interest during construction if financed by bond issue	90,000
Total cost including interest	$ 1,550,000

The annual output of tho plant is ostimatod as follows:

Firm powor - 4800 k.w. or 42,000,000 k.w.h.

Seasonal powor (excoss May-Sept. incl.) 4700 k.w. or 17,000,000 k.w.h.

Gross annual income:

Firm powor 42,000,000 k.w.h. at $.004 =	$168,000
Seasonal powor 17,000,000 k.w.h. at .002 =	34,000
Total	$202,000

Exponsos:

Operation and maintenance -	$ 24,000	
Annuity for depreciation -	24,000	
Total	$ 48,000	48,000
Net income if no interest on construction		154,000
Bond interest and retirement in 40 years		105,000
Net annual income if constructed by bond issue		$ 49,000

The construction of the Elkhorn storage reservoir and power plant appears to involve too great an expense to be undertaken by interest bearing capital.

The following is quoted from the U.S. B. R. report of May, 1928, page E:

"Should the Elkhorn reservoir be constructed with non-interest bearing funds with repayment in 40 years, and the power plant be independently financed as above indicated, the following set-up would obtain over a 40-year period -

Cost of reservoir	$3,790,000
Surplus power revenue	1,960,000
To be repaid by irrigation	1,830,000
Annual irrigation yield	20,000 ac.ft.
Cost per acre-foot of annual yield	$ 91.50

"At the prevailing price of $5.00 per acre-foot for storage water, and with a small allowance for operation and maintenance of the reservoir, the present value of water would need to be capitalized at 5% to equal the indicated net cost."

It is evidently contemplated in the above set-up that the government would construct the reservoir, without interest and expect to be repaid partly by the lands benefiting from increased irrigation water and partly from surplus revenues derived from the operation of the privately financed power plant, in 40 years after the plant was in operation. At the end of the 40 year period, the storage reservoir would be owned by the water users and the power plant controlled by the company who financed it.

A more satisfactory scheme and one less liable to result in friction between irrigation and power interests, would appear to be for the government to construct both the reservoir and power plant and repay itself in a shorter time from power plant revenues.

If the reservoir and power plant were built with government funds, the estimated power output delivered at Fort Collins and sold at $.004 for firm and $.002 for secondary power and the operation and maintenance of the power plant paid from power revenues, conditions would be as follows:

Cost of storage works (without interest)	$ 3,790,000
Cost of power plant (without interest)	1,460,000
Total	$ 5,250,000
Average annual power income, less operation and maintenance of power plant	154,000
Time required to repay construction cost	34 years

At the end of the 34 year period, the storage reservoir and power plant would be under the same control.

In neither of the above schemes is any provision made for operation and maintenance of the storage reservoir.

The cost probably would be about $4,000 or $5,000 per year and could be paid from power income or by assessments on water users.

Assuming that the money advanced by the government is worth 5% on deferred payments, the interest lost in supplying $3,790,000 to be repaid in 40 years would be a little less than that lost in supplying $5,250,000 to be repaid in 34 years as follows:

Interest at 5% on deferred payments on $3,790,000 in 40 annual installments	$ 3,884,750
Interest at 5% on deferred payments on $5,250,000 in 34 annual payments	4,605,300
Difference in favor U.S.B.R. scheme - - -	$ 720,550

However, under the Bureau's proposal, the water users would pay $1,830,000 towards the cost of the storage reservoir. They could therefore well afford to pay the difference in interest value of $720,550 if required so that there would be no loss to the government in constructing both the dam and power plant instead of the dam alone. The government would lose nothing, would be repaid in 6 years less time, and the farmers would save the difference between $1,830,000 and $720,550, or $1,109,450.

It is very probable that the $5,250,000 to be advanced by the government, could be repaid from power revenues in a shorter time than 34 years through increased transmountain diversions which would increase power output, the likelihood for larger prices for power output than the allowances made above, and the possibility of income from power plants that may be constructed on the river below the Elkhorn plant and utilize storage water released from the reservoir.

There is about 850 feet fall in the Cache la Poudre River from the proposed Elkhorn power plant to the mouth of the canyon in a distance of about 14 miles. This would indicate the possibility of additional power development below Elkhorn of about 10,000 k.w. from October to April, inclusive, and 20,000 k.w. from May to September, inclusive, or 7,000 k.w. and 14,000 k.w. respectively, delivered in the vicinity of Fort Collins.

There is a considerable area of good land lying to the north of the town of Eaton, above present irrigation ditches and underlaid with ground water at reasonable depths for pumping. Several electric and gas engine pumping systems are already in successful operation. This district should supply a good market for secondary power developed during the irrigation season and might make possible a considerably larger income from this source than the $.002 per k.w.h. estimated above.

The expenditure by the government of $5,250,000 for the Elkhorn reservoir and power plant would be a sound investment with certainty of the funds advanced being returned in a reasonable time through power sales and would result in great benefit to the Poudre Valley through supplying water for irrigation shortages and other purposes, and reducing damages.

from uncontrolled floods.

After the repayment period, power revenues above operation and maintenance costs could be placed in a fund for future development on the Poudre River such as construction of the Bellevue Reservoir, or the plant could be turned over to the Poudre Valley water users to supply their power needs.

(c) Halligan Reservoir Enlargement

Halligan reservoir, on the North Fork of the Cache la Poudre River, was constructed in 1909-1910 to its present capacity of 6,320 acre-feet. Its storage output, together with the natural flow of the North Fork is used on 35,000 acres of irrigated land under the North Poudre Canal.

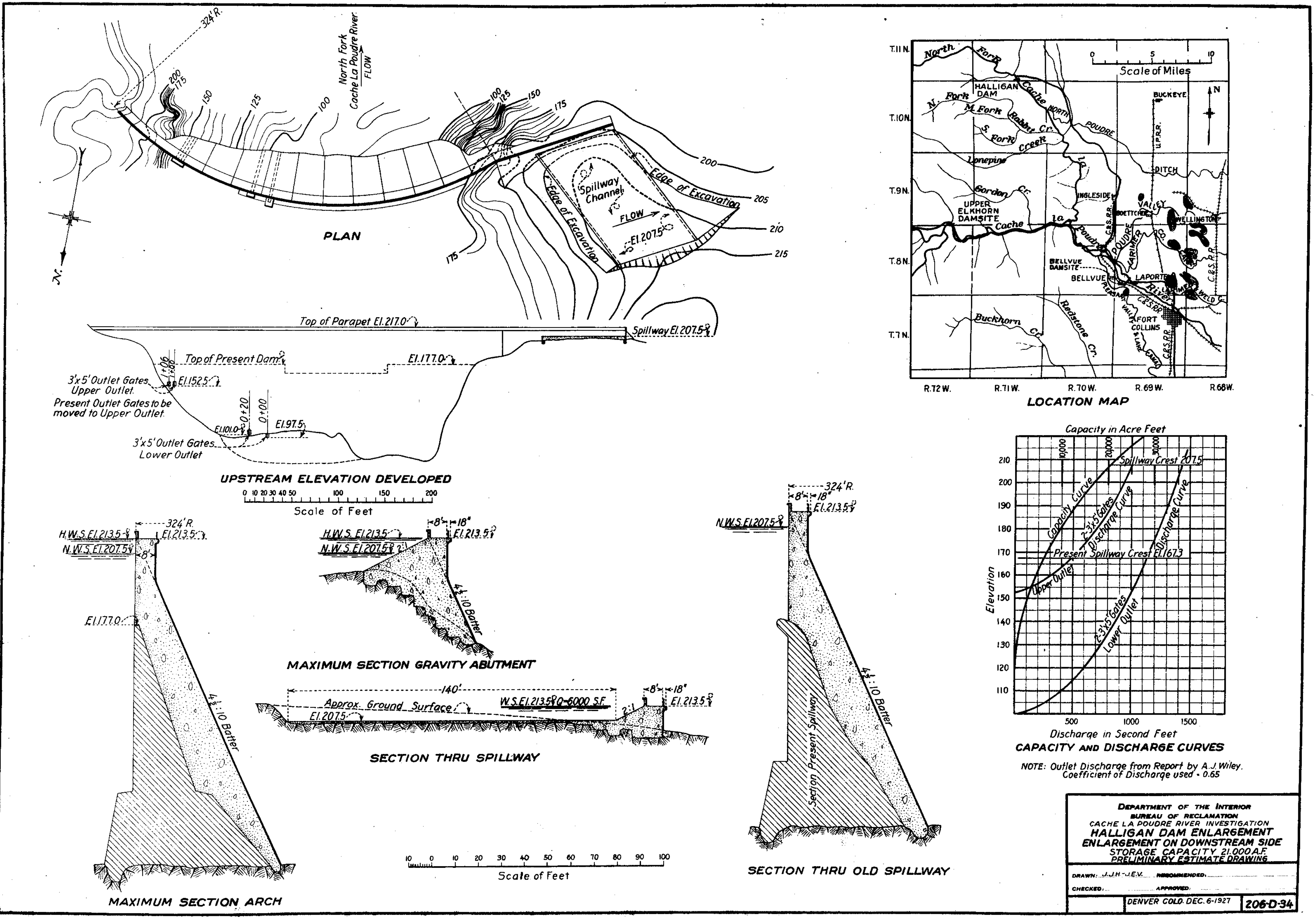
The lands are periodically short of water and the only source for increased supply is additional storage on the North Fork above the intake of the North Poudre Canal. Enlargement of the Halligan reservoir by increasing the height of the dam seems to be the best scheme available for providing the required storage.

TABLE NO. 14

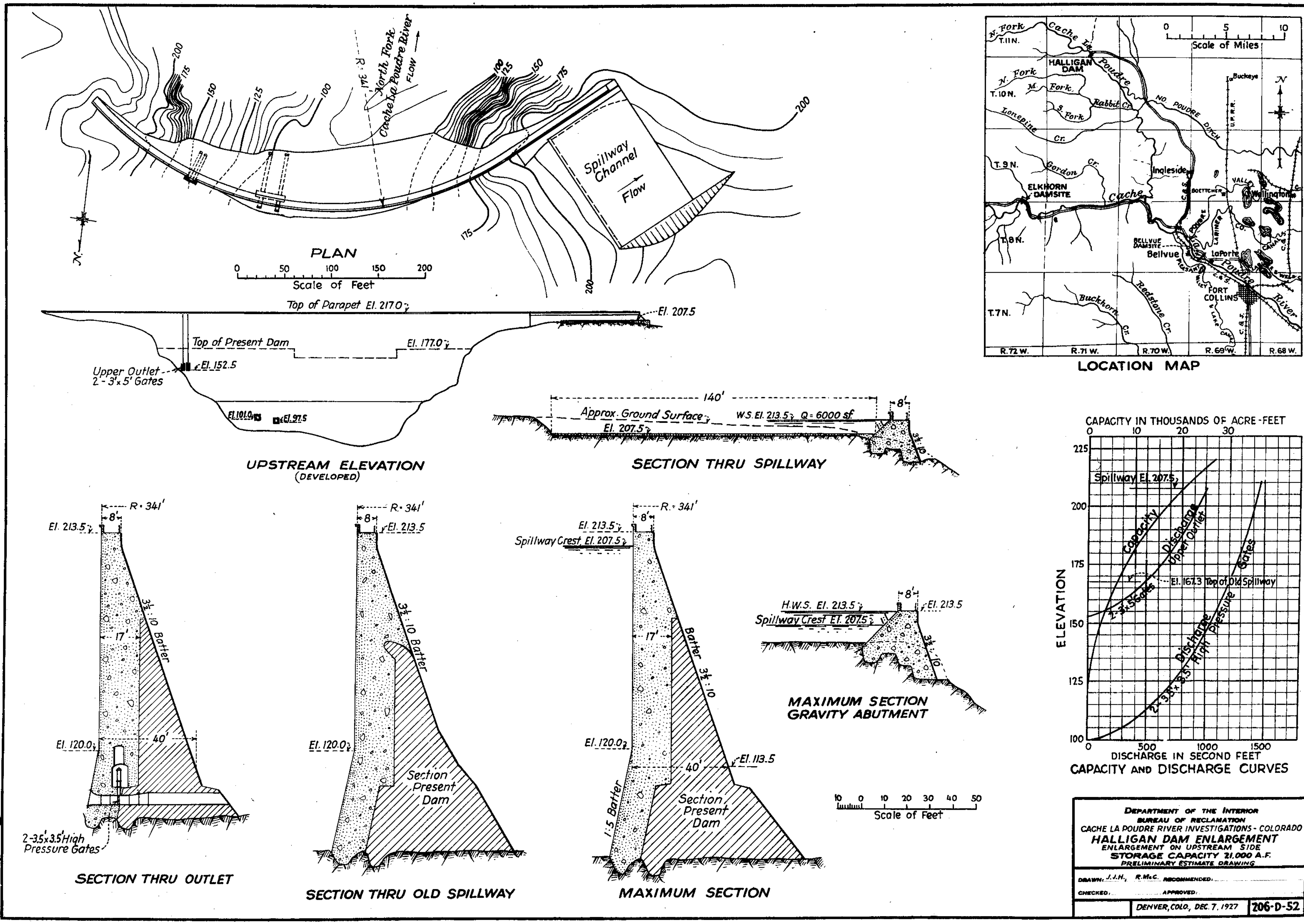
SURPLUS AVAILABLE FOR ADDITIONAL STORAGE AT HALLIGAN DAM AND N. POUDRE CANAL SHORTAGES

	Acre-Feet available for additional storage at Halligan				No. Poudre Canal	No. Poudre shortage 44,500 A.Ft.
	May	June	July	Total	Diversions	Required*
1919	0	0	0	0	14,460	30,040
1920	0	9,470	0	9,470	38,400	6,100
1921	0	10,420	0	10,420	38,800	5,700
1922	0	0	0	0	18,820	25,860
1923	0	27,120	0	27,120	45,630	0
1924	0	15,850	0	15,850	41,370	3,130
1925	0	0	0	0	28,940	15,560
1926	1,460	3,970	0	5,430	49,100	0
Avg.	182	8,354	0	8,536	34,440	13,085

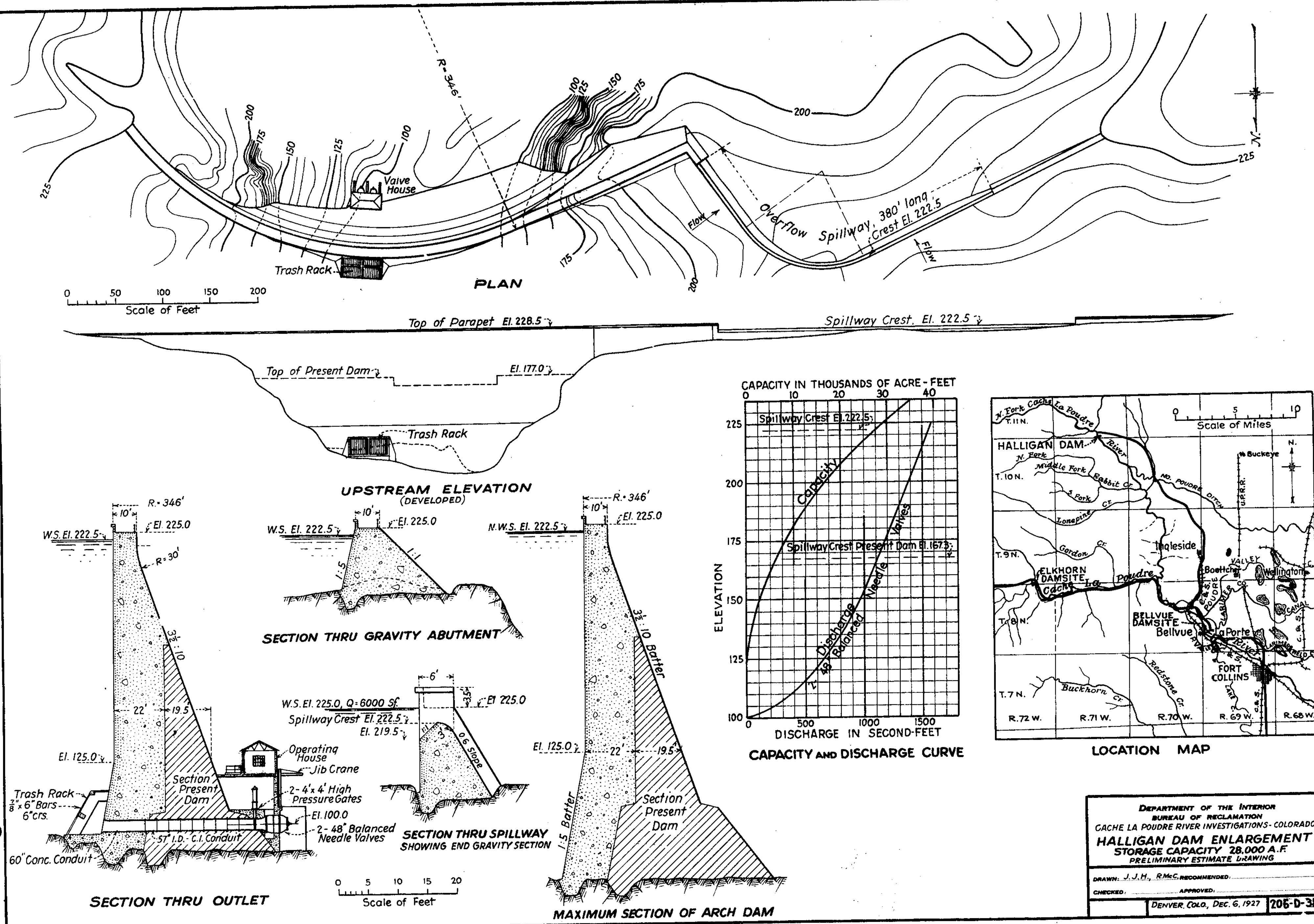
* The minimum requirement for the 35,000 acres of North Poudre lands is estimated at 1.3 acre-feet per acre, or 45,500 acre-feet. Box Elder Creek supplies about 1,000 acre-feet annually, leaving 44,500 acre-feet to be supplied by the North Poudre Canal.


PLAN
North Fork
Cache La Poudre River
FLOW
324'R.
Spillway Channel
Edge of Excavation
FLOW
El. 207.5
UPSTREAM ELEVATION DEVELOPED
Top of Parapet El. 217.0
Spillway El. 207.5
Top of Present Dam
El. 177.0
3'x5' Outlet Gates Upper Outlet.
Present Outlet Gates to be moved to Upper Outlet.
El. 152.5
3'x5' Outlet Gates Lower Outlet
El. 101.0
El. 97.5
Scale of Feet
MAXIMUM SECTION ARCH
H.W.S. El. 213.5
N.W.S. El. 207.5
El. 213.5
El. 177.0
4½:10 Batter
MAXIMUM SECTION GRAVITY ABUTMENT
SECTION THRU SPILLWAY
Approx. Ground Surface
W.S. El. 213.5 Q=6000 S.F.
El. 207.5
SECTION THRU OLD SPILLWAY
Section Present Spillway
LOCATION MAP
Scale of Miles
HALLIGAN DAM
UPPER ELKHORN DAMSITE
BELLVUE DAMSITE
BELLVUE
LAPORTE
FORT COLLINS
WELLINGTON
BUCKEYE
CAPACITY AND DISCHARGE CURVES
Capacity in Acre Feet
Discharge in Second Feet
Elevation
Capacity Curve
2-3'x5' Gates Discharge Curve
Discharge Curve
Upper Outlet
2-3'x5' Gates Lower Outlet
Spillway Crest 207.5
Present Spillway Crest El. 167.3
NOTE: Outlet Discharge from Report by A.J. Wiley. Coefficient of Discharge used = 0.65
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATION
HALLIGAN DAM ENLARGEMENT
ENLARGEMENT ON DOWNSTREAM SIDE
STORAGE CAPACITY 21,000 A.F.
PRELIMINARY ESTIMATE DRAWING
DRAWN: J.J.H.-J.E.V.
RECOMMENDED:
CHECKED:
APPROVED:
DENVER COLO. DEC. 6-1927
206-D-34

300a


PLAN
Scale of Feet
0 50 100 150 200
North Fork Cache La Poudre River
FLOW
R. 341'
Spillway Channel
Flow
Top of Parapet El. 217.0
El. 207.5
Top of Present Dam
El. 177.0
Upper Outlet 2 - 3'x 5' Gates
El. 152.5
El. 101.0
El. 97.5
UPSTREAM ELEVATION (DEVELOPED)
140'
Approx. Ground Surface
W.S. El. 213.5 Q = 6000 sf
El. 207.5
8'
SECTION THRU SPILLWAY
LOCATION MAP
Scale of Miles
0 5 10
Cache La Poudre
HALLIGAN DAM
N. Fork
M. Fork
S. Fork
Rabbit Cr.
Lonepine Cr.
Gordon Cr.
ELKHORN DAMSITE
NO. POUDRE DITCH
Ingleside
Cache
BELLVUE DAMSITE
Bellvue
LaPorte
Poudre River
FORT COLLINS
Wellington
Buckhorn Cr.
Redstone Cr.
Buckeye
T.11N.
T.10N.
T.9N.
T.8N.
T.7N.
R.72 W.
R.71 W.
R.70 W.
R.69 W.
R.68 W.
CAPACITY IN THOUSANDS OF ACRE-FEET
0 10 20 30
ELEVATION
100 125 150 175 200 225
Spillway El. 207.5
Capacity
Discharge Upper Outlet
2-3'x5' Gates
El. 167.3 Top of Old Spillway
Discharge 2-3.5'x3.5' High Pressure Gates
DISCHARGE IN SECOND FEET
0 500 1000 1500
CAPACITY AND DISCHARGE CURVES
R. 341'
El. 213.5
8'
3½ : 10 Batter
17'
40'
El. 120.0
2-3.5'x3.5' High Pressure Gates
SECTION THRU OUTLET
3½ : 10 Batter
Section Present Dam
SECTION THRU OLD SPILLWAY
Spillway Crest El. 207.5
Batter 3½ : 10
El. 113.5
1:5 Batter
MAXIMUM SECTION
H.W.S. El. 213.5
Spillway Crest El. 207.5
3½ : 10
MAXIMUM SECTION GRAVITY ABUTMENT
Scale of Feet
10 0 10 20 30 40 50
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS - COLORADO
HALLIGAN DAM ENLARGEMENT
ENLARGEMENT ON UPSTREAM SIDE
STORAGE CAPACITY 21,000 A.F.
PRELIMINARY ESTIMATE DRAWING
DRAWN: J.I.H., R.McC. RECOMMENDED:
CHECKED: APPROVED:
DENVER, COLO, DEC. 7, 1927
206-D-52

300b

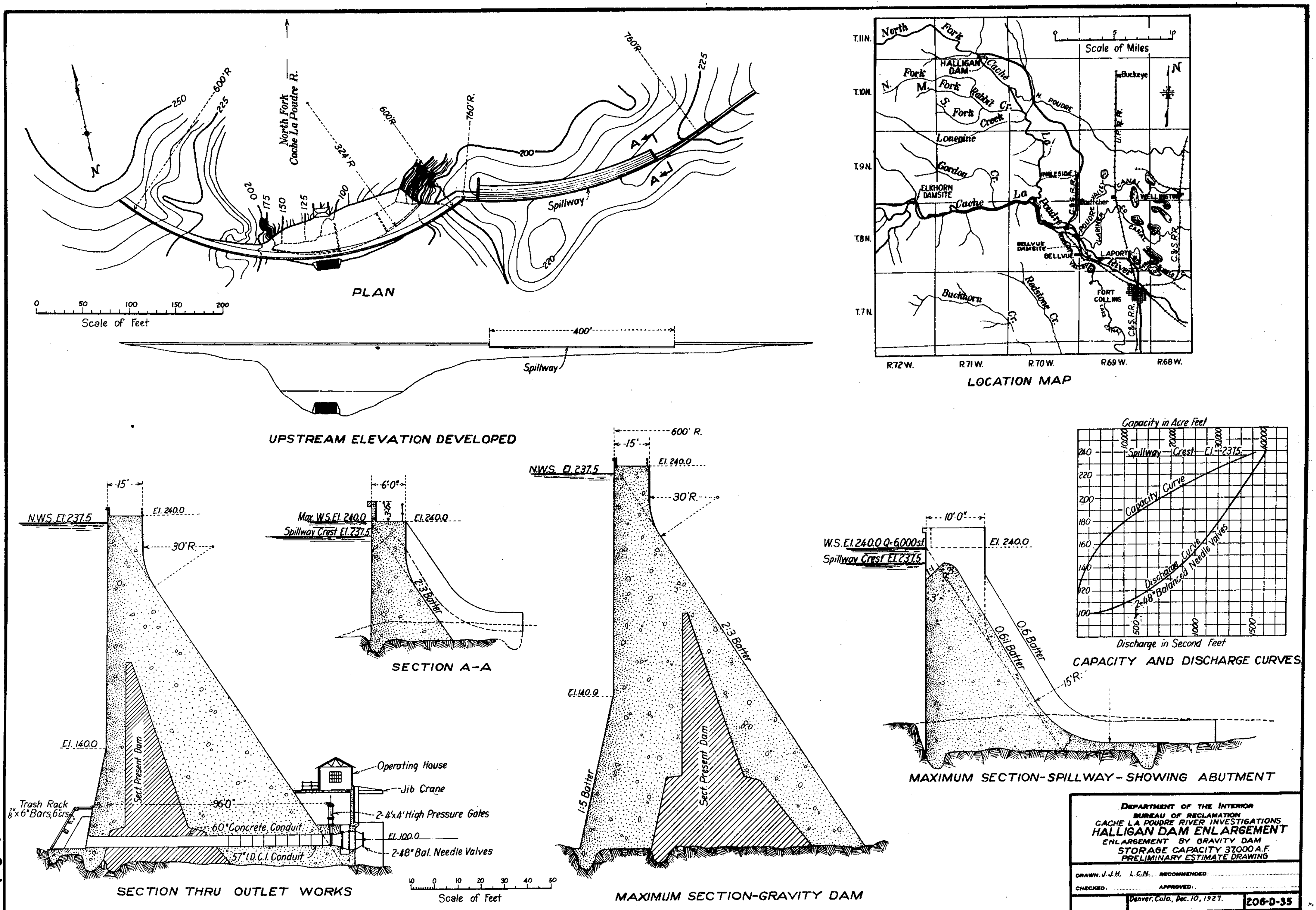


DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS - COLORADO

HALLIGAN DAM ENLARGEMENT
STORAGE CAPACITY 28,000 A.F.
PRELIMINARY ESTIMATE DRAWING

DRAWN: J.J.H., R.McC. RECOMMENDED:
CHECKED: APPROVED:
DENVER, COLO., DEC. 6, 1927 | 206-D-38

300 c



DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CACHE LA POUDRE RIVER INVESTIGATIONS
HALLIGAN DAM ENLARGEMENT
ENLARGEMENT BY GRAVITY DAM
STORAGE CAPACITY 37,000 A.F.
PRELIMINARY ESTIMATE DRAWING

DRAWN: J.J.H. L.C.N. RECOMMENDED:
CHECKED: APPROVED:
Denver, Colo., Dec. 10, 1927. 206-D-35

300 d

The Bureau of Reclamation estimates that the most serviceable increase in capacity for Halligan reservoir would be between 10,000 acre-feet and 25,800 acre-feet, or between 16,000 and 32,000 acre-foot total capacity.

Preliminary cost estimates were prepared for Halligan dam enlargements as follows:

TABLE NO. 15

U.S.B.R. ESTIMATES FOR HALLIGAN DAM ENLARGEMENTS

Capacity Acre-Ft.	Added Capacity A.Ft.	Type of Enlargement	Total Estimated Cost	Cost per A.Ft. of added Capacity	Remarks
21,000	14,680	Arch dam on lower side present dam.	$326,136	$22.22	Objectionable construction
21,000	14,680	Arch dam on upper side present dam.	344,448	23.45	Preferred construction
28,000	21,680	Arch dam on upper side present dam.	588,306	27.15	Max. practicable development
37,000	30,680	Gravity dam enfolding present dam	1,168,621	38.10	Max. possible development

Preliminary designs by the Bureau of Reclamation covering the 4 types of enlargements in Table No. 15 are shown in Plates 13 to 16, inclusive.

The cost for the enlargement to 28,000 acre-feet amounts to $16.80 per acre of irrigated land, or a little more than the estimated crop loss in a short year such as 1925. Storage rights of the North Poudre Company in reservoirs 5 and 6, which divert from the Cache la Poudre River, could be transferred to Halligan, if it were enlarged and, thereby, limit the exchange situation to trans-mountain diversions.

The 35,000 acres of irrigated land under the North Poudre Canal system should be able to pay for the proposed enlargement to 28,000 acre-feet capacity, by means of a bond issue, and without government assistance.

2. PROPOSED SEDGWICK SYSTEM

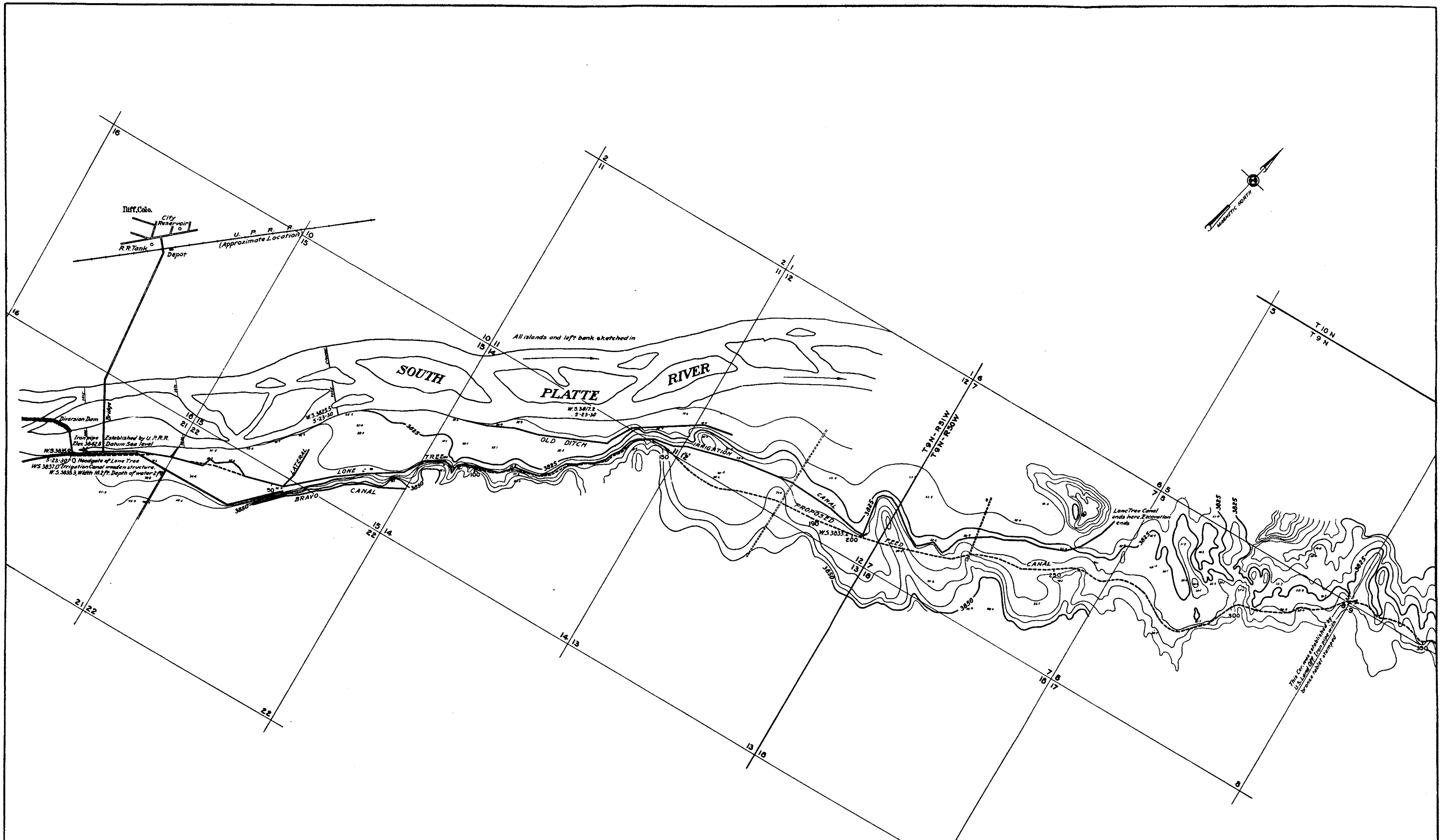
The Sedgwick storage system has been designed to take care of the preferred right of District 64 to store an additional 35,000 acre-feet annually during the non-irrigation season, according to the Colorado-Nebraska Compact.

As herein discussed, it would consist of a concrete diversion weir or dam and headgates in the South Platte River opposite Iliff, a feed canal extending for about 19 miles along the south side of the river, and 3 reservoirs under this canal, all located in natural depressions supplemented by earth dikes. The storage system is all in Logan County and would supply water for irrigating about 20,000 acres of unimproved land, the bulk of which is situated in Sedgwick County.

The proposed diversion weir is similar to a number that have been constructed in the South Platte River in that vicinity, the base to consist of a concrete slab supported on round and sheet piling, the water way to be divided into 40 openings by concrete piers spaced 12 feet on centers with a reinforced concrete walk on top. The height of water above the weir base is controlled by wooden flashboards, working in slots in the piers and supported in the middle by collapsible steel I-beams. A gravity retaining wall or abutment would be required at the left or north end, and a low dirt dike about 1,300 feet in length on the south end of the weir.

The headgate structure would be of reinforced concrete and contain 5- 4' x 8' steel radial gates with hand hoists. The proposed dam would be located a few hundred feet above the present inlet for the Lone Tree Ditch.

The feed canal would follow approximately the location of the Lone Tree Ditch for the first ½ mile, after which it would be above this



STATE OF COLORADO
ENGINEERING DEPARTMENT
M.C. HINDERLIDER, STATE ENGINEER

SOUTH PLATTE RIVER INVESTIGATIONS
SEDGWICK STORAGE SYSTEM

SHEET 1 OF 3 SHEETS
SCALE: 1" = 1000' - CONTOUR INTERVAL 5' - U.P.R.R. DATUM
FROM SURVEY BY U.S. ENGINEER OFFICE 1930
TRACED BY: F.J. KRISTOF DENVER, COLO. FEB. 1931

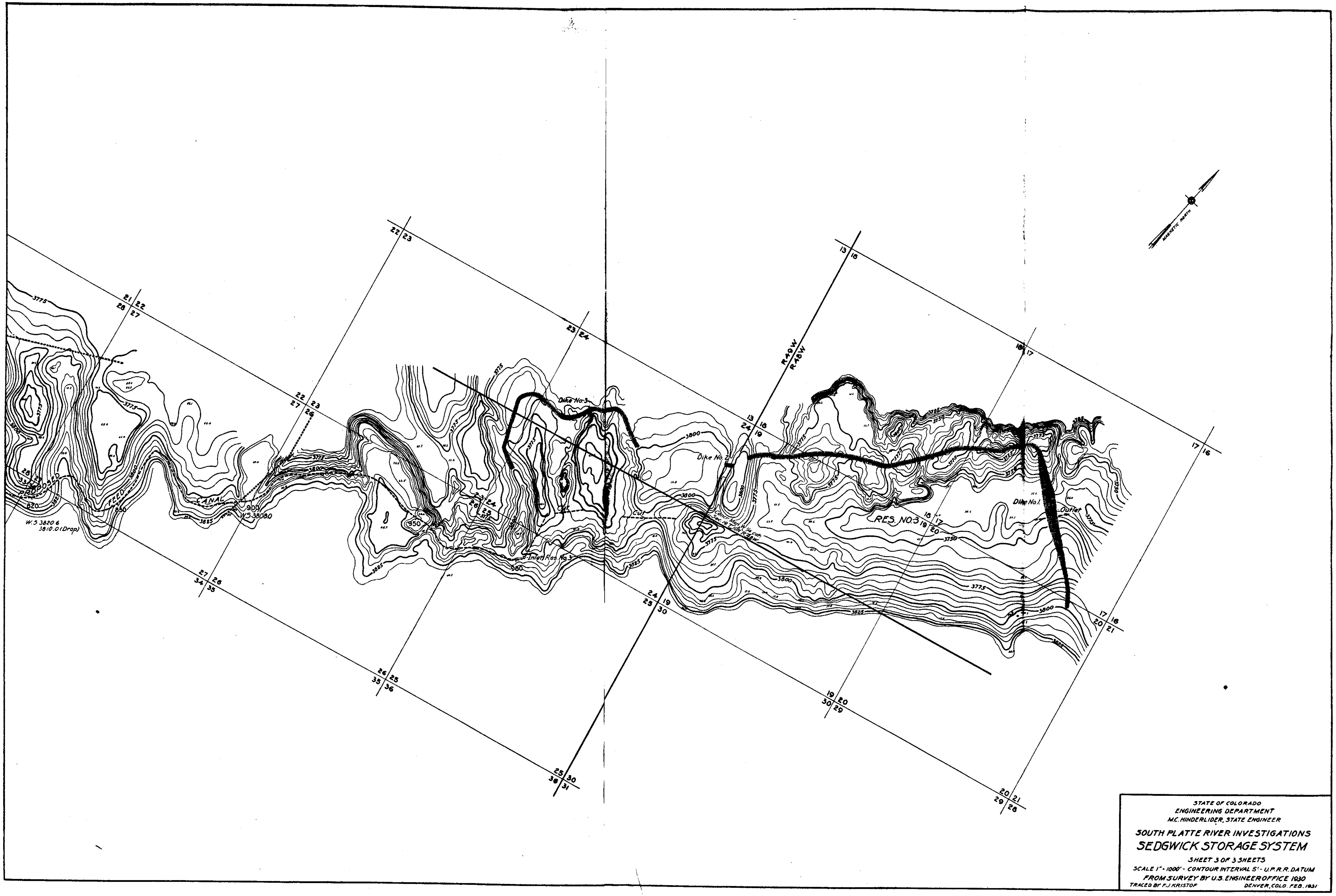
302 a

STATE OF COLORADO
ENGINEERING DEPARTMENT
M.C. HINDERLIDER, STATE ENGINEER

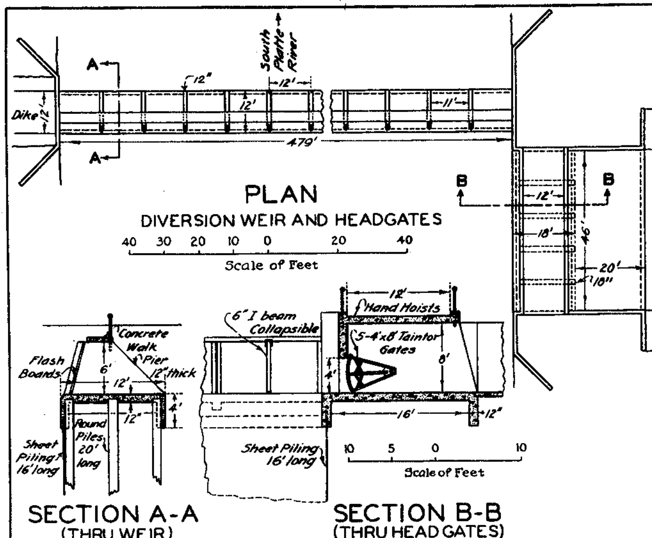
SOUTH PLATTE RIVER INVESTIGATIONS
SEDGWICK STORAGE SYSTEM

SHEET 2 OF 3 SHEETS
SCALE: 1" = 1000' - CONTOUR INTERVAL 5' - U.P.R.R. DATUM
FROM SURVEY BY U.S. ENGINEER OFFICE, 1930
TRACED BY: F.J. KRISTOF DENVER, COLO. FEB. 1931

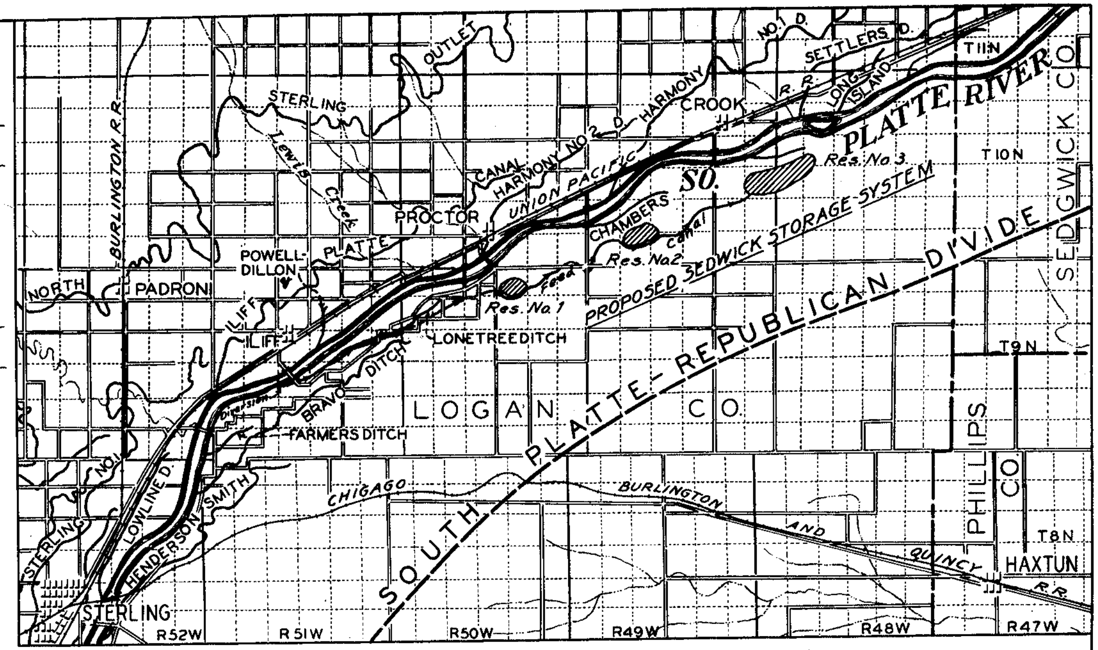
302b


PROPOSED FEED CANAL
W.S 3820.6
3810.0 (Drop)
W.S 3808.0
Inlet Res. No. 3
Dike No. 3
Dike No. 2
Dike No. 1
Cut
RES. NO. 3
Outlet
R.49W
R.48W
MAGNETIC NORTH
STATE OF COLORADO
ENGINEERING DEPARTMENT
M.C. HINDERLIDER, STATE ENGINEER
SOUTH PLATTE RIVER INVESTIGATIONS
SEDGWICK STORAGE SYSTEM
SHEET 3 OF 3 SHEETS
SCALE 1" = 1000' - CONTOUR INTERVAL 5' - U.P.R.R. DATUM
FROM SURVEY BY U.S. ENGINEER OFFICE 1930
TRACED BY F.J. KRISTOF
DENVER, COLO. FEB. 1931

302c



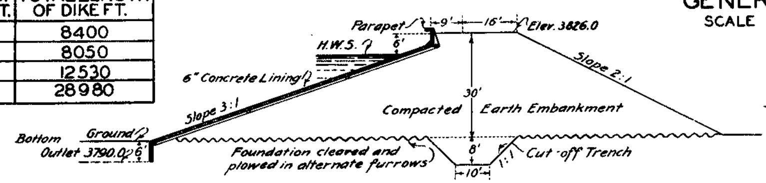
DIVERSION WEIR AND HEAD GATES



GENERAL MAP
SCALE : 1" = 15,000'

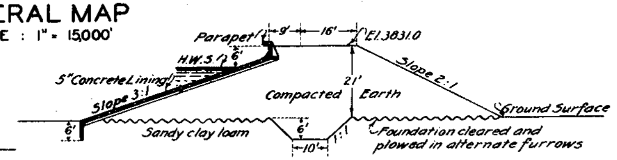
SUMMARY SEDWICK RESERVOIRS

RESERVOIR	CAPACITY A.F.	MAXIMUM HT. DIKE FT.	TOTAL LENGTH OF DIKE FT.
NO 1	3700	21	8400
NO 2	7300	30	8050
NO 3	24000	66	12530
TOTAL	35000		28980



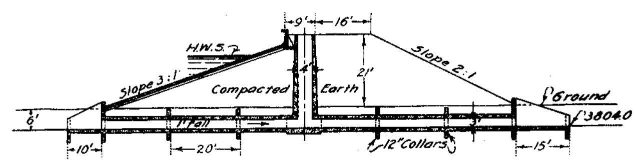
MAXIMUM SECTION DIKE FOR RESERVOIR NO.2.

Outlet similar to that for Res. No. 1
Total Storage Capacity = 7,300 A.F.
Length of Dike = 8,050 ft.

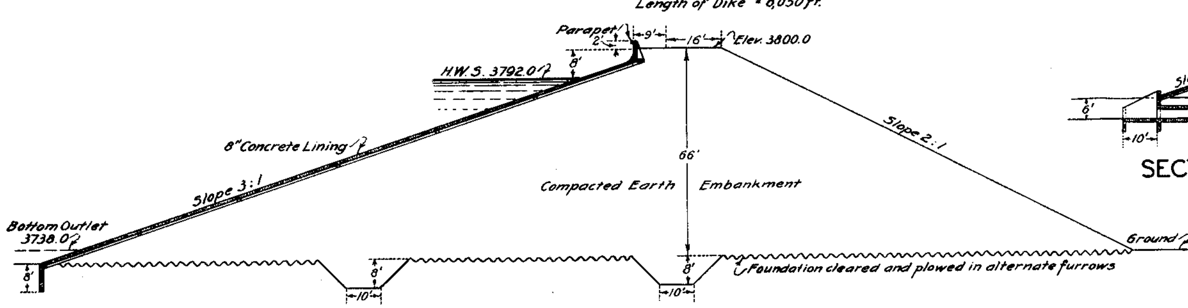


MAXIMUM SECTION DIKE FOR RES. NO.1.

Total Length of Dike = 8,400 ft.
Total Storage Capacity = 3,700 A.F.
No Spillway

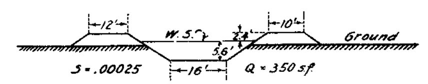


SECTION THROUGH OUTLET RES. NO.1.



MAXIMUM SECTION DIKE FOR RESERVOIR NO 3

Outlet is double-barrelled and similar to that for Res. No. 1.
Total Storage Capacity = 24,000 A.F.
Total Length of Dike = 12,530 ft.



SECTION FEED CANAL

Scale of Feet

STATE OF COLORADO
ENGINEERING DEPARTMENT
M.C. HINDERLIDER, STATE ENGINEER
SOUTH PLATTE RIVER INVESTIGATIONS
SEDGWICK STORAGE SYSTEM
STORAGE CAPACITY 35,000 A.F.
PRELIMINARY ESTIMATE DRAWING

Drawn: Thos. Hawthorne
Traced: F.J. Kristof Denver, Colo., Jan. 1931

302d

ditch. It would be unlined and have a carrying capacity of 350 second-feet. The soil in the vicinity is a deep sandy clay loam. The sand is fine and probably contains enough clay to prevent excessive seepage losses from both the feeder canal and reservoirs.

The three storage reservoirs will be made by constructing earth dykes across the outlets of natural depressions commanded by the feed canal. The dykes will consist of compacted earth fills with 3 to 1 and 2 to 1 side slopes, the upper, or 3 to 1 slope being protected by 6" to 8" of reinforced concrete lining according to the height of the dykes. Provision has been made for concrete chute inlets and concrete outlet conduits for each reservoir. The flow through the outlet conduits to be controlled by iron gate valves in gate towers located within the dykes. No reservoir spillways are considered necessary as there is little or no drainage into the reservoir sites.

All of the reservoir outlets will connect with a common irrigation supply canal starting below Reservoir No. 1 and extending along the south side of the South Platte River until about 20,000 acres of unimproved land have been covered. This canal would be located below the reservoirs and parallel to the last 10 miles of the feeder canal, and should, therefore, pick up considerable seepage from these sources.

If this storage system had been in operation during the period 1918 to 1928, inclusive, the reservoirs would have filled every year except 1923, when there would have been a shortage of only 1,170 acre-feet.

Topography on a scale of 1" = 1,000' was taken for the Sedgwick storage project during the summer of 1930 by surveyors from the Kansas City Office of the U. S. Engineers. From this survey the following preliminary estimate of quantities and costs has been made:

TABLE NO. 16

PRELIMINARY ESTIMATE OF COST OF SEDGWICK STORAGE SYSTEM WITH EARTH DAMS

Concrete Diversion Works--Feed Canal Capacity, 350 Sec. Ft.

Three reservoirs, with combined capacity of 35,000 acre-feet.

Item	Quantity	Unit Cost	Total Field Cost	Total Cost
Diversion Works.				
Clearing and Grubbing	Lump Sum	---	$1,000	
Excavation (Earth)				
Dry Excavation	4,000 c.y.	$ 0.20	800	
Wet Excavation	2,000 c.y.	1.50	3,000	
Dyke Embankment	2,500 c.y.	0.50	1,250	
Concrete (Reinforced)				
For diversion weir	500 c.y.	22.00	11,000	
For head-gates	200 c.y.	22.00	4,400	
Reinforcing Steel	40,000 lbs.	0.05	2,000	
Steel for Pier Slots and noses	6,000 lbs.	0.10	600	
I beams between piers	4,200 lbs.	0.10	420	
Gates and hoists	6,000 lbs.	0.20	1,200	
Pipe hand rails	730 lin.ft.	3.00	2,190	
Steel sheet piling	9,300 sq. ft.	1.80	16,740	
Round timber piling	2,880 lin.ft.	0.50	1,440	
Flash-boards (2" x 6")	3.6 M.B.M.	60.00	216	
				$46,256
Feed Canal. 19 miles long.				
Excavation, (earth)	555,000 c.y.	$0.16	$88,800	
Concrete check and drop into Reservoir No. 1	Structure Comp.	---	3,550	
Concrete check and drop into Reservoir No. 2	" "	---	4,500	
Concrete Chute to Res. No. 3	" "	---	2,300	
Bridges	Lump Sum	---	5,000	
Right of way	206 acres	15.00	3,090	
				$107,240
Reservoir No. 1 --Capacity 3,700 A. Ft. Length Dykes = 8,400 ft. Max. h't. = 21 ft.				
Clearing and plowing	15 acres	$100.00	1,500	
Excavation, (earth):				
For cut-off Trench and Outlet Conduit	22,500 c.y.	0.25	5,625	
Embankment (compacted earth)	145,000 c.y.	0.40	58,000	
Concrete-(Reinforced)				
Parapet Wall	870 c.y.	18.00	15,660	
Upper cut-off wall	670 c.y.	16.00	10,720	
6" slope lining(inc.Sills)	2,600 c.y.	16.00	41,600	
36" Outlet Conduit	87 c.y.	20.00	1,740	
Gate-tower	41 c.y.	21.00	861	
Reinforcing steel:	190,000 lbs.	0.05	9,500	
Gates and operating devices	1,500 lbs.	0.20	300	
Flooded R.O.W.	320 acres	15.00	4,800	
				$150,306

TABLE NO. 16 (Cont'd.)

Item	Quantity	Unit Cost	Total Field Cost	Total Cost
Reservoir No. 2--Capacity 7,300 Ac.Ft. Length Dykes = 8,050 ft. Max. h't. - 30 ft.				
Clearing and plowing	20 Acres	$100.00	$2,000	
Excavation (earth):				
For cut-off Trench and Outlet Conduit	28,400 c. y.	0.25	7,100	
Embankment-(Compacted earth)	276,000 c. y.	0.40	110,400	
Concrete-(Reinforced)				
Parapet wall	850 c. y.	18.00	15,300	
Upper out-off wall	810 c. y.	16.00	12,960	
5" & 6" Lining (incl.sills)	4,920 c. y.	16.00	78,720	
Outlet conduit	132 c. y.	20.00	2,640	
Gate-tower	51 c. y.	21.00	1,071	
Reinforcing steel	300,000 lbs.	0.05	15,000	
Gates and operating devices	2,500 lbs.	0.20	500	
Flooded R.O.W.	210 Acres	15.00	3,150	
				$248,841
Reservoir No. 3-- Capacity 24,000 Ac. Ft. Length Dykes = 18,530 ft. Max. h't. = 66 ft.				
Clearing and plowing	50 Acres	100.00	$5,000	
Excavation (earth):				
For cut-off Trench and Outlet Conduit	126,100 c.y.	0.25	31,525	
Embankment - (compacted earth)	445,000 c. y.	0.40	578,000	
Concrete-(Reinforced):				
Parapet wall	2,910 c. y.	18.00	52,380	
Upper cut-off wall	2,180 c. y.	16.00	34,880	
5", 6" & 8" lining(incl. sills)	23,000 c. y.	16.00	368,000	
Outlet conduit	414 c. y.	20.00	8,280	
Gate-tower	101 c. y.	21.00	2,121	
Reinforcing steel	1,300,000 lbs.	0.05	65,000	
Gates and operating devices	10,000 lbs.	0.20	2,000	
Flooded R.O.W.	950 Acres	15.00	14,250	
				$1,161,436

Total Field Cost, Sedgwick Storage System	$1,714,079
Engineering and Inspection (5%)	85,704
Contingencies (10%)	171,408
Total Estimated Cost	$1,971,191

Estimated cost per Acre-Foot for 35,000 Ac.Ft.
Storage = $56.32

3. District No. 4 - Reservoir Sites.

There are few locations on the Big Thompson River suitable for storing large quantities of water.

The two most promising ones are the Arkins site, just below the mouth of the river canyon, and the Mt. Olympus site, about 20 miles upstream from the latter site, and below Estes Park.

(a) Arkins Reservoir Site

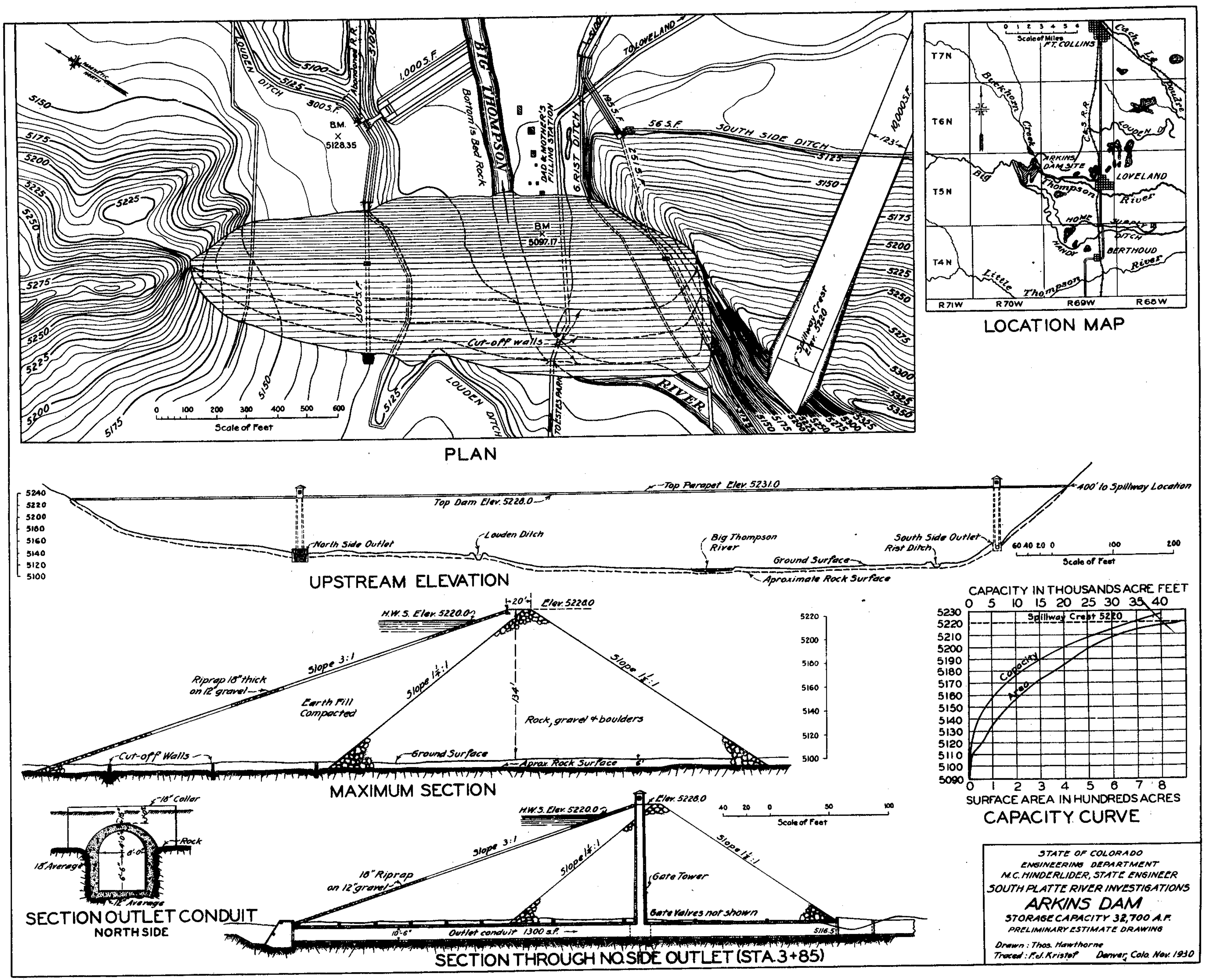
The dam site is in a rift or gash through a sandstone ridge below the mouth of the Big Thompson Canyon and about 7 miles west of Loveland, on the highway to Estes Park. The Louden ditch, the South Side ditch and the George Rist ditch divert from the river within the proposed reservoir site and would have to be provided with outlets through the proposed dam. It will be necessary to re-locate about 4 miles of the present highway through the site, around the north side of the reservoir above highwater line. The land in the site is mostly privately owned and improved for farming.

Geology of Arkins Site.

A preliminary geological report was made in 1930 by Prof. Chester K. Wentworth, Geologist for the Kansas City U. S. Engineer Office. This report follows:

"Introduction

This dam site is located on the Big Thompson River about 8 miles north of Loveland in Larimer County, Colorado. The site is approximately 25 miles nearly due west of Greeley, Colorado, and about 50 miles northwest of Denver. The Arkins district is located at the border line between the Rocky Mountain and Great Plains Physiographic Provinces.


PLAN
UPSTREAM ELEVATION
MAXIMUM SECTION
SECTION OUTLET CONDUIT
NORTH SIDE
SECTION THROUGH NO. SIDE OUTLET (STA. 3+85)
LOCATION MAP
CAPACITY CURVE
CAPACITY IN THOUSANDS ACRE FEET
SURFACE AREA IN HUNDREDS ACRES
Spillway Crest 5220
Capacity
Area
BIG THOMPSON
RIVER
Bottom is Bed Rock
SOUTH SIDE DITCH
LOUDEN DITCH
G. RIST DITCH
TO LOVELAND
TO ESTES PARK
Abandoned R.R.
DAD & MOTHER'S FILLING STATION
B.M. 5128.35
B.M. 5097.17
Cut-off walls
Spillway Crest Elev. 5220
Scale of Feet
Top Parapet Elev. 5231.0
Top Dam Elev. 5228.0
400' to Spillway Location
North Side Outlet
Louden Ditch
Big Thompson River
South Side Outlet
Rist Ditch
Ground Surface
Aproximate Rock Surface
H.W.S. Elev. 5220.0
Elev. 5228.0
Slope 3:1
Slope 1½:1
Riprap 18" thick on 12" gravel
Earth Fill Compacted
Rock, gravel & boulders
Cut-off Walls
Aprox. Rock Surface
18" Collar
Rock
18" Average
12" Average
18" Riprap on 12" gravel
Gate Tower
Gate Valves not shown
Outlet conduit 1300 s.f.
FT. COLLINS
Cache La Poudre
Buckhorn Creek
ARKINS DAM SITE
LOVELAND
Big Thompson River
HOME SUPPLY DITCH
HANDY
BERTHOUD
Little Thompson
T7N
T6N
T5N
T4N
R71W
R70W
R69W
R68W
STATE OF COLORADO
ENGINEERING DEPARTMENT
M.C. HINDERLIDER, STATE ENGINEER
SOUTH PLATTE RIVER INVESTIGATIONS
ARKINS DAM
STORAGE CAPACITY 32,700 A.F.
PRELIMINARY ESTIMATE DRAWING
Drawn: Thos. Hawthorne
Traced: F.J. Kristof
Denver, Colo. Nov. 1930

Stream elevation at the site is about 5,100 feet and the gradient of the Big Thompson River in this vicinity is somewhat less than fifty feet to the mile. In this district the stream flows alternately across the structure, through narrows cut in hogback ridges and across broader valley flats developed in the intervening belts of softer rocks.

"General Geology.

The easternmost component of the Rocky Mountain belt in this latitude is the Colorado Front Range, which consists of granite and other crystalline rocks, and which rises to elevations of somewhat greater than 14,000 feet. Flanking the crystalline core of the mountains and dipping steeply eastward is a series of sedimentary formations of Paleozoic and Mesozoic age which consist of alternating layers of hard and soft rocks and which give rise to long lines of hogback ridges extending north and south. Progressing eastward the beds assume lower angles of dip and presently the strata flatten to form the comparatively general monocline of the western Great Plains.

Various names have been applied to the formations which flank the Front Range in Wyoming and Colorado and numerous uncertainties still exist regarding the correlation of some of these variable strata. They were studied a few years ago by the late Willis T. Lee of the U. S. Geological Survey and the results summed up in Professional Paper 149. For the purpose of this report, however, no especially detailed consideration of stratigraphy is necessary and it is sufficient to state that the hogback ridges cut by the stream at the site is undoubtedly the Lytle sandstone member of the Purgatoire formation of lower Cretaceous age.

"Detailed Geology.

At the site the Lytle sandstone appears to be approximately 100 feet thick and is divisible into a lower, thicker member which is about 15 feet thick and a higher, thinner member about 7 to 10 feet thick with less resistant sandstone beds intervening. The sandstone is medium coarse in grain, buff to pinkish or even darker red in color and fairly massive. In places there are thin zones of conglomerate with pebbles ranging to one inch in diameter.

The stratae in the hogback ridge dip at an angle of approximately twenty degrees downstream, and are fairly uniform in the vicinity. In both the right and left abutments sound rock is exposed to somewhat over 100 feet above stream level, and little difficulty should be encountered in preparing adequate rock support for the horizontal and vertical stresses involved in a hundred foot dam.

The valley flat at this point is approximately 1,200 feet in width and consists of a lower and southeastern flood plain, and a higher northwestern terrace. Bedrock is exposed in the channel of the stream a few feet downstream from the axis of the dam. Bedrock is also exposed in the wall of the Louden ditch near the axis of the dam, and it appears probable that the northwestern terrace is largely cut on rock and has only a four or five foot veneer of alluvial gravel.

Beneath the Lytle sandstone and exposed in the lower face of the right abutment hogback are shale beds of the Morrison formation which are probably 200 or more feet in total thickness. In places these are somewhat calcareous and toward the bottom carry thin beds of fine-grained gray limestone containing small, irregular nodules of pink chalcedonic chert. In part the gray shale of the Morrison formation is somewhat soft and clay-like and carries a moderate amount of gypsum which is subject to solution or softening in contact with water.

Since the shale underlies the deep sandstone beds and is thus exposed farther downstream in the channel than it is in the abutments it will be necessary to carefully probe the site to determine the exact boundary between the two. Sandstone and shale thus outline the general area in which an adequate foundation can be secured.

The sandstone at this site is probably capable of carrying loads of 10 to 12 tons to the square foot and probably is fairly massive in bedding. On the other hand the shale which underlies it is a considerably weaker rock and is probably much more subject to deformation and slippage along the joints as well as to solution by ground water. Where the shale is sound and can be kept dry it is quite possibly capable of carrying loads as high as 6 or 8 tons to the square foot, but if a portion of the foundation is developed on it great care should be used in providing adequate footings and arranging for adequate protection from circulating ground water under the increased heads produced by the impounding.

The downstream dip of the rocks, while not theoretically so favorable as an upstream dip of the same amount, is probably chiefly of significance at this site in its effect on the sandstone shale boundary. It is believed that the sandstone is sufficiently thick-bedded and strong so that the dam can be safely anchored against downstream thrust.

The water table in both abutment hogbacks is probably quite low and the rocks composing them are sufficiently porous so that a certain amount of leakage would probably follow raising of the upstream water level. It is thought, however, that following careful probing the points of greatest probable leakage can be determined and repaired by grouting or some similar expedient.

"Recommendation.

In part geological conditions at this site are quite favorable but one or two problems remain for further study. Bedrock of sufficient strength can undoubtedly be found across the entire valley flat at a very moderate depth below the surface. Because, however, of the dip of the rocks the sandstone foundation in the channel is considerably farther downstream than the outcrop of the same rock at the valley sides. It will be necessary to carefully explore the site up and downstream from the axis to determine what compromising position for the dam can be used in order to utilize the sandstone foundation in the channel section and at the same time anchor the ends of the dam to the sandstone of the hogbacks somewhat further upstream. It is possible that a moderate part of the heel of the dam can be placed on a shale foundation upstream from the sandstone boundary with a properly designed footing. This is for the determination by engineers after exploration has been carried out.

It is probable that moderate quantities of gravel for construction can be had at the site but possibly it would be cheaper to haul gravel from some point where it occurs in deeper beds. The sandstone of the Lytle formation is probably not especially suitable for concrete aggregate or plumbstones for cyclopean masonry, and such materials might require to be hauled from some point further upstream where more suitable materials occur.

Respectfully submitted"

(Signed) Chester K. Wentworth,
Geologist.

Surplus for Storage.

The average annual surplus for storage at the Arkins site for the period 1918 to 1928, inclusive, was 28,000 acre-feet ranging from 0 to 87,000 acre-feet. The average annual shortage of water for irrigation in District 4 is about 25,000 acre-feet, from nothing in good years to 60,000 acre-feet in short years.

Reservoir Capacity. The site has been surveyed to elevation 5,220 or as high as it is practical to store water without interfering with the diversion point of the Home Supply Canal and Loveland Water Works. The total capacity of reservoir at this elevation, is 33,700 acre-feet, but allowing for dead water up to elevation 5,127, at which point diversions will be made to supply the Louden, South Side and George Rist ditches, the net available capacity is 32,700 acre-feet.

TABLE NO. 17

ARKINS RESERVOIR-CAPACITIES AND SURFACE AREAS

(From Survey by U. S. Engineers, 1930)

Elevation Water Surface	Capacity Acre-Feet	Surface Area Acres
5,091	0	0
5,100	6	1.4
5,110	103	18
5,120	463	54
5,130	1,138	51
5,140	2,163	124
5,150	3,613	166
5,160	5,513	214
5,170	8,013	286
5,180	11,263	364
5,190	15,283	440
5,200	20,058	515
5,210	26,258	625
5,220	33,693	862

Proposed Arkins Dam.

A preliminary design for the Arkins dam is shown on Plate 18. It is of the earth and gravel fill type, protected by riprap on the up-stream side and with 3 concrete cut-off walls in solid rock beneath the earth fill portion. It is intended to strip the foundation before placing the embankment.

There are two outlet conduits, one on the north side of 1,300 second-feet capacity to supply the Louden Canal and other canals downstream in District 4, and one on the south side of 251 second-feet to supply the South Side and George Rist ditches.

The spillway consists of a cut in the sandstone ridge on the south side and is designed for a capacity of 10,000 second-feet.

TABLE NO. 18

PRELIMINARY ESTIMATE OF COST FOR ARKINS DAM OF EARTH AND GRAVEL TYPE

Maximum height of dam = 134 ft. Net storage Capacity = 32,700 acre-feet

Spillway Capacity = 10,000 sec.ft. Outlet Capacity = 1,551 sec.ft.

Item	Quantity	Unit Cost	Total Cost
Care of River Water during construct.	Lump Sum		$15,000
Clearing and Grubbing Dam Site	20 Acres	$100.00	2,000
Stripping Dam Site	14,000 c.y.	0.30	4,200
Excavation - Earth:			
For Spillway Channel	12,000 c.y.	0.15	1.800
For Outlet Channels	5,200 c.y.	0.20	1,040
Excavation - Rock:			
For Spillway	175,000 c.y.	2.00	350,000
For Outlets in open cut	4,700 c.y.	6.00	28,200
For So. Side Outlet Tunnel	200 c.y.	10.00	2,000
For Upper Cut-off Walls	1,000 c.y.	8.00	8,000
Embankment:			
Compacted Earth	730,000 c.y.	0.40	292,000
Sand, gravel & cobbles	725,000 c.y.	0.75	543,750
Rock from Spillway Excav.	245,000 c.y.	0.15	36,750
18" Hand placed Riprap on Upper Slope	31,000 c.y.	3.50	108,500
12" Gravel Blanket beneath Riprap	21,000 c.y.	1.00	21,000
Concrete (Reinforced):			
For Spillway Lining	530 c.y.	16.00	8,480
For So. Side Outlet - Conduit	337 c.y.	22.00	7,414
" " " " - Tunnel	221 c.y.	18.00	3,978
" " " " - Structures	276 c.y.	20.00	5,520
" " " " - Canal Lining	100 c.y.	16.00	1,600
For No. Side Outlet - Conduit	1,114 c.y.	22.00	24,508
" " " " - Structures	446 c.y.	20.00	8,920
" " " " - Canal Lining	400 c.y.	16.00	6,400
For Upper Cut-off Walls	1,800 c.y.	15.00	27,000
For Parapet Wall	250 c.y.	18.00	4,500
Reinforcing Steel	220,000 lbs.	0.05	11,000
Gates and Operating Devices:			
For So. Side Conduit	60,000 lbs.	0.20	12,000
" " " Ditch	1,500 lbs.	0.15	225
" Chute to Rist Ditch	3,500 lbs.	0.15	525
For No. Side Conduit	200,000 lbs.	0.20	40,000
" Louden Ditch	5,000 lbs.	0.15	750
" chute to river	10,000 lbs.	0.15	1,500
Relocating 4 mi. of highway around No. side of Res. and 1 bridge	Lump sum		35,000
Flooded R. O. W.	870 Acres	150.00	130,500
Total Field Cost			$1,744,060
Engineering and Inspection (5%)			87,203
Contingencies (10%)			174,406
Total Estimated Cost			$2,005,669

Estimated cost per Acre-Foot for 32,700 Acre-Feet, Net Storage = $61.34.

The average annual yield of a reservoir of 32,700 acre-feet capacity at the Arkins site for the period 1918 to 1928, inclusive, would have been about 15,000 acre-feet or 60% of the average annual shortages in District No. 4.

(b) Mt. Olympus Reservoir Site.

The Mt. Olympus dam site is in the narrow granite canyon of the Big Thompson River about ½ mile below the lower edge of the Estes Park Meadows. The right abutment is on the lower slope of Mt. Olympus which rises to an elevation of 8,808 feet. It is about 28 miles from Loveland by the Estes Park and Rocky Mt. National Park highway to the dam site. It will be necessary to relocate the highway around the reservoir.

The land in the reservoir site is mostly meadow, pasture land and of small agricultural value on account of its altitude.

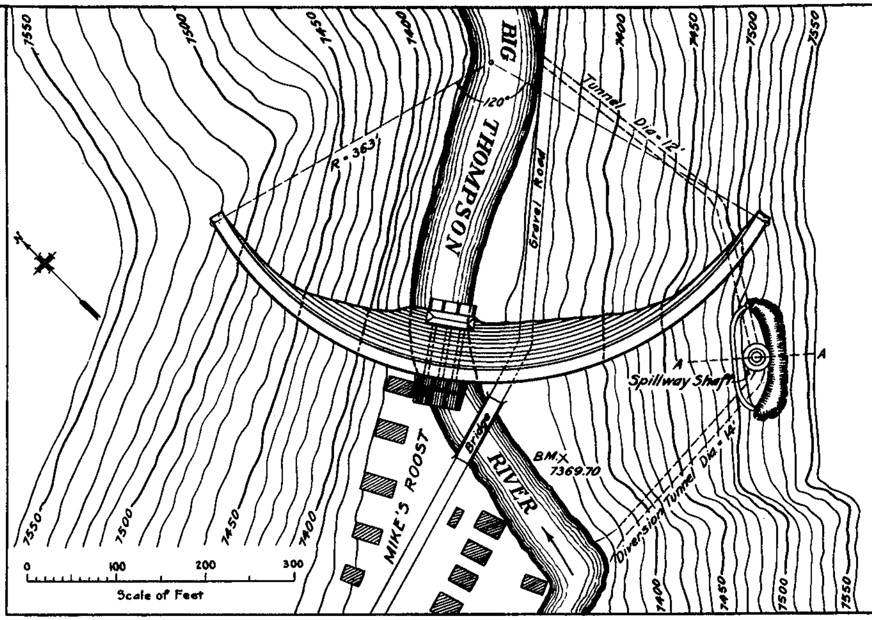
The reservoir water surface cannot be raised above elevation 7,510 without flooding the village of Estes Park. A sewage disposal plant lies below this elevation but could be moved to higher ground and the sewage pumped to it.

Geology of Mt. Olympus Site.

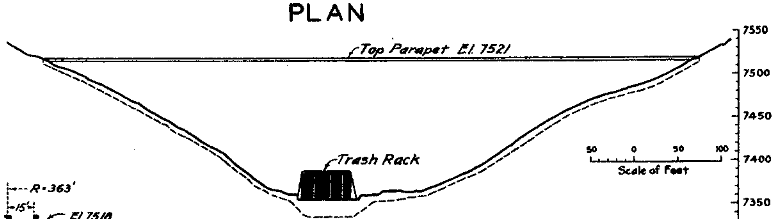
Professor Wentworth's geological report on this site is given below:

"Introduction.

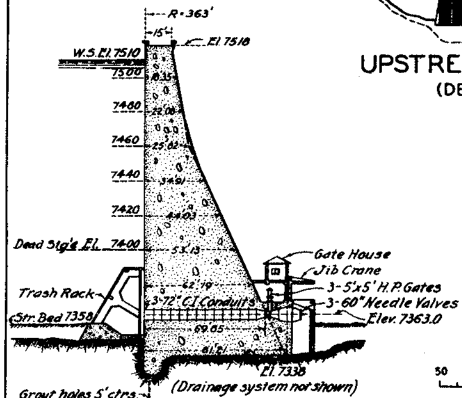
The Mount Olympus Dam Site is located on the Big Thompson River about 21 miles due west of Loveland and about 53 miles northwest of Denver. The Big Thompson River is tributary to the South Platte and rises on the eastern flank of the Front Range north of Longs Peak which flows in a general easterly direction to join the South Platte near La Salle,



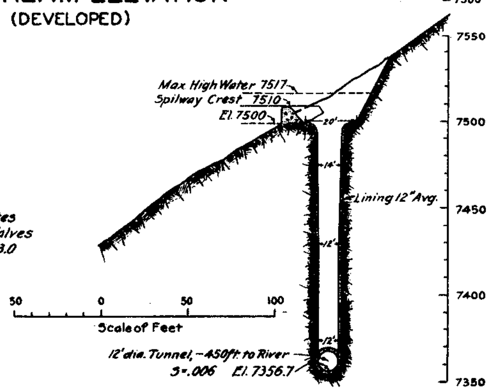
PLAN



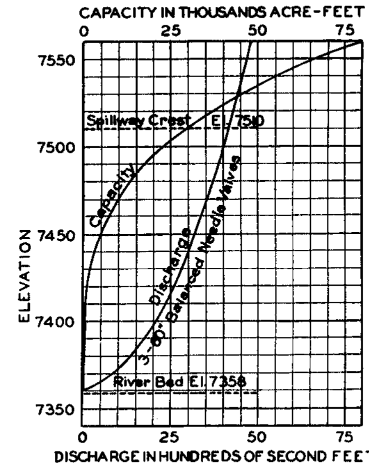
UPSTREAM ELEVATION
(DEVELOPED)



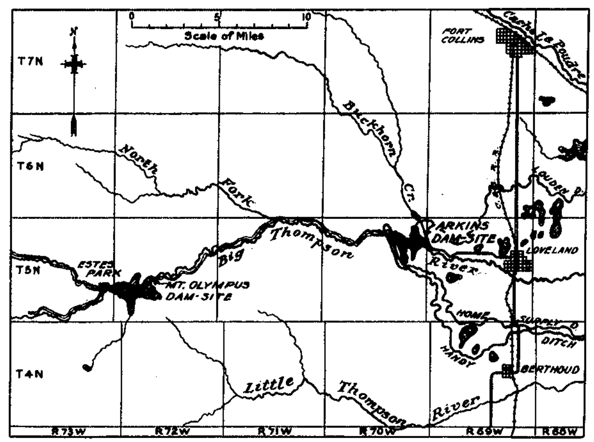
MAXIMUM SECTION DAM
THRU OUTLET WORKS



SECTION A-A
THRU SPILLWAY SHAFT



CAPACITY AND DISCHARGE CURVE



LOCATION MAP

STATE OF COLORADO
ENGINEERING DEPARTMENT
M.C. HINDERLIDER, STATE ENGINEER
SOUTH PLATTE RIVER INVESTIGATIONS

MT. OLYMPUS DAM

STORAGE CAPACITY 28,400 A.F.
PRELIMINARY ESTIMATE DRAWING

Drawn: Thos. Hawthorne
Traced: F.J. Krislof
Denver, Colo. Nov. 1930

314a

Colorado. This district is located near the eastern margin of the Rocky Mountain Physiographic Province, and only a short distance west of the Great Plains.

"General Geology.

The Front Range of Colorado which forms the easternmost component of the Rocky Mountain system in this vicinity, consists of a crystalline core of granite and other igneous and metamorphic rocks. Originally there was laid down upon it a series of sedimentary rocks ranging from Cambrian to Tertiary in age and by virtue of the deformation and uplift of the crystalline core these rocks have now been stripped off the top of the range by erosion and their truncated edges now flank the eastern slope of the mountains. Streams which flow eastward from the range have cut across the linear outcrops of these rocks and divided the ridges formed by the hard layers into numbers of separate hogbacks.

"Detailed Geology.

The Mount Olympus Dam Site is located several miles west of the contact between crystalline and sedimentary rocks and hence lies wholly within the crystalline area. The valley of the Big Thompson at the site is a "V" shaped, narrow gorge not more than 150 feet wide at the bottom and having valley walls rising at average angles of 30 or 40 degrees. The bedrock at the site is a medium to coarse-grained, pink granite with some flecks of dark biotite. It is exposed in continuous bare rock slopes to elevations of upward of 200 feet above the stream level. The structure is generally quite massive except for superficial sheet jointing which has been developed parallel to the surface of the valley walls. It is believed that this jointing is inconspicuous and unimportant at the depths below fifteen or twenty feet.

No bed rock was seen exposed in the channel of the stream, but the narrowness of the channel and the convergence of the exposed rock profile is such that it seems quite probable that bedrock lies within twenty or twenty-five feet of stream level. No evidence of a high water table was seen in the valley walls but from the ruggedness of surrounding country and the general impervious character of the granite it is thought that the water table rises to a hundred or more feet above stream level in a comparatively short distance. The rock at this site is superficially somewhat weathered, but it is believed that this impairment extends only a few feet below the surface and the writer is confident that the underlying sound rock is capable of carrying loads of at least eighty to a hundred tons to the square foot.

"Recommendation.

Geological conditions at this site are highly favorable for the economic construction of a dam two hundred feet in height. Mechanically, the rock both of the foundation and the abutments is amply strong to sustain both the horizontal and vertical stresses transmitted by such a dam, and only a small amount of excavation will be needed. Moreover, an abundance of high grade material for concrete aggregate and other construction materials can be had at the immediate site.

In order to determine the depth of weathering of the granite and to learn the configuration of the water table and the existence of any possible channels for ground water movement which may exist it is essential that a comprehensive scheme of drilling be carried out as a standard precaution. It is believed, however, that no conditions which cannot be readily met by an economical design will be encountered.

Respectfully submitted"

(Signed) Chester K. Wentworth,
Geologist.

Surplus for Storage

The daily surplus flows of the Big Thompson River at the mouth of the canyon were considered as surplus at Mt. Olympus to the extent that they were flowing at Mt. Olympus. The river discharge at Mt. Olympus was determined by comparative measurements to be about 75% of that at the mouth of the Canyon. Applying this ratio and making a further allowance of 20 sec. ft. for the Loveland Power Plant in the canyon below Mt. Olympus, the following table was derived:

TABLE NO. 19

SURPLUS AVAILABLE FOR ADDITIONAL STORAGE AT MT. OLYMPUS DAM SITE

Acre-Feet

Year	Apr.	May	June	July	Aug.	Total
1918	0	0	8,200	0	0	8,200
1919	0	0	0	0	0	0
1920	0	0	3,720	0	0	3,720
1921	0	3,440	51,320	488	0	55,248
1922	0	0	0	0	0	0
1923	0	38	47,480	21,860	5,730	75,108
1924	0	6,360	59,540	0	0	65,900
1925	0	0	0	0	0	0
1926	4,580	20,190	27,560	1,500	0	53,830
1927	0	0	7,220	0	0	7,220
1928	0	5,190	8,450	1,080	0	14,720
Av'g.	416	3,202	19,408	2,266	521	25,813

The average annual yield of Mt. Olympus Reservoir with 28,400 acre-feet net capacity would have been about 13,000 acre-feet for the period 1918 to 1928, inclusive. Mt. Olympus and Arkins Reservoirs, together would store practically all of the surplus of the Big Thompson River.

Reservoir Capacity.

The Mt. Olympus site was surveyed by U. S. Engineers, in 1930 to elevation 7,560 but the intention to store above 7,510 was abandoned on account of the difficulties involved in moving the town of Estes Park.

TABLE NO. 20

MT. OLYMPUS RESERVOIR CAPACITIES AND SURFACE AREAS
(From Survey by U. S. Engineer Office, 1930)

Elevation	Capacity Acre-Feet	Surface Area Acres	Remarks
7,356	0	0	Bed of Stream at dam site.
7,370	34	4.9	
7,380	100	8.2	
7,390	197	11.2	
7,400	337	16.7	Elev. for dead storage.
7,410	554	26.7	
7,420	950	52.5	
7,430	1,671	93.8	
7,440	2,762	124.4	
7,450	4,301	181.4	
7,460	6,417	241.8	
7,470	9,151	304.9	
7,480	12,600	385.0	
7,490	16,912	477.4	
7,500	22,254	591.0	
7,510	28,705	699.2	Just below Estes Park Village.
7,520	36,311	822.0	
7,530	45,140	943.8	
7,540	55,144	1,057.0	
7,550	66,351	1,184.3	
7,560	78,877	1,321.0	Top Contour of Survey.

Proposed Mt. Olympus Dam

A preliminary estimate for this dam has been made according to the design shown on Plate 19.

The foundation material and topography are suitable for a dam of the concrete arch type. The outlet to the river is made by means of 3-72" C.I. conduits controlled by high pressure gates, with needle valves on the downstream side of the dam. The three conduits will discharge 2,000 second-feet, the required capacity, under a head of approximately 37 feet.

Spillway capacity of 8,000 second-feet is provided for by a concrete lined shaft and 12 foot tunnel connection with the river below the dam.

An unlined 14-foot tunnel connecting with the spillway tunnel from a point upstream, is designed to by-pass the river during construction, and to be plugged after the dam is finished.

TABLE NO. 21

PRELIMINARY ESTIMATE OF COST OF MT. OLYMPUS DAM OF CONCRETE ARCH TYPE

Maximum h't. of dam = 180 ft.----Net Storage Capacity = 28,400 acre-feet.
Spillway Capacity = 8,000 sec.ft.-----Outlet Capacity = 2,000 sec. ft.

Shaft Spillway

Item	Quantity	Unit Cost	Total Cost
Cofferdam and pumping water during construction	Lump Sum		$20,000
Excavation:			
Earth & loose rock, dam & outlet structures	3,200 c.y.	$1.50	4,800
Solid rock, dam & outlet structures	10,000 "	3.50	35,000
" " above spillway shaft	4,000 "	3.50	14,000
" " shaft and tunnel	4,000 "	12.00	48,000
" " upper cut-off	2,600 "	8.00	20,800
Drilling grout holes	4,500 lin.ft.	1.50	6,750
Fitting and placing grout pipes	180 holes	5.00	900
Pressure Grouting	220 c.y.	45.00	9,900
Drainage System	Lump Sum		24,000
Concrete:			
Dam	92,800 c.y.	8.50	788,800
Trash rack floor	425 "	12.00	5,100
Trash rack frame	450 "	24.00	10,800
Valve house, substructure	300 "	21.00	6,300
Valvehouse, superstructure	40 "	28.00	1,120
Footwalk	80 "	24.00	1,920
Parapets	195 "	24.00	4,680
Spillway Weir	390 "	18.00	7,020
Shaft and Tunnel lining	910 "	20.00	18,200
Tunnel Portal	20 "	18.00	360
Reinforcing Steel	240,000 lbs.	0.05	12,000
Rail reinf. for Outlet Pipes	45,000 "	0.06	2,700
Steel in Trash racks (in place)	100,000 "	0.10	10,000
Outlet Cond. lining (in place)	380,000 "	0.12	45,600
3-High pressure gates (in place)	260,000 "	0.15	39,000
3-Needle valves and op. mech.	250,000 "	0.20	50,000
Valve crane & hoist (in place)	12,000 "	0.20	2,400
Valve house	Lump sum		4,000
Handrail, steel stairway and miscl. metal (in place)	26,000 lbs.	0.15	3,900
Electrical apparatus (in place)	Lump sum		2,000
Permanent Improvements	Lump sum		3,000
Road relocation - 5 miles on No. and So. Sides of Reservoir	Lump sum		44,200
Flooded R.O.W. and damages	Lump sum		40,000
Total Field Cost			$1,287,250
Engineering and Inspection (5%)			64,362
Contingencies (10%)			128,725
Total Estimated Cost			$1,480,337

Estimated cost per acre-foot for 28,400 acre-feet net capacity = $52.12.

4. DISTRICT NO. 5 - RESERVOIR SITES.

The only storage sites on St. Vrain Creek where large quantities of water can be impounded at comparatively reasonable cost, are in the vicinity of Lyons. The first site examined is about 1¼ miles below Lyons on the main stream, below the junction of the North and South Forks and has been designated the Lyons site. To store more than about 6,000 acre-feet at this site, it would be necessary to move the town of Lyons, which would be especially difficult as its buildings are mainly of stone. A dam 100 feet high above stream bed at this site would be 1,150 feet long on top and would store 21,400 acre-feet of water. One 150 feet high would be 1,300 feet long and store 56,000 acre-feet and one 180 feet high would be 1,600 feet long and store about 86,000 acre-feet. A branch of the Colorado Southern Railroad runs through the site; also the Estes Park highway, the Highland Canal, the Supply ditch and the South Ledge ditch. The latter ditch passes the site at elevation 5,375 or 105 feet above stream bed. The floor of the reservoir site is mostly improved farm land.

A dam about 150 feet high at this site would store practically all of the surplus from St. Vrain Creek and probably would be the most economical storage construction on the creek if it were not for the complications presented by the improvements mentioned above. It was considered that, under present improvement conditions and unfavorable geology, a dam at the Lyons site would be impractical and no estimate has been made.

Dam-sites quite similar to the Lyons site but with less storage capacity each, were found on the North Fork of St. Vrain Creek about ½ mile upstream from Lyons, and on the South Fork about 1¼ miles south of Lyons. The first mentioned has a net storage capacity of 30,000 acre-feet for a dam 160 feet high and the second has 20,000 acre-feet capacity for a dam 169 feet of maximum height. A highway traverses each site and some hay land would be flooded.

Geology of the St. Vrain Dam-Sites.

Professor Wentworth included all three of the above mentioned sites in one geological examination and report made in 1930.

This report follows:

"Introduction.

The Lyons Dam Site is located at the village of Lyons in Boulder County, Colorado. It is approximately 35 miles northwest of Denver and about 32 miles southwest of Greeley, Colorado. The site consists of three alternative locations, - One about one and one-fourth miles below the village of Lyons on St. Vrain Creek; another one-half mile upstream from Lyons on the north fork of St. Vrain Creek, and the third about one and one-fourth miles south of Lyons on the south fork of St. Vrain Creek. The locations which are here designated as A (Lyons), B (North St. Vrain), and C (South St. Vrain), respectively, are described in the following report.

Lyons is located in the foothill district which forms a transition zone between the Rocky Mountain Physiographic Province and the Great Plains Province. St. Vrain Creek arises on the eastern slope of the Front Range of Colorado in the district between Arapahoe Peak and Longs Peak, and flows eastward to join the South Platte at a point about 13 miles southwest of Greeley. The village of Lyons is located at the northern corner of a triangular lowland area which St. Vrain Creek has eroded in the dipping rocks of the foothill district. The eastern point of this triangular area coincides with Location A, the northern point, approximately, with Location B, and the southwest point with Location C. The triangular lowland is approximately one mile on each side and in it the two forks of the creek join to form the St. Vrain proper.

Channel elevation at Location A is approximately 5280 feet; at Location B is about 5390 feet; and at Location C is about 5395 feet. The stream flat is approximately 1400 feet wide at Location A; at Location B is about 900 feet wide; and at Location C is about 500 feet wide. At all three locations rock bluffs rise fairly steeply on both sides to elevations 150 or more feet above stream level.

"General Geology.

As has already been stated the bedrock of this district dip eastward at fairly high angles off the eastern slope of the crystalline core of the Front Range. The narrows which constitutes Location A is located at the stream cut across the Lytle sand stone member of the Purgatoire formation and the sandstone forms hogback ridges extending north and south from the site. About a mile upstream and forming the narrows for both Locations B and C and also the rock bluff which forms the western wall facing the Lyons triangular flat is the sandstone of the Lyons formation.

"Detailed Geology.

At Location A the chief ridge-forming member is a 50 or 60 feet layer of medium to coarse-grained buff sandstone known as the Lytle formation. Underneath this sandstone is a thick series of gray-blue shale beds with gray fine-grained lenses of limestone. About 200 feet stratigraphically below the Lytle sandstone is a massive layer, 25 to 30 feet thick, of cream-colored sandstone of the Sundance formation. The beds at this location have an average dip of 9 or 10 degrees in a direction approximately 80 degrees eastward.

At Location B the rocks of the Lyons formation consist of fine-grained somewhat quartzose red sandstone in beds 6 inches to 3 feet in thickness. The rock is much cross-bedded and toward the top shows a considerable amount of jointing. It is probably capable of carrying 12 to 15 tons to the square foot where sound. No evidence was seen of bedrock in the channel and it is quite possible that the alluvial gravel which fills the valley bottom may extend down to depths of 50 feet or more below channel level. It is probable that the ground water surface is comparatively low in the bluffs adjacent to this site and tests should be made to determine the configuration of permanent water level at the time the abutments are diamond drilled.

At Location C the Lytle sandstone in the abutments is similar to that in the abutments of Location B. The valley flat largely consists of coarse alluvium which may extend 50 feet or more below channel level. In places in the section there are beds of arkose, feldspar-bearing sandstone which are somewhat more easily weathered than the common sandstone beds, but these probably do not constitute any serious impairment of the rock for foundation or abutment purposes.

Each of the three locations is moderately favorable from the geological standpoint for the construction of a dam of 100 feet or thereabouts in height. Locations B and C have considerably narrower cross-sections and correspondingly would provide less storage capacity than Location A, the latter involving the flooding of the town of Lyons. Determination of the relative practicability of the locations from the standpoint of cost and of ultimate worth is outside the scope of this report and is the controlling consideration in selection of one of the locations.

Abutment rock at Locations B or C is considerably more continuous and sound than at A, where the shale which underlies the Lytle sandstone might have to be excavated to a considerable depth to find suitable foundation material. Similarly, the thickness of the sandstone of the Lyons formation at B and C furnishes considerable assurance that at whatever depth under the flood plain the rock surface is encountered it will be fairly strong sandstone, whereas at A the shale probably underlies the larger part of the available foundation area, owing to its thickness upstream from the Lytle sandstone and the dip of the strata.

"Recommendation.

The most immediately promising of the locations from the geological standpoint is C, on the South Fork of the St. Vrain Creek. Next is B, and last is A. It is believed that it would prove feasible, however, to construct a dam of moderate height at any one of these locations. It will be necessary in making further studies of the location selected to explore it by diamond drilling and by probing under the flood plain. While there is a possibility that a moderate amount of leakage may take place through the rocks of the abutments or foundation at any one of these locations it is not thought that any system of openings or fissures constituting a serious impairment or not readily remedied, if known in advance, will be found.

Respectfully submitted"

(a) North St. Vrain Reservoir Site.

Preliminary designs and estimates were prepared for an earth and gravel fill dam at this site.

Surplus for Storage.

The average annual surplus for storage on St. Vrain Creek (below the Two Forks) is about 20,000 acre-feet for the period 1918-28, ranging from 0 in 1925 to 56,000 acre-feet in 1921. Storage capacity of 50,000 acre-feet would have yielded annually about 19,000 acre-feet. 40,000 to 50,000 acre-feet of storage capacity evidently would be required to regulate the aggregate surplus from both forks of the creek.

The run-off of the North Fork is estimated as 57 per cent of the main creek and, if it is assumed that the total surplus is divided between the two forks in proportion to their discharges, storage up to about 30,000 acre-feet would be required on the North Fork and 20,000 on the South Fork. Shortages in District No. 5 vary from nothing in good years to 58,000 acre-feet in 1925, and average 13,400 acre-feet per season.

Reservoir Capacity.

This reservoir site A was surveyed by the U. S. Army Engineers in 1930, to elevation 5,550, and mapped on a scale of 1,000 feet per inch with 10 foot contour intervals. The following table was prepared from their map.

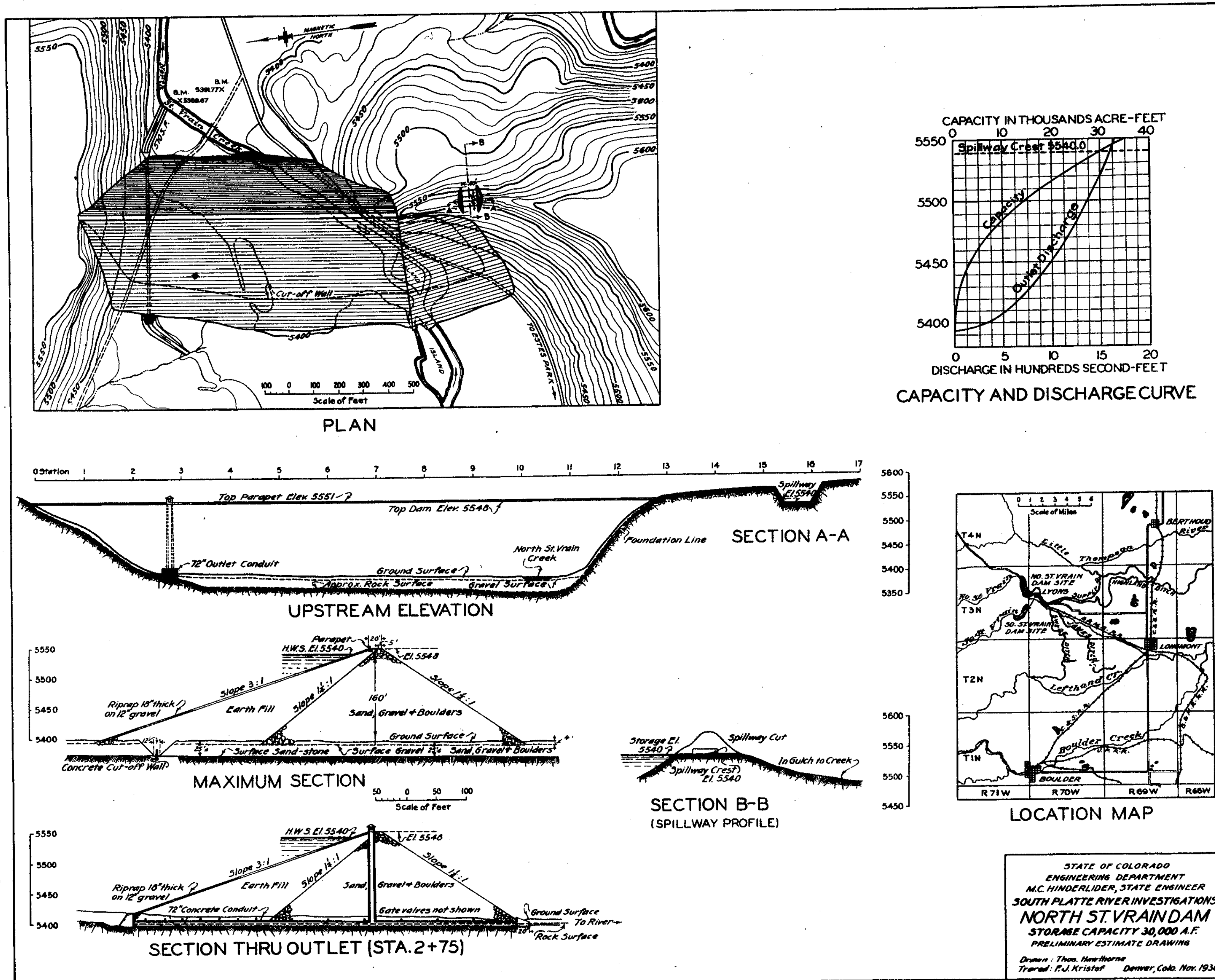

PLAN
MAGNETIC NORTH
B.M. 5361.77X
B.M. X 5368.67
North St. Vrain Creek
Cut-off Wall
ISLAND
TO ESTES PARK
Scale of Feet
100 0 100 200 300 400 500
CAPACITY IN THOUSANDS ACRE-FEET
Spillway Crest 5540.0
Capacity
Outlet Discharge
DISCHARGE IN HUNDREDS SECOND-FEET
CAPACITY AND DISCHARGE CURVE
Top Parapet Elev. 5551
Top Dam Elev. 5548
72" Outlet Conduit
Ground Surface
Approx. Rock Surface
Gravel Surface
North St. Vrain Creek
Foundation Line
Spillway El. 5540
SECTION A-A
UPSTREAM ELEVATION
Parapet
H.W.S. El. 5540
El. 5548
Slope 3:1
Slope 1½:1
160'
Riprap 18" thick on 12" gravel
Earth Fill
Sand, Gravel + Boulders
Ground Surface
Surface Sand-stone
Surface Gravel
Sand, Gravel + Boulders
Concrete Cut-off Wall
MAXIMUM SECTION
Scale of Feet
50 0 50 100
Storage El. 5540
Spillway Cut
Spillway Crest El. 5540
In Gulch to Creek
SECTION B-B
(SPILLWAY PROFILE)
72" Concrete Conduit
Gate valves not shown
To River
Rock Surface
SECTION THRU OUTLET (STA. 2+75)
Scale of Miles
Little Thompson
Berthoud River
NO. ST. VRAIN DAM SITE
LYONS
SO. ST. VRAIN DAM SITE
Highland Ditch
LONGMONT
Lefthand Cr.
Boulder Creek
BOULDER
T4N
T3N
T2N
T1N
R71W
R70W
R69W
R68W
LOCATION MAP
STATE OF COLORADO
ENGINEERING DEPARTMENT
M.C. HINDERLIDER, STATE ENGINEER
SOUTH PLATTE RIVER INVESTIGATIONS
NORTH ST. VRAIN DAM
STORAGE CAPACITY 30,000 A.F.
PRELIMINARY ESTIMATE DRAWING
Drawn: Thos. Hawthorne
Traced: F.J. Kristof
Denver, Colo. Nov. 1930

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TABLE NO. 22

NORTH ST. VRAIN RESERVOIR CAPACITIES AND SURFACE AREAS
(From Survey by U. S. Engineers, 1930)

Elevation	Capacity Acre-Feet	Surface Area Acres	Remarks
5390	0	0	Stream bed at dam-site
5400	63.	12.6	
5410	290.	32.7	
5420	713.	51.9	
5430	1,317.	69.0	
5440	2,126.	92.7	
5450	3,221.	126.3	
5460	4,679	165.3	
5470	6,496.	198.0	
5480	8,681.	239.1	
5490	11,305.	285.6	
5500	14,390.	331.5	
5510	17,879.	366.3	
5520	21,671	392.1	
5530	25,724.	418.5	
5540	30,055.	447.6	Reservoir flow line.
5550	34,681.	477.6	Top contour of Survey.

Proposed North St. Vrain Dam.

A preliminary design for a dam at this site is shown in Plate 20. It is of the earth and gravel fill type with riprap protection on the upstream slope. The materials for the embankment are obtainable in the vicinity of the proposed dam.

The outlet is a concrete conduit founded on solid rock at the left end of the dam, with gate tower control in the middle of the embankment.

A short cut in the sandstone ridge forming the right abutment would provide a spillway of 3,000 second-feet capacity.

TABLE NO. 23

PRELIMINARY ESTIMATE OF COST OF NORTH ST. VRAIN DAM OF EARTH & GRAVEL FILL TYPE

Maximum h't. dam = 160 ft.   Storage Capacity = 30,000 Acre-feet.

Spillway Capacity - 3,000 sec. ft.   Outlet Capacity - 570 sec. ft.

Item	Quantity	Unit Cost	Total Cost
Care of Creek during Construction	Lump sum	$	$10,000.
Clearing and grubbing dam-site	25 Acres	100.00	2,500.
Stripping dam-site for embkt.:			
Earth Excavation	100,000 c.y.	0.40	40,000.
Earth and loose rock excav.	30,000 c.y.	1.50	45,000.
Excavation:			
Earth for outlet works	2,000 c.y.	0.15	300.
Gravel for outlet works	3,000 c.y.	0.50	1,500.
Gravel for cut-off trench	40,000 c.y.	0.50	20,000.
Rock for outlet works	850 c.y.	6.00	5,100.
Rock for spillway cut	5,800 c.y.	3.00	17,400.
Rock for cut-off wall	1,300 c.y.	6.00	7,800.
Embankment:			
Compacted earth fill	1,260,000 c.y.	0.40	504,000.
Sand, gravel and cobble fill	1,228,000 c.y.	0.75	921,000.
18" riprap on upper slope	38,000 c.y.	3.50	133,000.
12" gravel blanket	25,000 c.y.	1.00	25,000.
Concrete (reinforced):			
Intake and outlet for conduit	60 c.y.	20.00	1,200.
Outlet conduit and collars	580 c.y.	22.00	12,760.
Gate-tower	450 c.y.	22.00	9,900.
Upper cut-off wall	2,400 c.y.	15.00	36,000.
Parapet wall	190 c.y.	18.00	3,420.
Spillway lining	134 c.y.	15.00	2,010.
Reinforcing steel	200,000 lbs.	0.05	10,000.
Trashracks steel	30,000 lbs.	0.10	3,000.
Gates and operating devices	200,000 lbs.	0.20	40,000.
Re-locating 3 mi. of road around north side of reservoir	Lump sum		25,000.
Flooded R.O.W.:			
Cultivated area	120 acres	150.00	18,000.
Steep, rocky slopes	330 "	20.00	6,600.

Total Field Cost	$1,900,490.
Engineering and Inspection (5%)	95,025.
Contingencies (10%)	190,049.
Total Estimated Cost	$2,185,564.

Estimated cost per acre-foot for 30,000 acre feet capacity = $72.85

(b) South St. Vrain Reservoir Site.

The dam-site on the South Fork of St. Vrain Creek is similar to the one on the North Fork but has only about 2/3 the storage capacity behind it. Preliminary designs and estimates have been prepared for an earth and gravel fill type dam at this point of about the maximum height that would be justified by the surplus storage water available.

Reservoir Capacity.

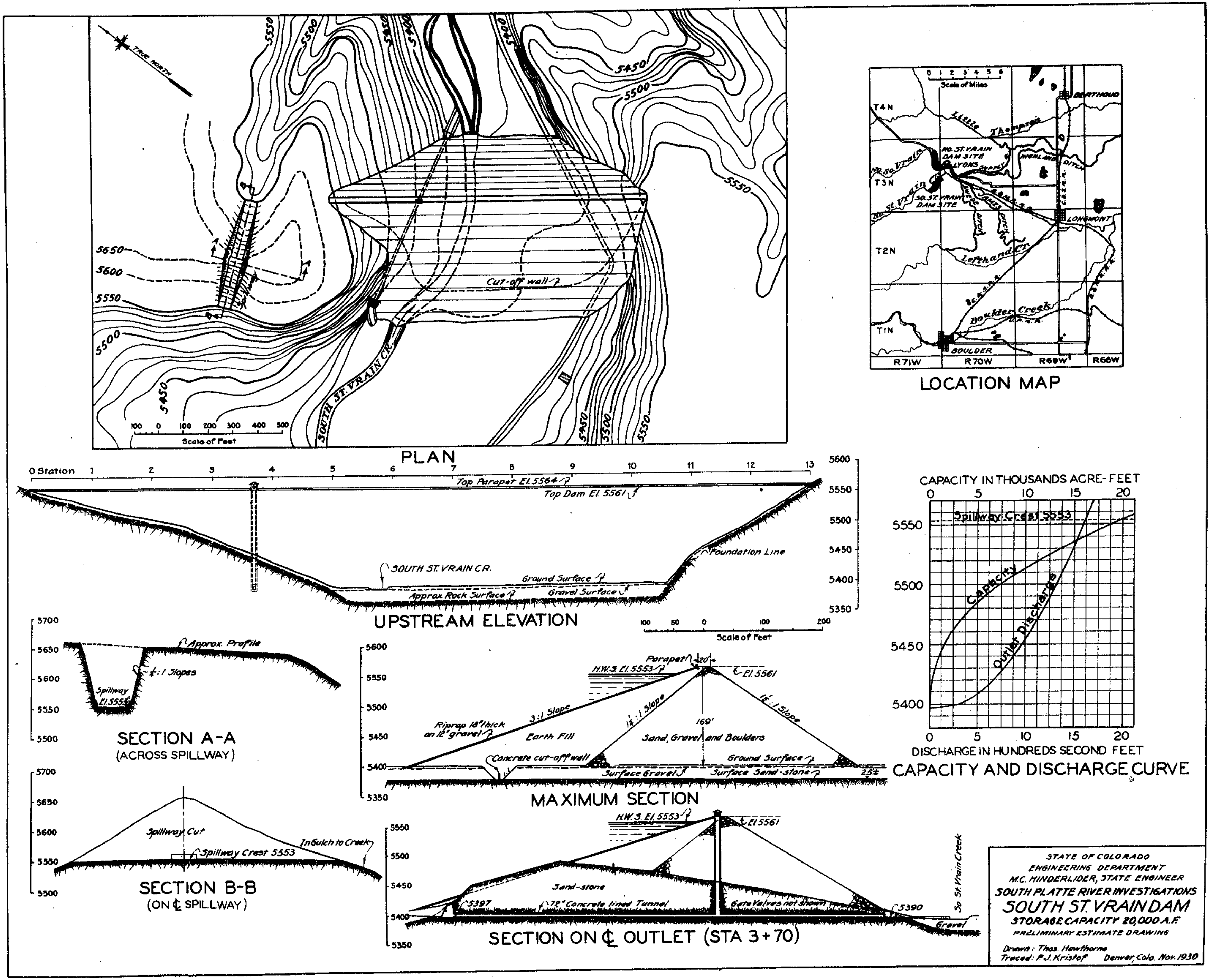
The capacity of this reservoir site was determined by measurements made on a 1000 foot per inch scale map surveyed by the U. S. Engineers' Office in 1930.

TABLE NO. 24.

SOUTH ST. VRAIN RESERVOIR - CAPACITIES AND SURFACE AREAS

(From Survey by U. S. Army Engineers, 1930)

Elevation	Capacity Acre-Feet	Surface Area Acres	Remarks
5396	0	0	Stream bed at dam-site.
5400	9.	1.8	
5410	105.	17.4	
5420	323.	26.1	
5430	629.	35.1	
5440	1,031.	45.3	
5450	1,571.	62.7	
5460	2,297.	82.5	
5470	3,240.	106.2	
5480	4,413.	128.4	
5490	5,807.	150.3	
5500	7,413.	171.0	
5510	9,246.	195.6	
5520	11,337.	222.6	
5530	13,683.	246.6	
5540	16,274.	271.5	
5550	19,131.	300.0	Top contour at survey.
5553	20,046	310.0	Reservoir flow line.


PLAN
TRUE NORTH
5650
5600
5550
5500
5450
5400
Spillway
Cut-off wall
SOUTH ST. VRAIN CR.
100 0 100 200 300 400 500
Scale of Feet
LOCATION MAP
0 1 2 3 4 5 6
Scale of Miles
BERTHOUD
LONGMONT
BOULDER
Little Thompson
No. So. Vrain
So. St. Vrain
Lefthand Cr.
Boulder Creek
NO. ST. VRAIN DAM SITE
SO. ST. VRAIN DAM SITE
LYONS
T4N
T3N
T2N
T1N
R71W
R70W
R69W
R68W
UPSTREAM ELEVATION
0 Station 1 2 3 4 5 6 7 8 9 10 11 12 13
Top Parapet El. 5564
Top Dam El. 5561
SOUTH ST. VRAIN CR.
Ground Surface
Approx. Rock Surface
Gravel Surface
Foundation Line
100 50 0 100 200
Scale of Feet
CAPACITY AND DISCHARGE CURVE
CAPACITY IN THOUSANDS ACRE-FEET
DISCHARGE IN HUNDREDS SECOND FEET
Spillway Crest 5553
Capacity
Outlet Discharge
SECTION A-A
(ACROSS SPILLWAY)
Approx. Profile
¼:1 Slopes
Spillway El. 5553
SECTION B-B
(ON ℄ SPILLWAY)
Spillway Cut
Spillway Crest 5553
In Gulch to Creek
MAXIMUM SECTION
Parapet
20'
H.W.S. El. 5553
El. 5561
3:1 Slope
1½:1 Slope
1½:1 Slope
169'
Riprap 18" thick on 12" gravel
Earth Fill
Sand, Gravel and Boulders
Concrete cut-off wall
Ground Surface
Surface Gravel
Surface Sand-stone
25±
SECTION ON ℄ OUTLET (STA 3+70)
H.W.S. El. 5553
El. 5561
Sand-stone
5397
72" Concrete lined Tunnel
Gate Valves not shown
5390
So. St. Vrain Creek
Gravel
STATE OF COLORADO
ENGINEERING DEPARTMENT
M.C. HINDERLIDER, STATE ENGINEER
SOUTH PLATTE RIVER INVESTIGATIONS
SOUTH ST. VRAIN DAM
STORAGE CAPACITY 20,000 A.F.
PRELIMINARY ESTIMATE DRAWING
Drawn: Thos. Hawthorne
Traced: P.J. Kristof
Denver, Colo. Nov. 1930

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Proposed South St. Vrain Dam.

A preliminary design, on which the following estimate is based, is shown in Plate 21. It is similar to the one proposed for the North St. Vrain dam.

The outlet of 430 second-feet capacity is a concrete lined tunnel in rock through the left abutment, the control gates being in a shaft near the middle of the dam.

The spillway would consist of a cut through a rock saddle, about 350 feet from the left end of the dam. It is designed for a capacity of 2,000 second-feet.

TABLE NO. 25

PRELIMINARY ESTIMATE - SOUTH ST. VRAIN DAM OF EARTH AND GRAVEL EMBANKMENT

Maximum h't. dam - 169 ft. Storage Capacity - 20,000 Acre-Feet.

Spillway Capacity - 2,000 sec.-ft. Outlet Capacity - 430 sec.-ft.

Item	Quantity	Unit Cost	Total Cost
Care of Creek during construction	Lump Sum		$ 10,000.
Clearing and grubbing dam-site	20 Ac.	$100.00	2,000.
Stripping dam-site for embkt.:			
Earth excavation	81,000 c.y.	0.40	32,400.
Earth and loose rock excav.	45,000 c.y.	1.50	67,500.
Excavation:			
Earth for outlet works	1,000 c.y.	0.15	150.
Gravel for outlet works	800 c.y.	0.50	400.
Gravel for cut-off trench	24,000 c.y.	0.50	12,000.
Rock for outlet works	500 c.y.	6.00	3,000.
Rock for spillway cut	59,000 c.y.	2.50	147,500.
Rock for cut-off wall	1,500 c.y.	6.00	9,000.
Rock for outlet tunnel	1,500 c.y.	12.00	18,000.
Rock for gate shaft	230 c.y.	12.00	2,760.
Embankment:			
Compacted earth fill	981,000 c.y.	0.40	392,400.
Sand, gravel and boulder fill	1,043,000 c.y.	0.75	782,250.
Rock fill from spillway cut	82,000 c.y.	0.15	12,300.
18" riprap on upper slope	30,000 c.y.	3.50	105,000.
12" gravel blanket	20,000 c.y.	1.00	20,000.
Concrete (reinforced):			
Intake and outlet for conduit	164 c.y.	19.00	3,116.
Outlet tunnel lining	600 c.y.	20.00	12,000.
Gate-tower and shaft	350 c.y.	22.00	7,700.
Upper cut-off wall	1,610 c.y.	15.00	24,150.
Parapet wall	150 c.y.	18.00	2,700.
Spillway lining	125 c.y.	15.00	1,875.
Reinforcing steel	150,000 lbs.	0.05	7,500.
Trash rack steel	30,000 lbs.	0.10	3,000.
Gates and operating devices	200,000 lbs.	0.20	40,000.
Re-locating 3 mi. of road around reservoir	Lump Sum		25,000.
Flooded R.O.W.			
Cultivated area	100 Ac.	150.00	15,000.
Steep, rocky slopes	210 Ac.	20.00	4,200.

Total Field Cost	$1,762,901.
Engineering and Inspection (5%)	88,145.
Contingencies (10%)	176,290.
Total Estimated cost	$2,027,336.

Estimated cost per acre-foot for 20,000 acre-feet capacity = $101.37

5. DISTRICT NO. 7 - RESERVOIR SITES.

The channel of Clear Creek affords little opportunity for construction of storage reservoirs at reasonable costs. No feasible stream-bed storage sites exist below the mouth of the canyon at Golden, where the fall of the creek is not excessive, and between Golden and the mouth of the west Fork of Clear Creek, about 8 miles above Idaho Springs, the channel is almost uniformly steep and narrow.

Two possible sites, where the stream bed widens out and the grade becomes less steep, were examined. The first is at Floyd Hill about 11 miles due west of Golden; the second is near Empire Station about 3/4 mile below the mouth of the west Fork of Clear Creek, and 7 miles above Idaho Springs.

Estimates of cost for dams at both of these sites, made by the U. S. Engineers' Office at Kansas City, indicate that the cost would be prohibitive and, therefore, the only feasible means for storing the surplus water of Clear Creek is the use of off-channel reservoir facilities to be served by large inlet canals.

(a) Floyd Hill Reservoir Site.

This dam-site is in a narrow stretch of Clear Creek Canyon, in granite formation just below Floyd Hill Station on the Georgetown branch of the Narrow Gauge Colorado and Southern R. R. The U. S. Highway leading to Berthoud Pass, as well as the C. & S. R.R. pass thru the dam and reservoir site. The reservoir would extend upstream about 3 miles to the Gem Power Plant and would cover a few small buildings at Floyd Hill Station and about 400 acres of rocky, unimproved land.

The construction of this reservoir would require a relocation of the highway, but it is likely that the railway could be abandoned at small cost.

Geology of the Floyd Hill Site.

Professor Wentworth made a geological examination of this dam and reservoir site in the summer of 1930. His report is quoted in full as follows:

"Introduction

The Floyd Hill Dam Site is located on Clear Creek about one-fourth mile downstream from Floyd Hill in Clear Creek County, Colorado. The site is about 25 miles due west of Denver. This district is located in the Rocky Mountain Physiographic Province and in the subdivision known as the Front Range of Colorado.

Clear Creek rises on the eastern slope of the Front Range and flows eastward to join the Platte a short distance north of Denver. Channel elevation at the Floyd Hill site is approximately 7185 feet and the average stream gradient is approximately 70 feet to the mile. The valley at the site is narrow, being only about 150 feet wide at the bottom and not over one-fifth mile at an elevation of 300 feet above the stream.

"General Geology

The Front Range of Colorado consists of granite and other crystalline rocks which form a core east of which there are exposed the steeply dipping edges of a long succession of Paleozoic and Mesozoic formations. The Floyd Hill site is located within the granite area and hence the sedimentary rocks are not involved in consideration of the present site.

"Detailed Geology

The crystalline rock in the immediate vicinity of the site consists largely of granite gneiss both light and dark in alternate bands and has a prevailing dip of approximately 40 degrees almost due north although there are some local variations. The right abutment consists of a debris-covered conical spur in which few bedrock outcrops are found. It is probable, however, that continuous bedrock will be discovered by excavation not over 15 or 20 feet deep on the average. The rock is considerably jointed and its surface portions may be somewhat pervious to water though this condition is probably only superficial. The left abutment is a nearly sheer rock face which also shows considerable jointing. The two abutments converge at such an angle as to indicate that it is probably not more than 15 or 20 feet from water level down to sound rock under the channel, but it will be necessary to explore both the abutments and the foundation by probing and diamond drilling to determine the exact configuration of sound rock. It is probable that the water table rises moderately steeply from water level on both sides but as is shown in the accompanying cross section the rock at this site is a sound and comparatively resistant rock which is capable, where unweathered, of carrying loads of at least 60 or 70 tons to the square foot.

"Recommendation

Geological conditions at this site are in the main favorable to the construction of a dam of any height up to

200 feet. The usual exploration by diamond drilling should be made and the design developed accordingly, but it is not considered that any really unfavorable conditions are likely to be found.

Respectfully submitted,

(Signed) Chester K. Wentworth.

Geologist."

Surplus for Storage

The average surplus available at Golden for the period 1918 to 1928, inclusive, was 27,000 acre-feet per year, and varied from practically nothing in the dry years 1919, '22, '25 and '27 to 108,000 acre-feet in 1921. The annual average surplus without the exceptional year of 1921, was 19,200 acre-feet. The average annual surplus for additional storage at Floyd Hill is estimated at approximately the same as that at the Golden gaging station.

Capacity

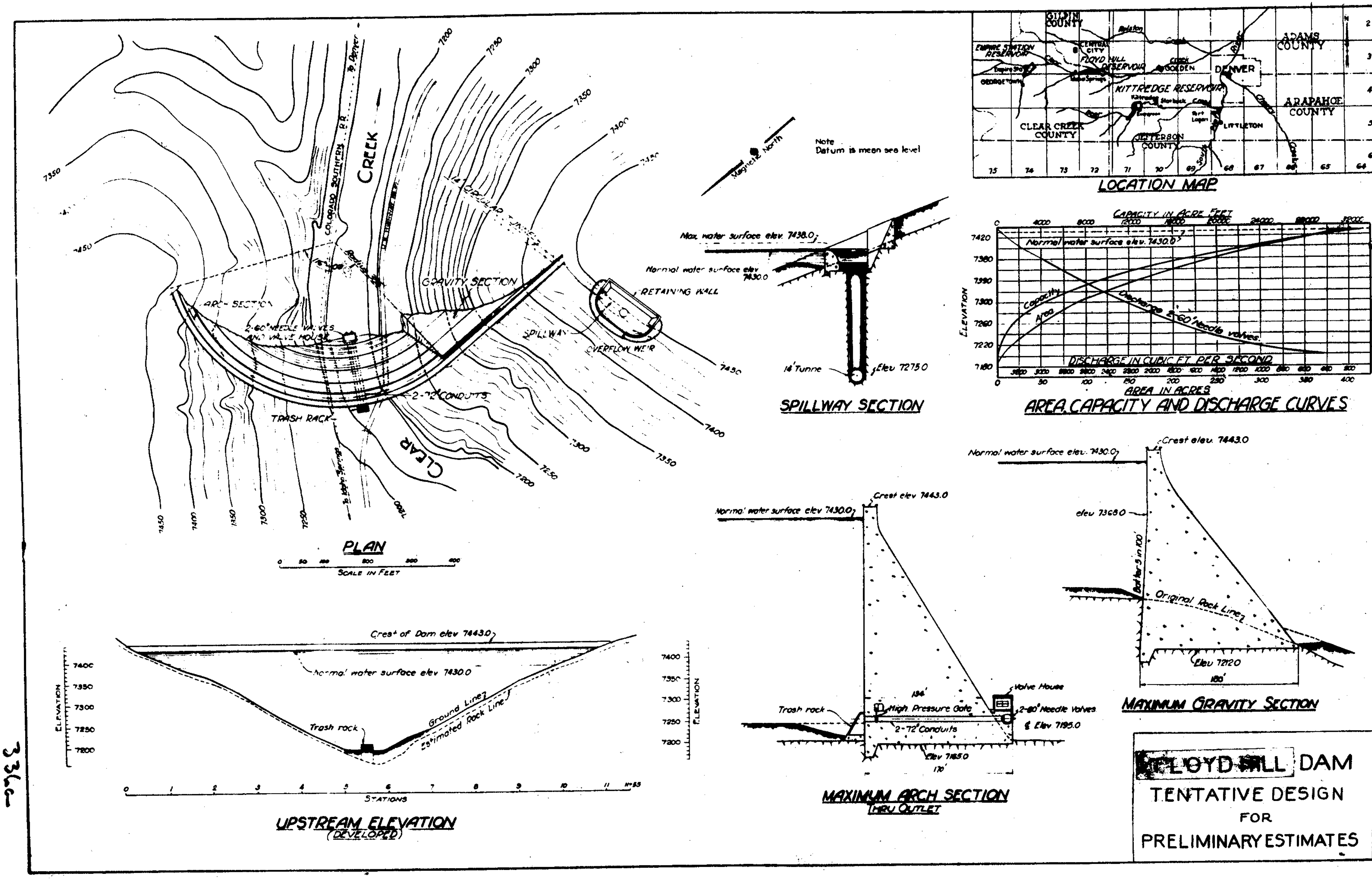
A dam 253 feet high above the stream-bed with a storage depth of 240 feet of water would form a reservoir about 3 miles long with a surface area of 397 acres and capacity of 33,110 acre-feet.

The average annual yield of this reservoir would be about 15,000 acre-feet, including reservoir seepage which would return to the stream and be available for diversion below.

The reservoir surface area and capacity for various depths, is shown graphically on Plate 22.

Proposed Floyd Hill Dam

Preliminary designs and estimates were made for a dam at this site by the U. S. Engineers' Office at Kansas City. The proposed design is shown on Plate 22.



FLOYD HILL DAM
TENTATIVE DESIGN
FOR
PRELIMINARY ESTIMATES
PLAN
SCALE IN FEET
CREEK
CLEAR
COLORADO SOUTHERN R.R.
To Denver
To Idaho Springs
GRAVITY SECTION
ARCH SECTION
2-60" NEEDLE VALVES AND VALVE HOUSE
2-72" CONDUITS
TRASH RACK
14' CIRCULAR TUNNEL
SPILLWAY
OVERFLOW WEIR
RETAINING WALL
Magnetic North
Note
Datum is mean sea level
SPILLWAY SECTION
Max. water surface elev. 7438.0
Normal water surface elev 7430.0
14' Tunnel
Elev 7275.0
LOCATION MAP
GILPIN COUNTY
ADAMS COUNTY
ARAPAHOE COUNTY
CLEAR CREEK COUNTY
JEFFERSON COUNTY
EMPIRE STATION RESERVOIR
CENTRAL CITY
FLOYD HILL RESERVOIR
GOLDEN
DENVER
KITTREDGE RESERVOIR
LITTLETON
AREA, CAPACITY AND DISCHARGE CURVES
CAPACITY IN ACRE FEET
Normal water surface elev. 7430.0
Capacity
Area
Discharge 2-60" Needle valves
ELEVATION
DISCHARGE IN CUBIC FT. PER SECOND
AREA IN ACRES
MAXIMUM GRAVITY SECTION
Crest elev. 7443.0
Normal water surface elev. 7430.0
elev 7368.0
Batter 5 in 100
Original Rock Line
Elev 7212.0
180'
MAXIMUM ARCH SECTION
THRU OUTLET
Crest elev 7443.0
Normal water surface elev 7430.0
Valve House
2-60" Needle Valves
℄ Elev 7195.0
High Pressure Gate
2-72" Conduits
Trash rack
134'
Elev 7165.0
170'
UPSTREAM ELEVATION
(DEVELOPED)
Crest of Dam elev 7443.0
Normal water surface elev 7430.0
Ground Line
Estimated Rock Line
Trash rack
STATIONS
ELEVATION

336a

The dam is of the concrete arch type with a gravity section on the right side. The outlet works to consist of 2- 72 inch conduits, controlled by 60 inch balanced needle valves and 5 x 6 feet high-pressure gates, capable of discharging 1,000 second feet of water under a head of 25 feet.

The spillway would consist of an overflow weir discharging into a concrete-lined shaft and tunnel 14 feet in diameter, which would pass the estimated maximum flood of 6,000 second feet with a depth on the weir crest of 5 feet.

TABLE NO. 26

PRELIMINARY ESTIMATE OF COST FLOYD HILL DAM OF CONCRETE ARCH TYPE
(By U. S. Army Engineers' Office, Kansas City)

Maximum h't. dam = 253 ft. Storage Capacity = 33,110 acre-feet.

Spillway Capacity = 6,000 sec. ft. Outlet Capacity = 1,000 sec. ft.

Item	Quantity	Unit Cost	Total Cost	
Excavation:				
Earth & loose rock, wet	16,000 c.y.	$ 2.00	$ 32,000	
" " " " dry	52,000 "	1.50	78,000	
Solid Rock, Dam	53,700 "	5.00	268,500	
Solid Rock, Tunnel	5,400 "	12.00	64,800	
Concrete:				
Dam	408,000 "	9.50	3,676,000	
Spillway	5,000 "	14.00	70,000	
Shaft and Tunnel	1,100 "	25.00	27,500	
Trash Rack floor	275 "	12.00	3,300	
Trash Rack frame	300 "	25.00	7,500	
Steel:				
Trash Rack	70,000 lbs.	0.10	7,000	
Conduit lining (C.I.P.)	540,000 "	0.12	64,800	
Reinforcing	200,000 "	0.05	10,000	
Misc. Steel & Metal	Lump Sum		5,000	
Gates, Valves & Machinery:				
2- 5 ft. x 6 ft. H.P.Slide	2 gates	25,000.00	50,000	
2- 60" Valves	2 valves	30,000.00	60,000	
Valve House & Controls:	Lump Sum		5,000	
Drainage System	Lump Sum		25,000	
Stream Control	Lump Sum		20,000	
Total Field cost			4,674,400	
Engineering and Contingencies, 20%			934,600	
Total Cost of Dam				$5,609,000.
Flowage Damages:				
Land	440 acres	$10.00	$ 4,400	
Gem Power Plant (600 H.P. installation)			75,000	
Highway Relocation (U.S.#40)	5 miles	15,000.00	75,000	
Field Cost			$154,400	
Engineering & Contingencies, 20%			30,600	
Total Cost Flowage Damages				185,000.
Total Cost of Reservoir				5,794,000.

Cost per acre-foot for 33,110 acre-ft. capacity = $175.00

Note: This estimate is based on the assumption that the Georgetown Branch of the Colo. & Southern Railway, which would be overflowed by the construction of this dam, will be abandoned.

(b) Empire Station Reservoir Site

The Empire Station dam-site is on Clear Creek about 3/4 mile below the mouth of the West Fork of Clear Creek and 7 miles above the town of Idaho Springs.

U. S. Highway No. 40, State Highway No. 91 and the Georgetown Branch of the Colorado and Southern Railway traverse the dam and reservoir site. The project could not be considered unless the railway is abandoned. About 7 miles of gravel highway would require relocation.

The area within the reservoir is unimproved with the exception of a few abandoned mining claims, a small idle power plant near the upper end, and the small station building at Empire Station.

Geology of the Empire Station Site

Following is a copy of a geological report on this site made by Professor Wentworth for the Kansas City U.S. Engineer Office in 1930:

"Introduction

This site is situated on Clear Creek about three-fourths mile downstream from Empire Station in Clear Creek County, Colorado. It is about thirty-five miles nearly due west of Denver. Clear Creek is a tributary of the South Platte and rises on the eastern slope of the Front Range of Colorado. It flows eastward to join the South Platte about five miles north of the City of Denver. This site is located near the eastern margin of the Rocky Mountain Physiographic Province.

The stream elevation at the site is approximately 8150 feet. The valley bottom is scarcely wider than the stream channel, and slopes some 60 or 80 feet to the mile.

The northwest valley wall is somewhat gentler close to stream level due to an accumulation of glacial debris and talus material, but further back the rock wall rises rather gently.

"General Geology.

The Colorado Front Range, which is the first mountain range one encounters in going west from the Great Plains, consists of a crystalline core of granite and igneous and metamorphic rocks. East of the granite is a series of sedimentary rocks of which the component formations dip steeply toward the plains and form, because of their contrasting resistance to erosion, a series of more or less continuous hogback ridges. The Empire Station site is located west of the lowermost sedimentary beds and well within the granite core of the mountains. The valley of Clear Creek is here some thousand feet or more in depth and shows a somewhat diversified topography due to the action of glacial ice during the Pleistocene period.

"Detailed Geology

The left abutment of the site is part of a partly detached rounded knob which has been molded by glacial erosion and which is connected with the left-hand valley wall by a saddle which rises about 220 feet above stream level. The summit of the knob is 50 or 75 feet higher than this longitudinally. Both the knob and the saddle have a length of somewhat over a thousand feet and probably constitute a fully adequate rock barrier. The right-hand abutment is in a mass of coarse talus material which probably contains also some glacial debris. This rises to a height of 70 or 80 feet above stream level and its upper surface rises toward the main valley wall at a slope of perhaps 15 degrees for several hundred feet. From its margin the main rock wall of the mountain rises at a 40 or 45 degrees angle.

About 400 feet downstream from the point of the left-hand spur the right-hand rock wall extends somewhat closer to the stream and is flanked by a considerably smaller cone of talus debris. It will be necessary to make a detailed exploration by probing to determine the depth and condition of the rock profile on the right-hand side. The bedrock of both valley walls is a medium to coarse-grained pink granite which has been much intruded by basic rock stringers which now have a somewhat gneissic structure. The rock on both sides is a strong, sound rock and will probably safely carry at least 75 or 80 tons to the square foot. No bedrock was seen in the stream channel in the vicinity and it is possible owing to the large mass of detrital material in the right abutment that the rock profile was cut during glacial time to a depth considerably below present stream level. No confident estimate can be given but it would not be surprising if detrital material extends fifty or a hundred feet below channel level.

The water table in the abutments probably rises at a moderate angle and may reach an elevation approximately of crest level in the wall of the valley proper, but a considerable cross section of unsaturated rock will probably be found in the immediate topographic abutments.

"Recommendation

The bedrock at this site is entirely adequate for the support of a dam 200 feet or more in height and little difficulty will be encountered in preparing a strong support in the left abutment. The principal problem to be investigated by further exploration and diamond drilling is the depth and convergence of the bedrock profile under the stream channel and the thickness of detrital material of the right abutment. Feasibility of construction and the character of the design will depend on the amount of detrital material which may need to be excavated on this side. It is possible that in part the detrital material may be sufficiently massive to form the mechanical barrier provided it is reinforced by a cut-off wall or some such impermeable structure.

Respectfully submitted

(Signed) Chester K. Wentworth
Geologist."

Surplus for Storage

Although the stream discharge at Empire Station averages about 75% that at Golden, a comparison of the flow at Empire Station at times when surplus flows become available at Golden shows that practically all of these surplus quantities were flowing at Empire Station and could have been impounded without infringing on water rights below. Therefore, the surplus at Empire Station is practically the same as that for the Golden gaging station and for Floyd Hill, or an average of about 27,000 acre-feet per year.

Capacity

The maximum practical capacity for a reservoir at this site is for a water depth of 230 ft., which corresponds to 59,680 acre-feet of storage.

The average annual yield of a reservoir of this size would be about 25,000 acre-feet, or nearly all of the storable surplus on Clear Creek.

See Plate 23 for reservoir capacity and area curves for different water depths.

Proposed Empire Station Dam

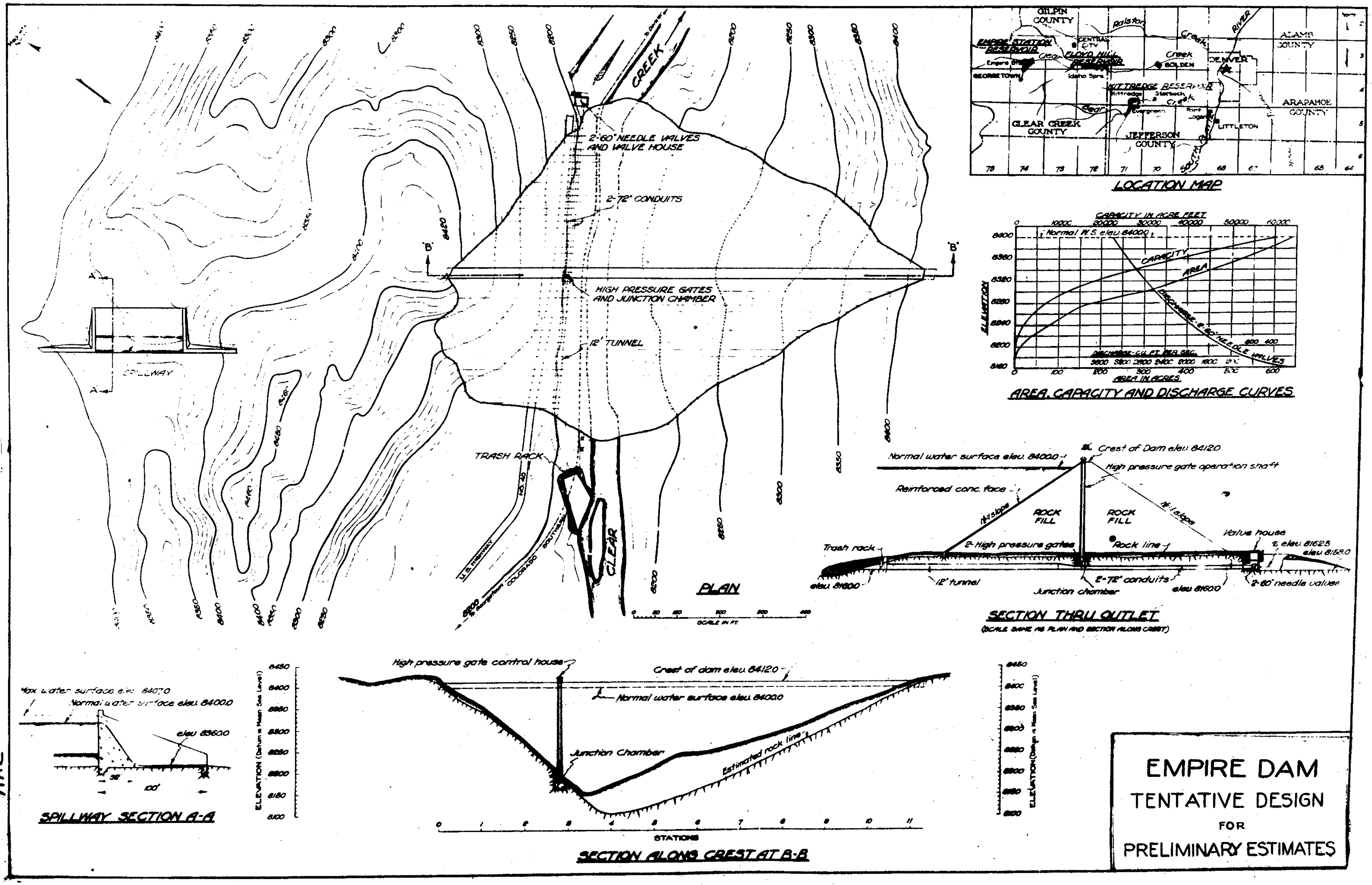
The preliminary estimate for this dam was made by the Kansas City U. S. Engineers' Office according to the design on Plate 23.

The site for the dam is in granite formation. Bedrock is exposed on the steep slope of the left abutment but is covered in the stream channel and on the lower slope of the right abutment by a talus or glacial deposit. No test pits or borings were put down to determine the depth to solid rock, but the assumption of 50 to 100 ft. depth is probably well on the safe side. If the depth to bedrock on the right side is materially less than that assumed, it is likely that a concrete dam could be constructed on this site at a considerable saving in cost per acre-foot stored, than shown.

The dam chosen for the estimate is of the rock fill type with reinforced concrete facing on the water face.

The outlet as planned consists of a concrete lined tunnel 12 feet in diameter, located in the solid rock of the left abutment from a point above the dam, to a gate tower on the center line, where connection is made with two 72" concrete lined tunnels, which extend to a point below the lower toe of the dam. Two high pressure gates in the gate tower at the center of the dam and a gate house containing 2- 60" balanced needle valves at the lower end of the 72" conduits are provided by the designs. The valves are estimated to have a capacity of 1,000 second feet under a head of 25 feet.

The spillway would be in a saddle behind the granite point which forms the left abutment, and about 700 feet from the left end of the dam. It is designed as a concrete overflow wair about 30 ft. high above the ground surface and 200 feet in length. It would discharge 6,000 second feet with a depth on the crest of 4 feet.


EMPIRE DAM
TENTATIVE DESIGN
FOR
PRELIMINARY ESTIMATES
PLAN
2-60" NEEDLE VALVES AND VALVE HOUSE
2-72" CONDUITS
HIGH PRESSURE GATES AND JUNCTION CHAMBER
12' TUNNEL
TRASH RACK
CREEK
CLEAR
SPILLWAY
U.S. HIGHWAY NO. 40
COLORADO SOUTHERN
SCALE IN FT.
LOCATION MAP
GILPIN COUNTY
ADAMS COUNTY
ARAPAHOE COUNTY
CLEAR CREEK COUNTY
JEFFERSON COUNTY
EMPIRE STATION RESERVOIR
FLOYD HILL RESERVOIR
KITTREDGE RESERVOIR
DENVER
GOLDEN
LITTLETON
GEORGETOWN
Idaho Sprs.
Evergreen
Kittredge
Ralston
RIVER
AREA, CAPACITY AND DISCHARGE CURVES
CAPACITY IN ACRE FEET
Normal W.S. elev. 8400.0
CAPACITY
AREA
DISCHARGE 2-60" NEEDLE VALVES
DISCHARGE-CU. FT. PER SEC.
AREA IN ACRES
ELEVATION
SECTION THRU OUTLET
(SCALE SAME AS PLAN AND SECTION ALONG CREST)
Crest of Dam elev. 8412.0
Normal water surface elev. 8400.0
High pressure gate operation shaft
Reinforced conc. face
ROCK FILL
ROCK FILL
Rock line
2-High pressure gates
Junction chamber
2-72" conduits
Trash rack
12' tunnel
elev. 8160.0
elev. 8160.0
Valve house
℄ elev. 8162.5
elev. 8158.0
2-60" needle valves
SECTION ALONG CREST AT B-B
High pressure gate control house
Crest of dam elev. 8412.0
Normal water surface elev. 8400.0
Junction Chamber
Estimated rock line
STATIONS
ELEVATION (Datum is Mean Sea Level)
SPILLWAY SECTION A-A
Max water surface elev. 8407.0
Normal water surface elev. 8400.0
elev. 8360.0
100'

344a

TABLE NO. 27

PRELIMINARY ESTIMATE OF COST OF EMPIRE STATION DAM OF ROCK FILL TYPE CONCRETE FACE
(By U. S. Army Engineers' Office, Kansas City)

Maximum h't. dam (above stream-bed) 242 ft. Storage Capacity = 59,680 acre-ft.

Concrete Weir Spillway in Saddle, capacity = 6,000 sec.ft. Outlet capacity = 1,000 sec. ft.

Item	Quantity	Unit Cost	Total Cost	
Excavation:				
Earth & Loose Rock, Dam	66,000 c.y.	$ 1.50	$ 99,000	
Rock Tunneling	3,400 "	12.00	40,800	
Cut-off Trench	10,000 "	10.00	100,000	
Rock Fill	1,500,000 "	2.50	3,750,000	
Concrete:				
Facing	19,300 "	16.00	308,500	
Cut-off Wall	8,500 "	20.00	170,000	
Outlet	1,600 "	25.00	40,000	
Parapet	220 "	35.00	7,700	
Trash Rack Floor	300 "	12.00	3,600	
Trash Rack Frame	360 "	25.00	9,000	
Weir, Bulkhead and Apron (Spillway)	12,100 "	12.00	145,200	
Steel:				
Trash Rack	80,000 lbs.	0.10	8,000	
Reinforcing	209 tons	100.00	20,900	
Miscl. Steel and Metal	Lump sum		5,000	
Gates, Valves & Machinery:				
2-5' x 6' H. P. Slide	2 gates	20,000.00	40,000	
2- 60" Valves	2 valves	25,000.00	50,000	
Valve House & Controls	Lump sum		5,000	
Stream Control	Lump sum		20,000	
Total Field Cost - - - - - - - - - - - - - - - -			$4,823,000	
Engineering and Contingencies, 20% - - - - - -			965,000	
Total Cost of Dam - - - - - - - - - - - - - - - - -				$5,788,000.
Flowage Damages:				
Relocated highway U.S.#40	2 miles	$15,000.00	$ 30,000	
" " State#91	5 miles	15,000.00	75,000	
Land	670 acres	10.00	6,700	
Field Cost -			111,700	
Engineering and Contingencies, 20% - - - - - - -			22,300	
Total Cost Flowage Damages				134,000.
Total Cost of Reservoir				$5,922,000.

Cost per Acre-Foot for 59,680 Acre-Feet Capacity = $99.30

Note: This estimate is based on the assumption that the Georgetown Branch of the Colorado and Southern Railway, which would be overflowed by construction of this dam, will be abandoned.

6. DISTRICT NO. 9 - RESERVOIR SITE, KITTREDGE

The channel of Bear Creek is similar to the other mountain tributaries of the South Platte River, in that there are few opportunities for economical storing of water. The Kittredge site, just below the summer resort of Kittredge, appears to be the one most favorably located on the creek for storing practically all of the available surplus. However, the size of the dam required makes the cost per acre-foot too great to be attractive as an irrigation supply.

State Highway No. 74 passes through the dam and reservoir site, and a secondary road runs up the Myers Gulch branch of the reservoir. About 40 small wooden buildings in the village of Kittredge would be below the flow line and require removal to higher ground. With the exception of the land in the townsite the reservoir site is rocky, unimproved pasture.

Geology of the Kittredge Site.

Professor Wentworth's geological report on the Kittredge site is given in full, as follows:

"Introduction

The Kittredge Dam Site is located on Bear Creek approximately one-half mile downstream from the hamlet of Kittredge, Colorado. The site is on Highway Number 8 and is approximately fifteen miles southwest of Denver in Jefferson County, Colorado. Bear Creek is tributary to the South Platte River and rises at a point a short distance east of Mount Evans near the summit of the Colorado Front Range. From this point it flows in a general easterly direction to enter the South Platte a short distance south of Denver.

The Kittredge District is near the eastern margin of the Rocky Mountain Physiographic Province and only a few miles from the western edge of the Great Plains. The stream elevation at this point is approximately 6800 feet and the stream gradient in the vicinity is about 50 feet to the mile. The local relief amounts to several hundred feet and the valley walls rise at rates of 500 feet to the mile. At the point chosen for the Kittredge Site the valley flat is not over 150 feet in width, and the width at an elevation of 108 feet above the stream is not over a quarter mile.

"General Geology

The Colorado Front Range consists of a central core of granite and other crystalline rocks. Eastward from these crystalline rocks is a long succession of sedimentary rocks from Cambrian to Tertiary in age. Close to the mountains these rocks dip steeply but the dips become less to the eastward and presently merge into gentler dipping strata which characterizes the Great Plains Province. North and South along the mountain front the varying resistance of different strata together with their trenching by-streams which flow eastward from the mountains gives rise to parallel belts of disconnected hogback ridges. The Kittredge Site is located east of the sedimentary belt and in the crystalline rocks of the mountainous area.

"Detailed Geology

In the immediate vicinity of the Kittredge Site the bedrock is chiefly a pink to gray granite with an average grain of one to two millimeters. The rock is largely made up of pink orthoclase feldspar and quartz with a few flecks of dark biotite. In some places the rock gives way to granite gneiss and in others there are developed great masses of coarse granite pegmatite which differs from the granite in the great size of individual masses of quartz and feldspar.

In the left abutment the rock is rather generally exposed up to 150 or more feet above stream level and probably massive and sound at a moderate distance under the surface. At the surface it is somewhat weathered into rounded masses and shows considerable irregular jointing in a spacing of 6 inches to 3 or 4 feet. It is probable that much of this jointing is brought into prominence by surface weathering and there is probably no great strata impairment at depth.

In the right abutment the rock is less well exposed and the somewhat gentler slope is more completely mantled with talus. However, scattered outcrops protrude through the talus and continue all the way to the top of the small knob which constitutes the abutment at an elevation of 190 feet above stream level. Back of this knob occurs a saddle which is about 25 feet lower than the summit of the knob and in which no bed-rock is visible. From the smoothness of the saddle it is probable that the sound rock profile may lie as much as 50 or 75 feet below the surface and some re-inforcement may be needed here.

The valley of the stream is underlain by alluvial sand and gravel and there is no evidence of bedrock at the site except at the margin of the flat. Even in a comparatively narrow gorge a short distance downstream no bedrock was seen in the immediate channel. Hence it seems probable that the bedrock profile may dip to as much as 50 or 100 feet below stream level. But if this is true the profile is rather narrow.

The granite and gneiss at the locality are strong and compact rocks except as they are weathered near the surface and capable of carrying loads as high as 75 or 80 tons to the square foot. On the right side of the stream, ground water level is probably somewhat low because of the narrowness of the saddle and spur, but the water table is probably somewhat higher on the left side, though no springs were seen to indicate water close to the bluff at any elevation near the probable crest height.

"Summary and Recommendation

There is little doubt that a strong abutment support can be prepared on the left side with the moderate amount of excavation. On the right side the depth to sound rock is not easily estimated and careful probing and drilling will be needed for a considerable distance along the axis to determine the depth and quality of rock here. This probing should extend across the above mentioned lower saddle to determine the sort of treatment needed here, and to aid in finding the practical crest height of the dam. Probing will also be needed across the stream flat to determine the profile of the existing rock foundation.

In the foundation and left abutment there is little doubt that the rock is sufficiently strong and impervious to provide for a stable and effective dam. But there is a possibility that in the right abutment and saddle the impairment may extend deep enough so as to require grouting or some other such measure to forestall dangerous leakage. With adequate preliminary exploration however, it is believed that no difficulty will be encountered in developing a safe design and the site is to be regarded as fairly favorable from the geological standpoint.

Respectfully submitted

(Signed) Chester K. Wentworth
Geologist."

Surplus for Storage at Kittredge

The average annual surplus for channel storage at this reservoir site is estimated at about 12,000 acre-feet, ranging from nothing in dry years, to 29,000 acre-feet in a wet year such as 1921. A 20,000 acre-foot reservoir would have yielded about 10,000 acre-feet annually for the past 12 years.

Capacity

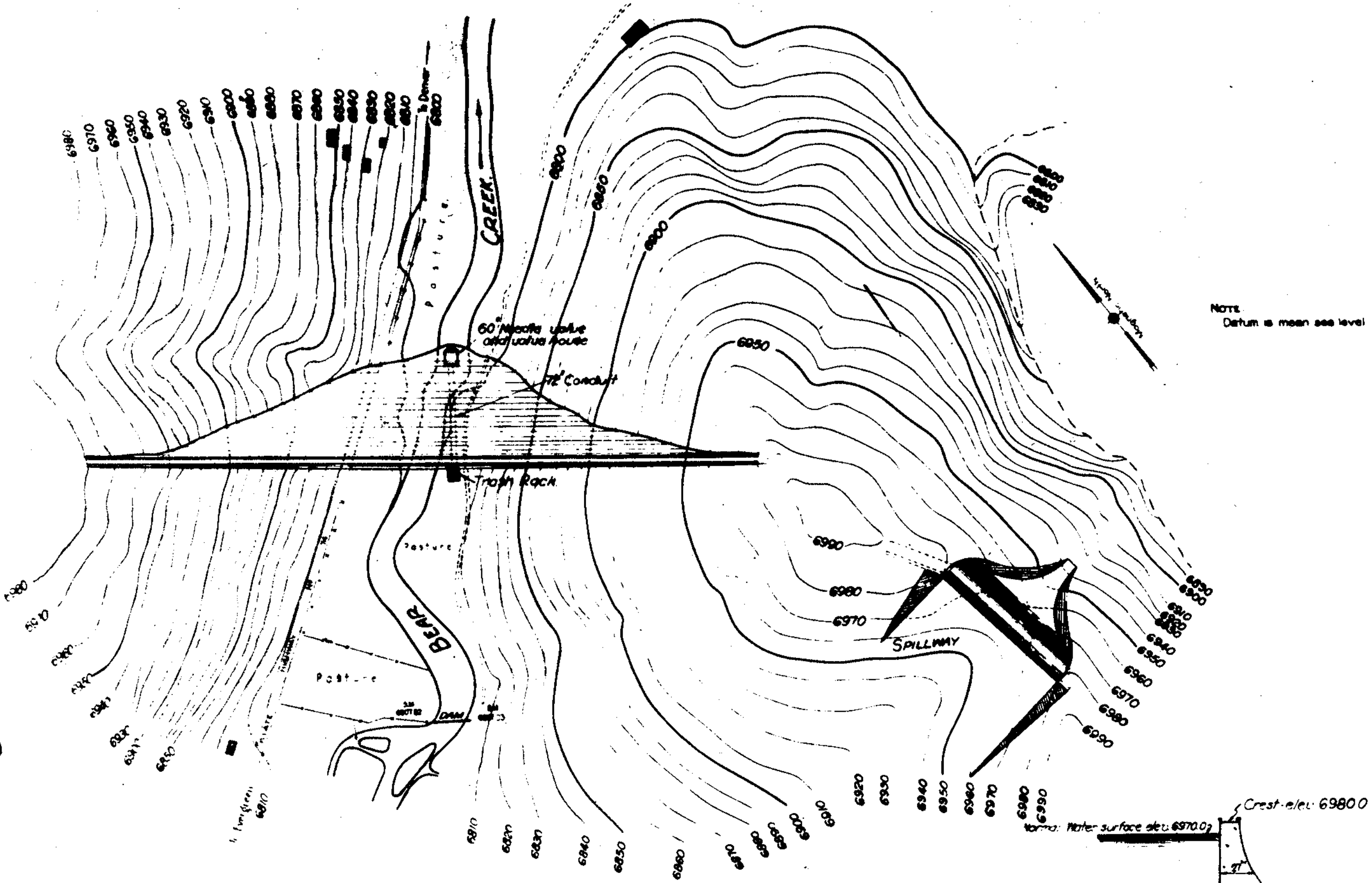
The maximum practical height for a dam at the Kittredge site is about 185 feet above a stream-bed, to store 175 feet in depth of water or 20,960 acre-feet, forming a surface area of 299 acres.

Reservoir area and capacity curves for depths from 0 up to the maximum of 175 ft. are shown on Plate No. 24.

Proposed Kittredge Dam

Preliminary designs and estimates for this dam were prepared by the Kansas City office of the U. S. Army Engineers. The proposed design is shown on Plate No. 24.

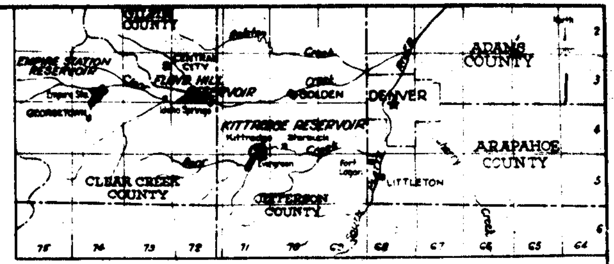
The dam is of the straight, concrete, gravity type 185 ft. in maximum height above the stream-bed. It is assumed that it will be necessary to excavate about 30 feet below the bed of the creek to secure



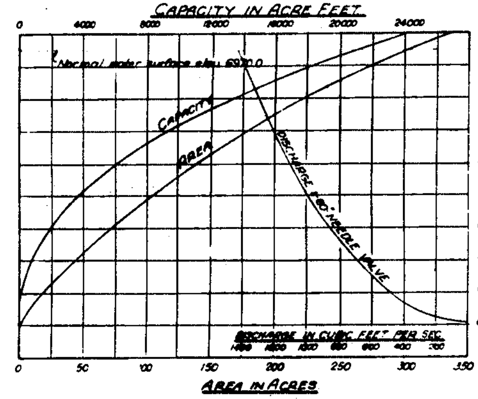
PLAN

SCALE IN FEET

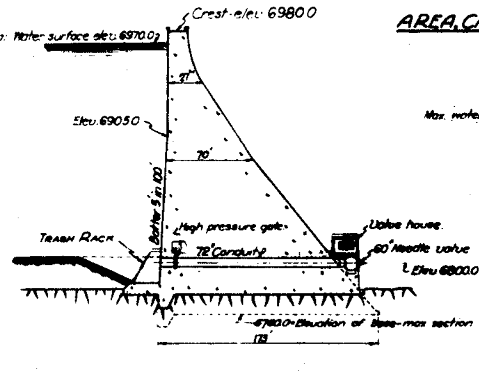
NOTE
Datum is mean sea level



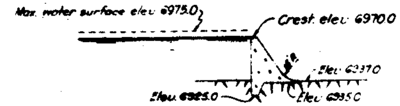
LOCATION MAP



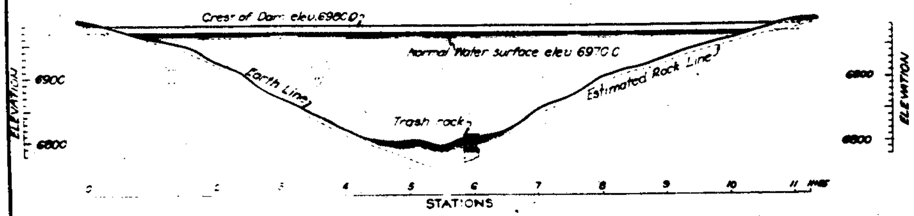
AREA, CAPACITY, AND DISCHARGE CURVES



SECTION THRU OUTLET



SPILLWAY SECTION



UPSTREAM ELEVATION
(NATURAL SCALE)

350a

KITTREDGE DAM
TENTATIVE DESIGN
FOR
PRELIMINARY ESTIMATES

solid rock foundation. The site has not been tested for foundation conditions.

The outlet would be a 72" C. I. conduit through the dam at stream level, controlled by one 60" needle valve at the lower end and one 5' x 6' high pressure emergency gate near the upper end. The valve would discharge approximately 400 sec. feet under a 15 ft. head.

The spillway structure would consist of a concrete overflow weir in the saddle about 500 feet south of the right end of the dam. It is designed for a height of 35 feet and length of 240 feet, with the assumption that it is about 30 feet to bed rock in the saddle, which seems to be far on the safe side. The weir would pass the estimated flood flow of 2,500 second feet with a depth on the crest of about 2 feet.

TABLE NO. 28

PRELIMINARY ESTIMATE OF COST KITTREDGE DAM - CONCRETE GRAVITY TYPE

(By U. S. Army Engineers' Office, Kansas City)

Max h't. above stream-bed = 185 ft. Storage Capacity = 20,960 acre-feet

Concrete Weir Spillway in Saddle, Capacity = 2,500 sec. ft.

Outlet Draft = 400 sec. ft.

Item	Quantity	Unit Cost	Total Cost	
Excavation:				
Earth & Loose Rock, Dam				
Dry	16,000 c.y.	$ 1.50	$ 24,000	
Wet	25,000 "	2.00	50,000	
Spillway	25,000 "	1.00	25,000	
Rock	16,000 "	5.00	80,000	
Concrete:				
Dam	230,000 "	9.50	2,185,000	
Spillway	7,000 "	14.00	98,000	
Trash Rack Floor	150 "	12.00	1,800	
Trash Rack Frame	160 "	25.00	4,000	
Steel:				
Conduit Lining (C.I.P.)	280,000 lbs.	0.12	33,600	
Reinforcing	100,000 "	0.05	5,000	
Trash Rack	40,000 "	0.10	4,000	
Misc. Steel & Metal	Lump Sum		5,000	
Gates, Valves & Machinery:				
1- 5' x 6' H.P. Slide	1 Gate	20,000.00	20,000	
1-60" Valve	1 Valve	25,000.00	25,000	
Valve House & Controls	Lump Sum		2,500	
Drainage System	Lump Sum		25,000	
Stream Control	Lump Sum		20,000	
Total Field Cost			$2,607,900	
Engineering & Contingencies, 20%			522,100	
Total Cost of Dam				$3,130,000.
Flowage Damages				
Relocated St.Highway #74	4 miles	$15,000.00	$60,000	
Reinforced Conc. Bridge	105 ft.long		10,000	
Land	280 acres	10.00	2,800	
Land	50 "	50.00	2,500	
Removal of buildings	Lump sum		100,000	
Field Cost			$175,300	
Engineering & Contingencies, 20%			34,700	
Total Cost Flowage Damages				210,000.
Total Cost of reservoir				3,340,000.

Cost per acre-foot for 20,960 acre-feet storage = $159.30

CHAPTER IV

GENERAL DESCRIPTION

of

METHODS OF IRRIGATION, CHARACTER OF CROPS AND IRRIGATED AREA

by

STREAM SYSTEM

DISTRIBUTION OF EXISTING IRRIGATION DEVELOPMENT
SOUTH PLATTE RIVER AREA

Note: The following tabulation is arranged geographically by water districts from the headwaters of the South Platte River to the Colorado-Nebraska State Line.

The crops are given in the order of importance in the district.

Water District	Stream System	Total Area Irrigated (Acres)	Principal Crops	METHODS Of Development
23	South Platte R. and tributaries above mouth of canon	48,000	All native hay	Heavy flooding of land from May to August. A few small irrigation reservoirs in the district.
8	South Platte R. and tributaries from mouth of Canyon to Denver	50,490	Cereals, alfalfa, market gardens, wild hay, sugar beets and orchards	Mostly direct irrigation from South Platte River, Cherry Cr. Plum Cr. and Deer Cr. Storage water is used from Antero Res. in Dist. 23 from Castlewood Res. on Cherry Cr. and from a number of small off-channel reservoirs.
9	Bear Creek and Turkey Creek	18,793	Cereals, Alfalfa wild hay and sugar beets.	There are 16 direct diversion canals below the mouth of the canyon. 15 small off-channel reservoirs provide storage.
2	South Platte R. and surplus from tributaries from Denver to mouth Cache la Poudre River.	199,170	Cereals, alfalfa, sugar beets, beans native hay and potatoes.	About 80% of the irrigation supply comes from direct diversion from the South Platte R., the remainder from off-channel reservoirs, the largest of which are Barr Lake and Milton Lake.
7	Clear Creek and tributaries, the main one being Ralston Creek	104,201	Cereals, alfalfa, market gardens, orchards, sugar beets, wild hay and cabbage.	Irrigation is mostly by direct diversion. Many small reservoirs in the district under the irrigation canals provide a limited amount of temporary storage. There are no channel reservoirs.

DISTRIBUTION OF EXISTING IRRIGATION DEVELOPMENT
SOUTH PLATTE RIVER AREA (Cont'd.)

Water District	Stream System	Total Area Irrigated (Acres)	Principal Crops	Methods of Development
6	Boulder Creek, S.Boulder Creek and Coal Creek	151,060	Native hay, cereals, alfalfa and sugar beets	Over 80% of the irrigation supply is from direct diversion. There are 22 small reservoirs in the district, mostly fed by irrigation canals. Barker Meadow power reservoir is the only channel reservoir in the district.
5	St. Vrain Creek and tributaries, the principal of which are North St. Vrain Cr., S. St. Vrain Cr., Left Hand Cr. & Dry Creek	81,565	Cereals alfalfa, sugar beets, wild hay and peas. (About ½ of the irrigated area is in cereals.)	77% of the water used comes from direct irrigation. Over 60 small off-channel reservoirs provide the balance of the supply. The Union Reservoir of 13,000 acre-feet capacity is the largest in the district but its stored water is used in districts 2 and 1. The Left Hand Ditch irrigates about 12,000 acres high in the mountains above the mouth of the canyon at Lyons.
4	Big Thompson R. Little Thompson Cr. and Buckhorn Creek.	137,931	Cereals alfalfa, sugar beets, potatoes, beans, and orchards. (Cereals comprise about ½ of the irrigated area).	Practically all irrigated lands are below the mouth of the canyon. About 77% of the irrigation supply is derived from direct diversion by many large and small canals. There are 21 storage reservoirs in the district with aggregate capacity of 101,000 acre-feet. Buckhorn Res. on Buckhorn Cr. is the only one on a main stream channel.
3	Cache la Poudre R. and tributaries and transmountain diversions from Laramie River, Michigan Creek and Grand River	267,014	Cereals, alfalfa, potatoes, sugar beets, beans and market gardens. (About 1/3 of the area is in cereals).	A little wild hay is irrigated above the mouth of the canyon. There are 23 principal canals which divert for direct irrigation from the Poudre River below the mouth of the canyon and one main diversion from the North Fork. 25% of the supply comes from storage in the district and about 11% from transmountain diversions. 48 reservoirs with a total storage capacity of 140,000 acre-feet are in operation. Two of these, Chambers Lake on the upper Poudre R. and Halligan on the North Fork are channel reservoirs and have a combined capacity of only about 13,000 acre-feet. The other reservoirs are in depressions away from the channel and are supplied by feed canals.

DISTRIBUTION OF EXISTING IRRIGATION DEVELOPMENT
SOUTH PLATTE RIVER AREA (Cont'd.)

Water District	Stream System	Total Area Irrigated (Acres)	Principal Crops	Methods of Development
1	South Platte R. and tributaries from mouth of Cache la Poudre R. to Washington County.	150,846	Alfalfa, cereals, wild hay, sugar beets, beans and potatoes. (Largest crop is alfalfa and covers about 29% of the area.)	About 65% of the water for this district is by direct diversion from the river supplemented by return flow which supplies a large part of the demand. Water is stored in 6 principal off-channel reservoirs ranging in size from 6,190 acre-feet to 57,500 acre-feet and totaling 155,543 acre-feet capacity. There are 21 main diversions from the river and numerous small ditches taking out from intermittent tributaries and irrigating a total of about 22,000 acres of land.
64	South Platte R. and tributaries from west boundary of Washington Co. to State line.	146,593	Cereals, alf., wild hay, sugar beets and beans.	Most of the water supply for this district has been developed from return flow incident to irrigation upstream. It is one of the latest districts to be formed and has one of the most reliable water supplies in the state. 68% of the water is taken from direct flow, the remainder coming from three large off-channel reservoirs, Prewitt, Point of Rocks and Julesburg. The first two mentioned reservoirs divert in Dist. 1, Julesburg being the only one to take its water from District 64.
	Totals	1,355,663	Cereals 36%, alf. 26%, wild hay 12%, sugar beets 11%, potatoes 5%. Misc. 4½%, Beans 2½%, Mk't gardens 2%, orchards 1%.	For the South Platte Basin as a whole about 3/4 of the irrigation supply is diverted directly from streams, the remainder being derived from hundreds of storage reservoirs, most of which are away from the streams in natural depressions and are fed by supply canals. Return flow plays an important part in the available irrigation supply of the basin. It is estimated at about 47% of the total annual average supply.

Note: The above includes areas in Colorado only. The areas irrigated are averages for the years 1921 to 1928, inclusive. By this scheme the average irrigated area for the western irrigation district would be 13,867 acres. I have no data for Lodge Pole ditch, Kimball Canal nor Paxton Canal. Irrigated areas in the South Platte area fluctuate considerably from year to year in accordance with the sufficiency of the water supply. The large percentage in cereals allows adjustment of the irrigated areas to fit the water available without total loss of crops as cereals usually can be matured by dry farming methods although the returns without irrigation are mostly unsatisfactory.

CHAPTER XV

PRINCIPAL EXISTING IRRIGATION PROJECTS (CANALS)

SOUTH PLATTE RIVER BASIN

PRINCIPAL EXISTING IRRIGATION PROJECTS (CANALS)
SOUTH PLATTE BASIN

Note: Original construction of ditches datesback to oldest priorities unless otherwise stated. Ditch lengths are for main ditches only without laterals. Decrees are present net decrees, including transfers and enlargements.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
23	Many small, private ditches	South Fork of South Platte R. & Tarryall Cr.	50,000	There are decrees for 409 small ditches dating from 1861 to the 1920's. Irrigated area is about equally divided between upper So. Fork & Tarryall Cr. Construction by private enterprise. Lands at 8,500 to 10,000 ft. elevation.
8	Brown Canal	South Platte R.	156	Priority of 1862. Decree for 16.5 sec. ft. Capacity 16 sec. ft., length 3 miles, constructed by pri-private enterprise.
	Nevada Canal (Nevada Ditch Co.)	South Platte R.	1,900	Priorities of 1861-1865. Decreed for 48.8 sec. ft. Capacity 60 sec. ft., length 6 miles. Constructed by cooperative enterprise. Land on west side of river.
	Highline Can. or Northern Colo. Irr. Co's Can. (City & County of Denver)	South Platte R.	100,000	Priority of 1879. Decree for 600 sec. ft. Capacity 600 sec. ft., length 95 miles. Diverts at mouth of Platte Canyon. Has 1/3 right in Antero Res., the total annual yield of which is 12,500 ac. ft. Constructed by cooperative enterprise. Land is on east side of river adjacent to City of Denver.
	Platte Canyon Can. (Platte Canyon Ditch Co.) (Includes Last Chance Ditch)	South Platte R.	2,450	Priorities of 1861-1868. Decree for 52.27 sec. ft. Capacity 52 sec. ft., length 10 miles. Diverts at mouth of Platte Canyon. Constructed by private enterprise.
	City Ditch or Platte Water Co.'s Ditch (City & County of Denver	South Platte R.	2,000	Priorities of 1860-1882. Decrees for 85.95 sec. ft. Capacity 50 sec. ft., length 27 miles. Constructed by private enterprise, owned by City of Denver and irrigates land adjacent to and in Denver.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
8	Fairview Ditch (P.A. Yeast, Owner)	Deer Creek	500	Priorities 1871-1886. Decree for 52 sec. ft. Capacity 50 sec. ft., length 4 miles, constructed by private enterprise. Has 2 small storage reservoirs under it.
	Lower Plum Cr. D. (Diamond K Ranch Owner)	Plum Creek	350	Priority of 1870. Decree for 11 sec. ft. Capacity 11 sec. ft., length 2.5 miles, constructed by private enterprise.
	Arapahoe Canal (Cherry Cr. Mutual Irrigation Co.)	Cherry Creek (Arapahoe Res.)	3,000	Priority of 1889. Decree for 50 sec. ft. Capacity 50 sec. ft., length 40 miles, constructed by private enterprise. Entire supply is stored water from Castlewood Res. on upper Cherry Cr. Considerable land under canal abandoned on acct. of lack of water.
9	Arnett Can. (City of Denver,-formerly Arnett D. Co.) (Also called Harriman Ditch)	Bear Cr. & Turkey Cr.	1,989	Priorities of 1869-1884. Decrees for 57.10 sec. ft. Capacity 132 sec. ft., length 7 miles, constructed by private enterprise,-has been enlarged twice. Turkey Cr. decree is for 10.75 sec. ft. Has 4 reservoirs under ditch.
	Bergen D. (Bergen D. & Res. Co.)	Turkey Creek	1,842	Priority of 1874. Decree for 12 Sec. ft. Capacity 65 sec. ft., length 3 miles. Constructed by private enterprise. Feeds 6 small reservoirs in natural depressions. Has no enlargement decrees.
	Hindry D. (Ross and Cykler	Bear Creek	184	Priorities of 1862-1867. Decrees crees for 12.88 sec. ft. Capacity 5 sec. ft., length 2 miles of laterals, water carried in ward ditch. Constructed by private enterprise.
	Independent Highline Canal (Arthur Ponsford)	Turkey Creek	191	Priorities of 1862-1881. Decrees for 33.69 sec. ft. Capacity 8 sec. ft., length 1.5 miles. Constructed by private enterprise. Has one small reservoir under it.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
9	Robert Lewis (City of Denver)	Bear Creek	490	Priority of 1865. Decree for 17 sec. ft. Capacity of 18 sec. ft. Constructed by private enterprise. Water now carried in Arnett Ditch.
	McBroom Ditch (Wm. McBroom)	Bear Creek	248	Priority of 1859. Decree for 11.58 sec. ft. Capacity 14 sec. ft., length 5 miles. Constructed by private enterprise.
	Pioneer-Union D. (Pioneer-Union Ditch Co.)	Bear Creek	1,000	Priorities of 1861-65. Decrees for 45.67 sec. ft. Capacity 36 sec. ft., length 6 miles. Constructed by private enterprise.
	Simonton Ditch (Henry Pollsaro)	Bear Creek	760	Priority of 1860. Decree for 35.76 sec. ft. Capacity 36 sec. ft., length 3 miles. Constructed by private enterprise. No enlargements.
	Ward Can. (Ward D. & Res. Co.) (Also called Ward & Kendrick Ditch)	Bear Creek	2,030	Priorities of 1862-1882. Decrees for 70.81 sec. ft. Capacity 50 sec. ft., length 17 miles. Constructed by private enterprise in 1882. Has 10 small reservoirs under it.
	Warrior Ditch (Warrior D. Co.)	Bear Cr. & Turkey Cr.	1,894	Priorities of 1861-1865. Decrees for 52.15 sec.ft. Capacity 52 sec. ft., length 3 miles. Construction started by private enterprise in 1861, extensions were added in 1862, 1864 and 1865.
2	Farmers and Gardener's Ditch (City & County of Denver)	South Platte R.	300	Priorities of 1863-1874. Decrees for 24 sec. ft. Capacity 25 sec. ft., length 5 miles. Constructed by private enterprise in 1863 and enlarged in 1874. Diverts on west side of river within city limits of Denver.
	Burlington Canal (Burlington D. & Land Co.)	South Platte R.	14,000	Priorities of 1862-1885. Decrees for 380.40 sec. ft. Capacity 350 sec.ft., length 20 miles. Constructed by private enterprise. Diverts water also for the O'Brian Can.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
2	O'Brian Canal (Farmer's Res. & Irr. Co.)	South Platte R.	32,000	Priority of 1908. Decree for 600 sec. ft. Capacity 600 sec. ft., length 20 miles. Constructed by private enterprise. Has common heading with Burlington Can. and feeds Barr Lake and Denver-Hudson Can. Speer, Beebe and Neres Canals are Barr Lake outlet canals and have no direct flow rights.
	Denver-Hudson Can. (Henry Lynn Irr. District	South Platte R.	34,000	Priority of 1907. Decree for 300 sec.ft. Capacity 350 sec.ft., length 60 miles. Constructed by irrigation district. Its water is diverted by the Burlington, passes into the O'Brian and is diverted from the O'Brian just before it reaches Barr Lake. The district is only partially developed on account of lack of water.
	Fulton Ditch (Fulton Ditch Co.)	South Platte R.	17,000	Priorities of 1865-1882. Decrees for 448.80 sec.ft. Capacity of 300 sec. ft., length 28 miles. Constructed by private enterprise in 1865,- has been enlarged 3 times.
	Brantner Ditch (New Brantner Ext. Ditch Co.)	South Platte R.	6,000	Priorities of 1860-1881. Decrees for 111.18 sec. ft. Capacity 111 sec.ft., length 20 miles. Constructed by private enterprise. Has been enlarged 3 times. Has several small reservoirs under it.
	Brighton Ditch (Brighton D. Co.)	South Platte R.	4,895	Priorities of 1863-1871. Decrees for 44.80 sec.ft. Capacity 50 sec.ft., length 10 miles. Constructed by private enterprise in 1863 and enlarged in 1871.
	Lupton Short Line Ditch (Lupton Short Line Ditch Co.)	South Platte R.	900	Priority of 1892. Decree for 72 sec. ft. Capacity 30 sec.ft., length 10 miles. By private enterprise.
	Lupton Bottom D. (Lupton Bottom Ditch Co.)	South Platte R.	6,000	Priorities of 1863-1873. Decrees for 150.57 sec. ft. Capacity 140 sec. ft., length 14 miles. By private enterprise.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
2	Platteville Can. (Platteville Irr. & Milling Co.)	South Platte R.	5,500	Priorities of 1862-1873. Decrees for 147.38 sec.ft. Capacity 137 sec. ft., length 10 miles. By private enterprise.
	Side Hill Ditch (Meadow Island No. 1 Ditch Co.)	South Platte R.	1,200	Priorities of 1866-1882. Decrees for 116.80 sec.ft. Capacity 40 sec.ft., length 6 miles. By private enterprise.
	Evans No. 2 Ditch (Platte Valley Ditch Co.)	South Platte R.	12,000	Priorities of 1871-1875. Decrees for 404.05 sec.ft. Capacity 225 sec. ft., length 26 miles. By private enterprise. Also feeds Milton Lake Res.
	Beeman D. (Beeman D. & Milling Co.)	South Platte R.	2,000	Priorities of 1866-1877. Decrees for 134.34 sec.ft. Capacity 50 sec.ft., length 6 miles. By private enterprise.
	Bucker's Ditch (New Bucker D. Co.)	South Platte R.	3,000	Priority of 1879. Decree for 121.87 sec.ft. Capacity 60 sec.ft., length 15 miles. By private enterprise.
	Farmer's Independent Ditch (Farmer's Independent D.Co.)	South Platte R.	11,000	Priorities of 1865-1879. Decrees for 520 sec.ft. Capacity 300 sec.ft., length 20 miles. Constructed by private enterprise. Has been enlarged twice.
	Hewes & Cook D. (Western Mutual Ditch Co.) (Includes Western Ditch)	South Platte R.	3,700	Priorities of 1866-1894. Decrees for 185 sec.ft. Capacity 130 sec.ft., length 16 miles. By private enterprise. Has been enlarged twice and consolidated with Western Ditch.
	Union Ditch (Union D. Co.)	South Platte R.	6,000	Priorities of 1873-1881. Decrees for 188.03 sec.ft. Capacity 150 sec.ft., length 12 miles. By private enterprise. Has been enlarged once, has 4 sec.ft. of 1873 water by transfer from Big Bend Ditch and obtains 20 sec. ft. of its supply from an intercepting seepage ditch.
	Section No. 3 D. (Godfrey Bottom Ditch Co.)	South Platte R.	1,700	Priorities of 1870-1873. Decrees for 57.71 sec.ft. Capacity 45 sec.ft., length 6 miles. By private enterprise. Was enlarged in 1873.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
2	Lower Latham D. (Lower Latham Ditch Co.)	South Platte R.	13,000	Priorities of 1869-1881. Decrees for 287.73 sec.ft. Capacity 350 sec.ft., length 15 miles. By private enterprise. Has been enlarged twice. Also receives water from Union Res.
	Patterson Ditch (Patterson D. Co.)	South Platte R.	1,400	Priority of 1871. Decree for 19.92 sec. ft., capacity 30 sec.ft., length 5 miles. By private enterprise. Original filing, - has not been enlarged.
	Plum Ditch (or Highland Ditch)	South Platte R.	720	Priority of 1871. Decree for 24.40 sec.ft. Capacity 25 sec. ft., length 5 miles. By private enterprise. Original appropriation was for 64.40 sec.ft.- transferred 40 sec. ft. to Bijou Canal in 1909.
	German Canal (German D. & Res. Co.)	Big Dry Creek	1,200	Priority of 1855. Decree for 85 sec. ft. Capacity 40 sec. ft., length 6 miles. By private enterprise. Feeds several small reservoirs.
	Thompson Ditch (or Big Dry Cr. D.) (Thompson D. Co.)	Big Dry Creek	600	Priority of 1889. Decree for 36.66 sec.ft. Capacity 37 sec. ft., length 6 miles. By private enterprise. Has a small reservoir under it.
7	Golden Ditch (Welch Ditch) (Agricultural D. & Res. Co.)	Clear Creek	3,200	Priorities of 1860-1871. Decrees for 27.53 sec.ft. Capacity 30 sec.ft., length 14 miles. By private enterprise. Constructed in 1871 for 26 sec.ft. Has 1.53 sec.ft. of 1860 and 1861 water by transfer.
	Golden City & Ralston Cr. D. (Church D.) (Farmer's Res. Co.)	Clear Cr. & Ralston Cr.	18,000	Priorities of 1862-1881. Decrees for 113.03 sec.ft. Capacity of 120 sec.ft., length 30 miles. By private enterprise. Constructed in 1865. Has a little 1862 water by transfer. Feeds Standley Lake Res. and a number of smaller reservoirs. Also receives transmountain water from Berthoud Pass diversion.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
7	Agricultural Can. (Agricultural D. & Res. Co.)	Clear Creek	16,000	Priorities of 1860-1883. Decrees for 159.186 sec.ft. Capacity 180 sec.ft., length 28 miles. By private enterprise. Has several small reservoirs under it. Constructed in 1874. Earlier water was secured by transfer.
	Golden Canal (Farmer's Highline) (Farmer's Highline Can. & Res. Co.)	Clear Creek	50,000	Priorities of 1860-1895. Decrees for 733.605 sec.ft. Capacity 350 sec.ft., length 45 miles. Construction started in 1860 by private interests. Has been enlarged 3 times and has 9 transfers from other ditches. Has several small reservoirs under it.
	Wannemaker Ditch (Wannemaker D. Co.)	Clear Creek	1,160	Priorities of 1860-1868. Decrees for 21 sec.ft. Capacity 23 sec.ft., length 6 miles. By private interests.
	Lee, Stewart & Eskins Ditch (Lee, Stewart & Eskins Ditch Co.)	Clear Creek	2,325	Priorities of 1861-1871. Decrees for 41.79 sec.ft. Capacity 25 sec.ft., length 5 miles. By private interests in 1863. 1861 water by transfer.
	Rocky Mountain Ditch (Rocky Mountain Water Co.)	Clear Creek	8,000	Priorities of 1861-1878. Decrees for 190 sec.ft. Capacity 125 sec.ft., length 18 miles. By private interests in 1862. 1861 water by transfer.
	Reno & Juchem D. (Consolidated D. & Res. Co.)	Clear Creek	1,900	Priorities of 1861-1878. Decrees for 34.575 sec.ft. Capacity 18 sec.ft., length 10 miles. By private interests in 1870. 1861 and 1865 water by transfer. Feeds Broad Lakes.
	Fisher Ditch (Fisher D. Co.)	Clear Creek	2,600	Priority of 1861. Decree for 35 sec.ft. Capacity 35 sec.ft., length 4 miles. By private interests. Feeds Copeland Res.
	Colo. Agricultural D. (Colo. Agricultural D. Co.)	Clear Creek	2,500	Priorities of 1863-1874. Decrees for 82.56 sec.ft. Capacity 50 sec.ft., length 9 miles. By private interests in 1867. 1863 water by transfer.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
7	Clear Cr. & Platte River D. (Clear Cr. & Platte R. D. Co.)	Clear Creek	2,600	Priority of 1861 Decree for 49.50 sec.ft. Capacity 50 sec. ft., length 11 miles. By private interests. Has common heading with Colo. Agricultural Ditch. Irrigates lands lying along west side of South Platte River below Denver.
	Ralston Creek Diversions (15 small ditches privately owned)	Ralston Creek	900	Priorities of 1860-1873. Decrees for 63.84 sec.ft. Capacities 63 sec.ft., various lengths. All build by private interests at various times between 1860 and 1873.
	The Slough (19 small ditches controlled by Consolidated D. Ass'n)	Slough from Clear Creek	2,335	Priorities of 1860-1874. Total decrees for 103.34 sec.ft., total capacities 96 sec.ft., various lengths. All built by private interests from 1860 to 1874. Capacity of Slough from Clear Cr. feeding these ditches is 40 sec.ft.
6	Anderson D. (New Anderson D. Co.)	Main Boulder Cr.	3,000	Priority of 1860. Decrees for 21.50 sec.ft. Capacity 25 sec. ft., length 6 miles. By private enterprise.
	Town of Boulder D. (City of Boulder)	Main Boulder Cr.	3,500	Priority of 1860. Decree for 9.07 sec.ft. Capacity 10 sec. ft., length 20 miles. Transferred water for domestic and irrigation use.
	Boulder & Left-hand D. (Boulder & Left-hand D. Co.)	Main Boulder Cr.	3,140	Priorities of 1862-1873. Decrees for 86.80 sec.ft. Capacity 35 sec.ft., length 12 miles. By private enterprise in 1873. Earlier decrees by transfer.
	Boulder & Weld Co. D. (Boulder & Weld Co.D.Co)	Main Boulder Cr.	5,000	Priorities of 1871-1883. Decrees for 61.9 sec.ft. Capacity 40 sec.ft., length 12 miles.
	Boulder & White Rock D. (Boulder & White Rock D. Co.)	Main Boulder Cr. & Goose Cr.	14,000	Priorities of 1873. Decrees for 216.58 sec.ft. Capacity 140 sec.ft., length 20 miles. By private enterprise. Has several small storage reservoirs.

Water District	Name of project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
6	Butte Hill D. (Butte Irr. & Milling Co.)	Main Boulder Cr.	3,000	Priority of 1865. Decree for 110.86 sec. ft. Capacity 25 sec. ft., length 6 miles. By private enterprise.
	Farmer's Ditch (Farmer's D. Co.	Main Boulder Cr.	9,000	Priority of 1862. Decree for 67.72 sec.ft. Capacity 73 sec. ft., length 15 miles. By private interests.
	Gooding, Dailey & Plumb Ditch (Scott Hershey, Sec'y, Longmont, Colo.)	Main Boulder Cr.	3,000	Priorities of 1861 and 1865. Decrees for 30.44 sec.ft. Capacity 15 sec.ft., length 6 miles. By private interests. Has one enlargement.
	Green Ditch (Several private owners, - not a corporation.)	Main Boulder Cr.	1,500	Priority of 1861. Decree for 34.58 sec.ft. Capacity 10 sec. ft., length 4 miles. By private enterprise.
	Harden Ditch (Privately owned not a corporation)	Main Boulder Cr.	1,500	Priority of 1862. Decree for 21 sec.ft. Capacity 6 sec.ft., length 3 miles. By private enterprise.
	Highland South Side D. (Gooding D. Co.)	Main Boulder Cr.	5,500	Priority of 1865. Decree for 99.70 sec.ft. Capacity 45 sec. ft., length 10 miles. By private enterprise.
	Leggett Ditch (Leggett D. & Res. Co.)	Main Boulder Cr.	7,000	Priority of 1868. Decree for 31.35 sec.ft. Capacity 90 sec. ft., length 12 miles. By private enterprise.
	Lower Boulder D. (Lower Boulder D. Co.)	Main Boulder Cr.	17,000	Priorities of 1859 and 1870. Decrees for 122 sec.ft. Capacity 150 sec.ft., length 8 miles. By private enterprise. Feeds lower Boulder Extension Reservoir.
	North Boulder Farmer's Ditch (North Boulder Farmer's Pr. & Water Co.)	Main Boulder Cr.	2,500	Priorities of 1862-1863. Decrees for 48 sec.ft. Capacity 48 sec. ft., length 6 miles. Built by private enterprise.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
6	Rural P.M. Ditch (Rural Ditch Co.)	Main Boulder Cr. through Idaho Slough	5,500	Priorities of 1862-1863. Decrees for 221.04 sec.ft. Capacity 65 sec.ft., length 7 miles. By private enterprise.
	Silver Lake D. (The Silver Lake D. & Res. Co.)	Main Boulder Cr.	3,500	Priorities of 1888-1900. Decrees for 45 sec.ft. Capacity of 20 sec.ft., length 12 miles. By private enterprise.
	Smith & Emmons D. (Smith & Emmons D. Co.)	Main Boulder Cr. via Idaho Slough	1,500	Priority of 1863. Decree for 47.16 sec.ft. Capacity 10 sec. ft., length 4 miles. By private enterprise.
	Wellman Ditch (Wellman D. Co.)	Main Boulder Cr.	2,000	Priority of 1878. Decree for 12.74 sec.ft. Capacity 10 sec.ft., length 4 miles. By private enterprise.
	Community Ditch (Farmers Res. & Irr. Co.)	South Boulder Cr., Coal and Rock Crs.	25,000	Priorities of 1885-1903. Decrees for 402.40 sec.ft. Capacity of 350 sec.ft., length 4 miles. By private enterprise. Feeds a number of storage reservoirs.
	Cottonwood No. 2 D. (Cottonwood No.2 D. Co.)	South Boulder Creek	2,500	Priority of 1863. Decree for 33.70 sec.ft. Capacity 35 sec. ft., length 5 miles. By private enterprise.
	Davidson Ditch (Davidson D. Co.)	South Boulder Creek	7,500	Priorities of 1872-1875. Decrees for 221.35 sec.ft. Capacity of 125 sec.ft., length 15 miles.
	Dry Cr. (Davidson Ditch) (J. Kelsey, et al)	South Boulder Creek	3,000	Priority of 1863. Decree for 19.80 sec.ft. Capacity 20 sec. ft., length 6 miles. By private enterprise.
	Dry Cr. No. 2 D. (Dry Cr. No. 2 D. Co.)	South Boulder Creek	3,000	Priority of 1869. Decree for 69 sec.ft. Capacity 30 sec. ft., length 1 mile. By private enterprise.
	East Boulder D. (East Boulder D. Co.)	South Boulder Cr. & Dry Cr.	3,000	Priorities of 1862-1872. Decrees for 229.50 sec.ft. Capacity 65 sec.ft., length 4 miles. By private enterprise.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
6	Enterprise Ditch (The Enterprise Irr. D. Co.)	South Boulder Creek	2,000	Priorities of 1865-1866 and 1881. Decrees for 128.09 sec. ft. Capacity 35 sec. ft., length 4 miles. By private enterprise.
	Howard Ditch (Howard D. Co.)	South Boulder Creek	2,500	Priority of 1860. Decree for 36 sec.ft. Capacity 25 sec. ft., length 2 miles. By private enterprise.
	Leyner & Cottonwood No. 1 D. (Leyner & Cottonwood D. Co.)	South Boulder Creek	7,500	Priorities of 1865-1870. Decrees for 66.72 sec.ft. Capacity 65 sec.ft., length 15 miles. By private enterprise.
	Marshallville D. (The Marshallville D. Co.)	South Boulder Creek	2,500	Priority of 1865. Decree for 46.68 sec.ft. Capacity 40 sec. ft., length 7 miles. By private enterprise. Feeds Teller No. 1 Res.
	McGinn Ditch (The McGinn D. Co.)	South Boulder Creek	2,500	Priorities of 1860-1865. Decrees for 17.25 sec.ft. Capacity 17 sec.ft., length 6 miles. By private enterprise.
	South Boulder & Bear Creek Ditch (The South Boulder & Bear Creek D. Co.)	South Boulder Creek	2,500	Priorities of 1862-1871. Decrees for 226.80. Capacity 20 sec. ft., length 7 miles. By private enterprise. Has decrees for three enlargement but canal cannot carry much more than original 1862 decree.
	South Boulder Canyon Ditch (The South Boulder Canyon D. Co.)	South Boulder Creek	6,000	Priorities of 1870-1871. Decrees for 66 sec.ft. Capacity 75 sec. ft., length 12 miles. By private enterprise. Supplies 4 small storage reservoirs.
	South Boulder & Coal Creek Ditch (The South Boulder & Coal Creek D. Co.)	South Boulder Creek	3,500	Priority of 1872. Decree for 53.55 sec.ft. Capacity 65 sec. ft., length 12 miles. By private enterprise. Feeds Louisville Res. for domestic supply.
	South Boulder & Foot Hills Irr. D. (The South Boulder & Foot Hills Irr. D. Co.)	South Boulder Creek	1,500	Priority of 1883. Decree for 20 sec. ft. Capacity 10 sec. ft., length 5 miles. By private enterprise.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
6	South Boulder & Rock Creek Ditch (Goodhue Ditch) (South Boulder & Rock Cr, D, Co.)	South Boulder Cr. & Rock Cr.	7,000	Priorities of 1873-1875. Decrees for 116.09 sec. ft. Capacity 114 sec. ft., length 15 miles. By private enterprise.
	Church Ditch (The Church D. Co.)	Coal Creek	2,000	Priority of 1870. Decree for 18.11 sec.ft. Capacity 20 sec. ft., length 7 miles. By private enterprise.
	Kinnear Ditch (Denver Land & Res. Co.)	Coal Creek	3,500	Priority of 1872. Decree for 26.47 sec.ft. Capacity 40 sec. ft., length 8 miles. By private enterprise. Feeds the Kinnear Res.
	Last Chance D. (Last Chance D. Co.)	Coal Creek	2,000	Priority of 1870, Decree for 10.78 sec.ft. Capacity 15 sec. ft., length 6 miles. Has 2 small reservoirs under it.
5	Left-hand Ditch (The Left-hand Ditch Co.)	Upper South Fork St. Vrain Cr. & Left-hand Cr.	20,000	Priorities of 1863-1870. Decrees for 726 sec.ft. Capacity 275 sec.ft., length 45 miles. by private enterprise. Has a little storage in Gold Lake Res. Lands are in high altitude.
	South Ledge D. (The South Ledge D. Co.)	South Fork St. Vrain Cr.	1,100	Priorities of 1870-1884. Decrees for 31 sec.ft. Capacity 12 sec.ft., length 6 miles. By private enterprise.
	Supply Ditch (The Supply D. Co.)	St. Vrain Creek	7,500	Priority of 1878. Decree for 92.20 sec.ft. Capacity 125 sec. ft., length 22 miles. By private enterprise. Is the feeder for a number of small reservoirs in the district.
	Highland Ditch (The Highland D. Co.)	St. Vrain Creek	35,000	Priorities of 1871-1902. Decrees for 324.03 sec.ft. Capacity 400 sec.ft., length 50 miles. By private enterprise. Feeds many small reservoirs.
	Rough & Ready D. (The Rough & Ready D. Co.)	St. Vrain Creek	7,760	Priorities of 1869-1873. Decrees for 83.34 sec. ft. Capacity 115 sec.ft., length 15 miles. By private enterprise. Also feeds several small reservoirs.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
5	St. Vrain & Palmerton Ditch (The St. Vrain & Palmerton D. Co.)	St. Vrain Creek	1,500	Priorities of 1865-1874. Decrees for 164.31 sec. ft. Capacity 60 sec.ft., length 8 miles. By private enterprise. Has 2 enlargement decrees but ditch will not carry the total rights.
	Swede Ditch (The Swede D. Co.)	St. Vrain Creek	4,150	Priorities of 1871 and 1873. Decrees for 24.55 sec.ft. Capacity 45 sec.ft., length 16 miles. By private enterprise. Carries nearly twice its direct flow rights as feeder for McCaslin Res.
	James Ditch (The James D. Co.)	St. Vrain Creek	2,000	Priorities of 1868-1877. Decrees for 27.11 sec.ft. Capacity 35 sec.ft., length 11 miles. By private enterprise. Feeds Clover Basin Res.
	Davis & Downing Ditch (The Davis & Downing D.Co.)	St. Vrain Creek	960	Priorities of 1866-1876. Decrees for 16.24 sec.ft. Capacity 23 sec.ft., length 5 miles. By private enterprise. Has been enlarged 4 times.
	Longmont Supply Ditch (The Longmont Sup. D. Co.)	St. Vrain Creek	3,500	Priority of 1865. Decree for 53.37 sec.ft. Capacity 50 sec. ft., length 10 miles. By private enterprise. Feeds the Independent Res.
	Oligarchy Ditch (The Oligarchy Irr. D. Co.)	St. Vrain Creek	6,500	Priorities of 1866-1870. Decrees for 237.51 sec. ft. Capacity 125 sec.ft., length 18 miles. By Private enterprise. Has 3 enlargement decrees. Feeds one small reservoir and the Union Res. of 13,000 ac.ft. capacity.
	Denio & Taylor Ditch (The Denio & Taylor D. Co.)	St. Vrain Creek	975	Priorities of 1865-1873. Decrees for 29.40 sec.ft. Capacity 20 sec.ft., length 4 miles. By private enterprise.
	Niwot Ditch (The Niwot D. Co.)	St. Vrain Creek	679	Priorities of 1863-1869. Decrees for 40.04 sec.ft. Capacity 30 sec.ft., length 4 miles. By private interests in 1865. The 1863 water is by transfer.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
5	South Flat Ditch (The South Flat D. Co.)	St. Vrain Creek	900	Priority of 1863. Decree for 16.70 sec.ft. Capacity 25 sec. ft., length 4 miles. By private enterprise.
	Last Chance D. (The Last Chance D. Co.)	St. Vrain Creek	2,500	Priority of 1872. Decree for 96.94 sec.ft. Capacity 40 sec. ft., length 12 miles . By private enterprise.
4	Handy Ditch (The Handy D. Co.)	Big Thompson R.	16,500	Priorities of 1861-1880. Decrees for 200.57 sec.ft. Capacity 225 sec.ft., length 26 miles. Built by private interests in 1878 and enlarged in 1880. 1861-1872 water by transfer. Feeds several small reservoirs.
	Home Supply D. (Consolidated Home Sup. D. & Res. Co.)	Big Thompson R.	30,000	Priorities of 1861-1881. Decrees for 349.63 sec.ft. Capacity 300 sec.ft., length 30 miles. By private interests in 1881. Has 16 transfers from other ditches for water dating from 1861 to 1872. Feeds the Home Sup. Res.
	South Side Ditch (The South Side Irr. & Res. Co.)	Big Thompson R.	2,500	Priorities of 1863-1880. Decrees for 56.30 sec.ft. Capacity 40 sec.ft., length 8 miles. By private enterprise in 1880. 1863-1872 water by transfer. Feeds South Side Res.
	George Rist D. (Consolidated Home Sup. D. & Res. Co.)	Big Thompson R.	5,250	Priority of 1873. Decree for 195 sec.ft. Capacity 300 sec. ft., length 8 miles. By private enterprise. Feeds several small reservoirs.
	Louden Irr. Can. (The Louden D. & Res. Co.)	Big Thompson R.	19,000	Priorities of 1861-1883. Decrees for 306.78 sec.ft. Capacity 200 sec.ft., length 20 miles. By private enterprise in 1871. Enlarged in 1877 and 1883. 1861 water by transfer. Feeds 4 storage reservoirs.
	Loveland & Greeley Can. (Barnes Ditch) (Greeley & Loveland Irr. Co.)	Big Thompson R.	34,500	Priorities of 1865-1881. Decrees for 444.79 sec.ft. Capacity 700 sec.ft., length 35 miles. By private enterprise. Feeds several reservoirs, the principals of which are Lake Loveland & Boyd Lakes.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
4	Big Thompson D. (Big Thompson D. & Mfg. Co.)	Big Thompson R.	3,000	Priorities of 1863-1872. Decrees for 64.88 sec.ft. Capacity 35 sec.ft., length 4 miles. By private enterprise.
	Farmer's Irr. Can. (Farmer's Irr. Can. Co.)	Big Thompson R.	6,000	Priorities of 1861-1878. Decrees for 75.26 sec.ft. Capacity 75 sec.ft., length 16 miles. By private enterprise in 1863. 1861 water by transfer.
	Hillsborough D. (Consolidated Home Sup. D. & Res. Co.)	Big Thompson R.	13,000	Priorities of 1861-1881. Decrees for 216.71 sec ft. Capacity 150 sec. ft., length 18 miles. By private enterprise in 1874. 1861 water by transfer.
	Hill & Brush D. (Hill & Brush D. Co.)	Big Thompson R.	1,500	Priority of 1866. Decree for 61.80 sec.ft. Capacity 40 sec. ft., length 3 miles. Built by private enterprise.
	Big Thompson & Platte River D. (The Big Thompson & Platte River D. Co.)	Big Thompson R.	4,000	Priorities of 1865-1876. Decrees for 121.18 sec.ft. Capacity 75 sec.ft., length 8 miles. By private enterprise.
	Evanstown Ditch (The Town of Evans)	Big Thompson R.	4,000	Priority of 1871. Decree for 29.28 sec.ft. Capacity 50 sec. ft., length 8 miles. By Town of Evans in 1882. Total decree of 29.28 sec.ft. of 1871 water transferred from South Platte River to new diversion point on Big Thompson in 1912.
	Boulder & Larimer Co. Ditch (Boulder & Larimer Co. D. & Res. Co.)	Little Thompson Creek	11,000	Priorities of 1875-1877. Decrees for 66.72 sec.ft. Capacity 200 sec.ft., length 25 miles. By private enterprise. Feeds the Boulder & Larimer Co. Res.
	Supply Lateral (Herbert Cole, Owner)	Little Thompson Creek	2,000	Priorities of 1867-1878. Decrees for 74.57 sec.ft. Capacity 35 sec.ft., length 6 miles. By private enterprise in 1878. 1867 water by transfer.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
3	North Poudre Can. (North Poudre Irr. Co.)	North Fork of Cache la Poudre River	35,000	Main priority of 1880 for 307 sec.ft. Also has priorities of 76.67 sec.ft. in Cache la Poudre R. by transfer dating from 1861 to 1877. Capacity 310 sec.ft. Built in 1880 by private enterprise. Also receives water from Halligan Res. of 6,320 ac.ft. capacity and situated about 4 miles above the canal intake and from Box Elder Cr. Also stores water in a number of reservoirs which divert from the Cache la Poudre R. and exchanges it with lower rights. Construction of canal was started in 1880 and finished in 1884. The length is 26 miles. The North Poudre Irr. Co. is a mutual ditch company, duly organized under the laws of the State of Colo.
	Poudre Valley Can. (Also called Greeley-Poudre & Laramie-Poudre Can.) (Laramie-Poudre Irrig. Co.)	Cache la Poudre R. and trans-mountain water from Laramie R.	125,000	Priority for 2.35 sec.ft. of 1868 water and 28.51 sec.ft. of 1873 water by transfer from Canon Can. Present safe capacity is 200 sec.ft. Length is nearly 80 miles, but only 16 miles was in operation in 1930 and irrigated only 3,000 acres. Has right to divert 15,500 ac.ft. from Laramie R. through Laramie-Poudre Tunnel. Average from this source, 1918-28, was 8,393 ac.ft. per year. District claims date of original appropriation (start of construction) as 1901. Has been in the hands of several private corporations before being taken over by the irrigation district. Feeds several reservoirs for exchange with lower ditches. Sold to Laramie-Poudre Irr. Co. in 1925.
	Pleasant Valley & Lake Can. (The Pleasant Valley & Lake Can. Co.)	Cache la Poudre River	7,000	Priorities of 1861-1881. Decrees for 137.93 sec.ft. Capacity 135 sec.ft., length 21 miles. Heading 12 mile above Ft. Collins on right bank of Poudre R. By private interests. Feeds Claymore Lake res. for exchange with river.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
3	Larimer County Can. (Water Sup. & Storage Co.)	Cache la Poudre R., Laramie R. & Grand R.	52,000	Main priority of 1881. Has 1862 to 1873 water by transfer. Total decrees for 496.32 sec.ft. Also diverts up to 18,000 ac.ft. annually from upper Laramie R. and about 13,000 ac.ft. from upper Grand R. Canal capacity is 700 sec.ft., length 67 miles. Controls Chamber's Lake and Long Draw Reservoirs for transmountain storage and several other reservoirs both above and below the canal. Constructed 1881 by private interests.
	Dry Creek Ditch (Jackson D. Co.)	Cache la Poudre River	2,500	Priorities of 1861-1879. Decrees for 50.92 sec.ft. Capacity 52 sec.ft., length 12 miles. By private enterprise. No storage.
	Little Cache la Poudre Ditch (Cache la Poudre Irr. Co.)	Cache la Poudre River	1,700	Priorities of 1869-1873. Decrees for 82.50 sec.ft. Capacity 100 sec.ft., length 5 miles. By private enterprise. Feeds Larimer & Weld Res.
	Taylor & Gill D. (Taylor & Gill D. Co.)	Cache la Poudre River	600	Priority of 1866. Decree for 12.17 sec.ft. Capacity 20 sec. ft., length 2 miles. By private enterprise. No reservoir water.
	Larimer Co.Can. No.2 (Larimer Co. Can. No. 2 Irr. Co.)	Cache la Poudre River	7,200	Priority of 1873. Decree for 175 sec.ft. Capacity 175 sec.ft., length 12 miles. By private enterprise. Has storage of 2,100 ac.ft. in Warren Lake Res.
	New Mercer Ditch (New Mercer D. Co.)	Cache la Poudre River	6,700	Main priority of 1880 (year of principal enlargement). Has other rights of 1867 to 1872 by transfer and enlargement. Total net decrees for 170.53 sec.ft. Capacity 120 sec.ft., length 13 miles. By private interests in 1869. Buys storage water when needed. Has common heading with Larimer Co. No. 2 and parallels this ditch above it.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
3	Fort Collins Irr. Can. (Arthur D.) (Fort Collins Irr. Can. Co.)	Cache la Poudre River	3,600	Priorities of 1861-1873. Decrees for 109 sec.ft. Capacity 55 sec.ft., length 6 miles. Built by private enterprise in 1869. 1861-1868 water by transfer. Has 3 enlargement decrees. Occasionally buys stored water when needed.
	Larimer & Weld Can. (The Larimer & Weld Irr. Co.)	Cache la Poudre River	60,000	Priorities of 1864-1878. Decrees for 720 sec.ft. Capacity 1,000 sec.ft., length 64 miles. By private enterprise. Has 4 enlargements. Has 9,800 acre-feet storage in Terry Lake, which is fed by Little Cache la Poudre Ditch. Also uses Cobb Lake water by purchase and water from a number of the Water Supply and Storage Co.'s reservoirs by exchange of river water for reservoir water.
	Josh Ames Ditch (The Josh Ames D. Co.)	Cache la Poudre River	710	Priority of 1867. Decree for 17.97 sec.ft. Capacity 16 sec. ft., length 2 miles. By private enterprise. No storage.
	Lake Canal (The Lake Can. Co. of Colo.)	Cache la Poudre River	8,000	Main priority of 1872 (date construction) for 158.35 sec.ft.; also has 4.93 sec.ft. of 1862-1864 water by transfer. Capacity 165 sec.ft., length 14 miles. By private enterprise. Has storage from Poudre River in Carpenter Lake or Res. No. 1 of 800 ac.ft. capacity and from Box Elder Cr. in 3 small reservoirs, totaling 1,120 ac.ft. capacity.
	John G. Coy D. (John Hoffman, Owner)	Cache la Poudre River	290	Priority of 1865 for 31.63 sec. ft. Capacity 20 sec.ft., length 2 miles. Built by John G. Coy. No storage.
	Chaffee Ditch (The Chaffee D. Co.)	Cache la Poudre River	500	Priority of 1872. Decree for 22.38 sec.ft. Capacity 22 sec. ft., length 2 miles. By private interests. No storage.
	Box Elder D. (The Box Elder D. Co.)	Cache la Poudre River	2,200	Priorities of 1866-1868. Decrees for 52.76 sec.ft. Capacity 30 sec. ft., length 6 miles. By private enterprise. Has storage of 1,890 ac.ft. in 5 small reservoirs fed from Box Elder Cr.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres	Description
3	Cache la Poudre or Greeley No. 2 D. (The New Cache la Poudre Irr. Co.)	Cache la Poudre	50,000	Priorities of 1869-1877. Decrees of 585 sec.ft. Capacity 600 sec. ft., length 26 miles. By private enterprise. Feeds the Windsor Lake Res. of 1,800 ac.ft. capacity and receives water from Cache la Poudre Res. of 9,500 ac.ft. capacity.
	Whitney Ditch (The Whitney Irr. Co.)	Cache la Poudre River	2,500	Priorities of 1862-1871. Decrees of 61.18 sec.ft. Capacity 50 sec. ft., length 6 miles. By private enterprise. No storage.
	B. H. Eaton D. (The B. H. Eaton D. Co.)	Cache la Poudre River	1,300	Priorities of 1864-1872. Decrees for 41.70 sec.ft. Capacity 40 sec.ft., length 4 miles. By private enterprise. Uses no storage water.
	Wm. R. Jones D. (Weld County Savings Bank, of Greeley)	Cache la Poudre River	900	Priority of 1867. Decree for 15.52 sec.ft. Capacity 20 sec. ft., length 2 miles. No storage.
	Canal No. 3 or Greeley No. 3 D. or Old Union	Cache la Poudre River	4,500	Priorities of 1870-1873. Decrees for 172.79 sec.ft. Capacity 130 sec. ft., length 11 miles. Built by Union Colony in 1870. Enlarged 3 times. Principal water supply is from seepage return in the river. Stores no water but occasionally receives reservoir water in exchange for river water.
	Boyd & Freeman D. (Boyd Irr. Co.)	Cache la Poudre River	740	Priorities of 1862-1873. Decrees for 87.28 sec.ft. Capacity 10 sec.ft., length 2 miles. Built by private interests. Has 2 enlargement decrees which it does not divert. No storage.
	Ogilvy Ditch (The Ogilvy Irr. & Land Co.)	Cache la Poudre River	4,000	Priority of 1881. Decree for 91 sec.ft. Capacity 90 sec.ft., length 6 miles. By private enterprise. Water supply almost entirely from return flow in river. No. storage.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
1	Hoover Ditch (Hoover Ranch Co.)	South Platte R.	1,280	Priority of 1884 for 23 sec.ft., by transfer from Hardin D. Original appropriation of 1868 transferred to Upper Platte and Beaver D. Capacity 23 sec.ft., length 7 miles. By private owner in 1868. Receives a small amount of stored water on river exchange.
	Riverside Canal (Riverside Irr. Dist.)	South Platte R.	30,000	Priorities of 1876-1907. Decrees for 308 sec.ft. Capacity 295 sec.ft., length 106 miles. Built by district in 1907. 1876 water by transfer. Receives stored water from Riverside Res. of 57,500 ac.ft. capacity.
	Bijou Canal (The Bijou Irr. Co.)	South Platte R.	40,000	Priorities of 1871-1900. Decrees for 596.32 sec.ft., the main decree being for 450 sec. ft. of 1888 water. 1871-1882 decrees by transfer. Capacity 500 sec.ft. Built by private interests in 1888. Length 45 miles. Has storage of 9,200 ac. ft. in Bijou No. 2 Res., which it feeds and 37,700 ac.ft. in Empire Res. upstream. Also has 30 sec.ft. decree of 1888 water from west Bijou Cr.
	Corona Ranch D. (A. Mackey, Owner)	South Platte R.	1,200	Priorities of 1875 and 1886. Decrees for 56 sec.ft. Capacity 15 sec.ft., length 6 miles. By private interests. No water used in 1930 on account of seepage conditions. No storage.
	Putnam Ditch (Putnam D. Co.)	South Platte R.	2,800	Priorities of 1880-1882. Decrees for 40 sec.ft. Capacity 40 sec.ft., length 10 miles. By private interests. Is operated as a lateral under Bijou Can.
	Weldon Valley D. (Weldon Valley D. Co.)	South Platte R.	12,000	Priority of 1881. Decree for 165 sec.ft., length 18 miles. Capacity 165 sec.ft. By private enterprise.
	Fort Morgan Can. (Fort Morgan Res. & Irr. Co.)	South Platte R.	15,000	Priority of 1882 for 323 sec.ft. Capacity 350 sec.ft., length 30 miles. By private enterprise. Receives storage water from Jackson Lake, which also supplies other ditches.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
1	Upper Platte & Beaver Ditch (Upper Platte & Beaver Can. Co.)	South Platte R.	14,000	Priorities of 1868-1888. Decrees for 234.17 sec.ft. Capacity 250 sec.ft., length 24 miles. Built 1882 by private enterprise. 1868 and 1869 water by transfer. Receives storage water from Prewitt Res. downstream by river exchange.
	Deuel & Snyder D. (The Deuel & Snyder Impr. Co.)	South Platte R.	3,200	Priorities of 1871-1888. Decrees for 84 sec.ft. Capacity 70 sec.ft., length 8 miles. Built by private interests in 1871. Diverts some reservoir water by river exchange.
	Lower Platte & Beaver D. (Lower Platte & Beaver Can. Co.)	South Platte R. & Beaver Cr.	18,000	Priorities of 1882-1888. Decrees for 322 sec.ft. Capacity 340 sec. ft., length 24 miles. By private enterprise. Has storage rights in Riverside Res.; also receives water from Bijou Res. No. 2 by exchange with Riverside.
	Tremont Ditch (Tremont Mutual D. Co.)	South Platte R.	2,500	Priority of 1901 for 150 sec.ft. Capacity 35 sec.ft., length 15 miles. By private interests. Water supply is augmented by purchase of reservoir water.
	Gill & Stevens D. (Whitford Gill, Owner)	South Platte R. and pumping	1,000	Priority of 1889 for 23 sec. ft. Capacity 10 sec.ft., length 5 miles. Does not divert directly from river but receives water from lower Platte & Beaver D. and supplements the supply by pumping from wells. By private interests.
	Snyder Ditch (The Snyder D. & Res. Co.)	South Platte R.	3,500	Priority of 1902 for 175 sec.ft. Capacity 50 sec.ft., length 6 miles. By private interests. Owns the Snyder Res. of 139 ac. ft. capacity, which it feeds.
	Trowell Ditch (Cox Estate, Owners)	South Platte R.	2,500	Priority of 1900 for 90 sec.ft. Capacity 25 sec.ft., length 6 miles. By private interests. Land is river bottom and subirrigates. No water diverted in 1930.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
1	A.A.Smith Ditch (A.A. Smith Irr. Can.& Pipe Line Co.)	South Platte R.	1,500	Priority of 1887 for 20 sec. ft. Capacity 30 sec.ft., length 6 miles. By private enterprise. Uses reservoir water occasionally by purchase from reservoirs in the district.
	Union Ditch (Union D. Co.)	South Platte R.	2,000	Priority of 1901 for 46.87 sec. ft. Capacity 20 sec.ft., length 4 miles. By private enterprise. Receives a small amount of reservoir water.
	Tetsel Ditch (Tetsel D. Co.)	South Platte R.	1,300	Priorities of 1874-1882 for 37 sec.ft. Capacity 40 sec.ft., length 6 miles. By private interests.
	Johnson & Edwards D. ((Johnson, et al. Owners)	South Platte R.	2,500	Priorities of 1872-1886 for 63 sec.ft. Capacity 50 sec.ft., length 5 miles. By private owners.
	Klug Ditch (John P. Klug, Owner)	Box Elder Creek	3,500	Priorities of 1891-1906 for 580 sec.ft. Capacity 500 sec.ft., length 2 miles. Mostly wild hay land. Water controlled by Klug Res. of 900 ac.ft. Capacity. By private interest.
	J.B. Cooke D. (J.B. Cooke, et. al.)	Lone Tree Creek	1,920	Priority of 1887. Amount not stated in decree. Capacity 35 sec.ft. By private interests. Has 184 ac.ft. storage on creek.
	Beaver Farmer's D. (Beaver Farmers Can. & D. Co.)	Big Beaver Creek	7,680	Priority of 1889 for 308 sec. ft. Capacity 308 sec.ft., length 20 miles. Is a flood water ditch.
	Wylie, Light & Follman Ditch (Wylie-Light-Follman D. Co.)	Big Beaver Creek	1,000	Priority of 1895 for 27.50 sec. ft. Capacity 30 sec.ft., length 6 miles. By private interests. Is a flood water ditch and irrigates mostly wild hay in creek bottom.
	Desert Ditches (Estate of H. Nordloh)	Kiowa Creek	1,500	Priority of 1895 for 140 sec. ft. Capacity 140 sec.ft. By private interests. Is a flood water ditch.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
1	A.A.Smith Ditch (A.A. Smith Irr. Can.& Pipe Line Co.)	South Platte R.	1,500	Priority of 1887 for 20 sec. ft. Capacity 30 sec.ft., length 6 miles. By private enterprise. Uses reservoir water occasionally by purchase from reservoirs in the district.
	Union Ditch (Union D. Co.)	South Platte R.	2,000	Priority of 1901 for 46.87 sec. ft. Capacity 20 sec.ft., length 4 miles. By private enterprise. Receives a small amount of reservoir water.
	Tetsel Ditch (Tetsel D. Co.)	South Platte R.	1,300	Priorities of 1874-1882 for 37 sec.ft. Capacity 40 sec.ft., length 6 miles. By private interests.
	Johnson & Edwards D. ((Johnson, et al. Owners)	South Platte R.	2,500	Priorities of 1872-1886 for 63 sec.ft. Capacity 50 sec.ft., length 5 miles. By private owners.
	Klug Ditch (John P. Klug, Owner)	Box Elder Creek	3,500	Priorities of 1891-1906 for 580 sec.ft. Capacity 500 sec.ft., length 2 miles. Mostly wild hay land. Water controlled by Klug Res. of 900 ac.ft. Capacity. By private interest.
	J.B. Cooke D. (J.B. Cooke, et. al.)	Lone Tree Creek	1,920	Priority of 1887. Amount not stated in decree. Capacity 35 sec.ft. By private interests. Has 184 ac.ft. storage on creek.
	Beaver Farmer's D. (Beaver Farmers Can. & D. Co.)	Big Beaver Creek	7,680	Priority of 1889 for 308 sec. ft. Capacity 308 sec.ft., length 20 miles. Is a flood water ditch.
	Wylie, Light & Follman Ditch (Wylie-Light-Follman D. Co.)	Big Beaver Creek	1,000	Priority of 1895 for 27.50 sec. ft. Capacity 30 sec.ft., length 8 miles. By private interests. Is a flood water ditch and irrigates mostly wild hay in creek bottom.
	Desert Ditches (Estate of H. Nordloh)	Kiowa Creek	1,500	Priority of 1895 for 140 sec. ft. Capacity 140 sec.ft. By private interests. Is a flood water ditch.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
64	Bravo Ditch (The Bravo D. Co.)	South Platte R.	4,000	Priorities of 1893-1906 for 60 sec.ft. Capacity 100 sec.ft., length 12 miles. By private interests. Has storage rights in Prewitt Res.
	Farmer's Ditch (36 shares in ditch owned by 5 individuals)	South Platte R.	1,600	Priority of 1895 for 16 sec.ft. Capacity 20 sec.ft., length 4 miles. By private interests.
	Iliff & Platte Valley D. (Iliff & Platte Valley D. Co.)	South Platte R.	10,700	Priority of 1883 for 150 sec.ft. Capacity 175 sec.ft., length 20 miles. By private interests. Receives stored water from Prewitt Res. Also has storage in small reservoir of 285 ac. ft. capacity.
	J.B. Ditch (24 shares in ditch owned by 7 individuals)	South Platte R.	1,300	Priority of 1895 for 10 sec.ft. Capacity 30 sec.ft., length 7 miles. By private interests. Receives water through Bravo D. and from river at high stages.
	Lone Tree Ditch (& Huston Transfer) (W.C. Harris, latest owner)	South Platte R.	2,700	Priorities of 1894-1895 for 92 sec.ft. Capacity 90 sec.ft., length 8 miles. By private interests in 1895. 10 sec.ft. of 1894 water by transfer. Has storage rights in Prewitt Res.
	Powell & Dillon D. (J. P. Dillon Owner)	South Platte R.	2,500	Priority of 1893 for 45 sec.ft. Capacity 40 sec.ft., length 7 miles. By private interests. Receives its water supply through the Iliff & Platte Valley D.
	Powell Ditch (Powell D.Co.)	South Platte R.	3,000	Priority of 1895 for 40 sec.ft. Capacity 40 sec.ft., length 7 miles. By private party.
	S. B. Rice Ditch (J. Ulch, Owner)	South Platte R.	1,100	Priority of 1904 for 35 sec.ft. Capacity 20 sec. ft., length 4 miles. By private interests.
	Harmony No. 2 D. (Harmony No. 2 D. Co.)	South Platte R. and seepage	2,900	Priorities of 1897-1900 for 212 sec.ft. Capacity 200 sec. ft., length 8 miles. By private interests. Supplied by seepage from irrigation and from river at high stages.

Water District	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
64	Ramsey Ditch (Guy Ramsey, Owner)	South Platte R.	2,500	Priority of 1894 for 12 sec.ft. Capacity 20 sec. ft., length 4 miles. By private party.
	Chambers Ditch (W. C. Harris, Owner)	South Platte R.	2,000	Priority of 1895 for 30 sec. ft. Capacity 30 sec.ft., length 6 miles. No storage. By private interests.
	Harmony No. 1 & No. 3 Ditch (Julesburg Irr. Dist.)	South Platte R.	7,560	Priority of 1895 for 252 sec.ft. Capacity 350 sec.ft., length 25 miles. By private interests. Irrigates lands lying west of Julesburg Res. Has storage rights in Prewitt Res. Serves also as feeder for Julesburg Res. by enlargement and agreement with Julesburg Irr. Dist. 7,000 acres also irrigated east of reservoir.
	Tamarack Ditch (C.F. Parker, Owner)	South Platte R.	2,500	Priority of 1902 for 134 sec.ft. Capacity 50 sec.ft., length 6 miles. By private interests. Irrigates mostly wild hay.
	Settler's Ditch (Julesburg Irr. Dist.)	South Platte R.	6,900	Priorities of 1897-1898 for 377 sec.ft. Capacity 200 sec.ft., length 23 miles. By private interests.
	Long Island D. (F.T. Thurber, et. al.)	South Platte R. and pumping	1,500	Priorities of 1897-1906 for 34.50 sec.ft. Capacity 17 sec.ft., length 4 miles. By private interests. Has pumping plant.
	Red Lion Sup. D. (F. O. Bell & Sons, et. al.)	South Platte R.	2,500	Priority of 1895 for 52 sec.ft. Capacity 52 sec.ft., length 6 miles. By private interests.
	Peterson Canal (Peterson Can. & Res. Co. & Julesburg Irr. Dist.)	South Platte R.	10,003	Priorities of 1895-1897 for 534 sec.ft. Capacity 350 sec. ft., length 22 miles. By Peterson Can. & Res. Co. in 1895.
	South Reservation D. (South Reservation D. Co.)	South Platte R.	2,000	Priority of 1892 for 25 sec.ft. Capacity 25 sec.ft., length 7 miles. By private interests.

Water Dis-trict	Name of Project and Organization	Source of Water Supply	Irrigable Area (Acres)	Description
64	Liddle Ditch (Tom Liddle, Owner	South Platte R.	1,350	Priorities of 1890-1891 for 19 sec. ft. Capacity 30 sec.ft., length 8 miles. By private party in 1891. Carries appropriation (1890) of Russell & Sidebotham D.
	Carlson Ditch (H.E.Reichelt, Owner)	South Platte R.	2,000	Priority of 1894 for 16 sec. ft. Capacity 16 sec. ft., length 5 miles. Constructed by S. H. Carlson in 1894.
	Cox Irr. D. (Robson Bros. Owners)	South Platte R.	1,400	Priority of 1907 for 42.50 sec. ft. Capacity 45 sec. ft., length 3 miles. Constructed by private interests. Starting in 1907 and finished in 1910. Water is all diverted through Liddle D.
Total	197 Ditches			

Note: The above list completes the date, with the exception of flow rights, capacities, lengths and dates of construction for Lodge Pole, North Lodge Pole and Paxton Canals, all located in Nebraska.

Only direct flow canals are listed, reservoir inlets and outlets without direct irrigation rights being considered as parts of reservoir systems.

The Ditch Companies listed above are usually described as "mutual ditch companies, existing under the laws of Colorado, which divide and distribute the water appropriated to their ditches in proportion to stock ownership, and pay the expenses of their operations by assessments on stockholders pro rata according to stock ownership."

CHAPTER XVI

PRINCIPAL CONSTRUCTED RESERVOIRS

IN SOUTH PLATTE RIVER BASIN

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
23	Lake Cheesman Reservoir. (City and County of Denver.)	South Fork of S. Platte R. and its tributaries	79,000	Storage for Denver Water Supply. Priorities of 1889 & 1893. Masonry dam. Height 217 ft., length crest 1300 ft. Area high water 874 A. A channel reservoir. Construction started 1893 and completed in 1904, by South Platte Canal and Reservoir Co. Storage decrees for 79,000 Ac. Ft. 50,000 Ac. Ft. held as reserve supply. Average annual yield 24,000 acre-feet.
	Antero Reservoir (City & County of Denver).	South Fork of South Platte R. and tributaries.	28,000 (Present Safe Cap.)	2/3 for Denver Water Supply and 1/3 for Highline Canal. Priority of 1907 for 85,600 acre-feet. Earth-fill dam. Height 36 ft. length 4100 ft. Area high water 3,764 acres. A channel res. also has a collection ditch. Constructed 1907 to 1909 by Antero and Lost Park Res. Co. Annual yield about 12,500 acre-feet
	Jefferson Lake Res. (Jefferson Lake Ditch Co.)	Head of Tarryall Creek	4,200	Storage for irrigating wild hay near continental divide. Priority of 1888 for 4,200 acre-feet. Is a natural dam made by earth slide, diversion being made by means of a cut in the slide. Work on cut began in 1888 and was finished in 1898, being dug 26 ft. deep. Cut is between 500 & 600 ft. long, has wooden outlet box and has been backfilled for distance of 150 ft. Area of Lake Surface 24 ft. above bottom outlet is 200 ac.
	Wellington Lake Reservoir. (Wellington Res. Co.-Water users under Burlington Ditch)	Small tributaries of N. Fork of So. Platte River	2,750	Storage for irrigation under Burlington Ditch. Priority of 1892 for 2,750 acre-feet. Earth and rockfilled timber crib dam, height 70 ft., length crest 800 ft., area high water surface 154 acres. Constructed entirely in 1892. Has collection ditches. Is in channel of Buffalo Creek.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water Dist.	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
23 Cont.	Tarryall Res. (State of Colo)	Tarryall Ck.	3,280	Is fish pond for Colo.-Fish and Game Commission. Has no decree. Filing was for 13,150 acre-feet but work was curtailed on account of depth necessary to excavate for foundations. Concrete arch dam completed by state in 1930. Height 69 ft., length 300 ft.
	Eleven Mile Canyon Reservoir (City and County of Denver)	South Fork of S. Platte R.	80,000 (When completed)	Storage for Denver water supply. City has filing for dam 120 ft. high and 450 ft. long to store 80,000 Ac.Ft. Decree will not be granted until after completion of construction, but probably will be dated 1930. Work started in 1930 and should be finished in 1932. Channel res. with spillway cut in saddle across left abutment. Concrete arch dam. Area water surface is 2,808 acres.
8	Castlewood Res. (Cherry Cr. Mutual Irrig. Co.)	Cherry Creek	5,260	Storage for Arapahoe Canal. Masonry and rock-fill dam with earth backfill, height 67 ft., length 600 ft. area high water 175 acres. Channel reservoir. Decree of 1889 for 5260 acre-feet, completed 1890. Spillway overcrest of dam.
9	Harriman Lake Res. (City and County of Denver)	Bear Creek & Turkey Creek	866	Storage for Arnett Ditch system. Off-channel res., supplied by Arnett Ditch. Constructed in 1873 and enlarged in 1875. Decrees for 55.87 Sec.Ft. to be taken 1/5 from Turkey Cr. and 4/5 from Bear Cr., Acre-Feet not stated. Area water surface 100 acres.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water Dis-trict	Name & Owner	Source of Water Supply	Capacity in Acre-Feet	Description
9 Cont.	Marston Lake Reservoir. (City and County of Denver).	South Platte R. and Bear Creek	19,800	Storage for Denver Water Supply. Off-channel res., supplied by pipeline from Platte Canyon and by the Arnett Ditch from Bear Creek. Decree of 1889 from So. Platte R. for 14,800 acre-feet and also stores 5,000 acre-feet from Bear Creek. Earth fill dam, long dike, max. h't. about 50 ft. and about 1½ miles long. Completed in 1890 by private interests.
	Bowles Lakes Reservoir. (W. J. May, Owner.)	Bear Creek	1,700	Storage for irrigation. Off-channel res's in natural depressions filled by Arnett Ditch. 4 small lakes having water surfaces controlled by low earth dikes. Priorities of 1876 and 1880 amounts not given in decree but lakes are filled each year. Original construction in 1876, enlarged in 1880. Total water surface area is 210 acres.
	Soda Lakes Res. (City and Co. of Denver)	Bear Creek	800	Storage for irrigation exchange. 2 small lakes with dirt dikes supplied by Arnett Ditch. No decrees have been granted, but filing shows 3400 ft. length of dikes with maximum height of 30 ft. Decree when granted probably will be for 800 Ac. Ft., the estimated present safe capacity. Built in 1893.
2	Barr Lake Res. (Includes Oasis Res.) Farmer's Res. and Irrigation Co.)	South Platte River.	32,150 (total)	Storage for Farmer's Res. and Irrigation Co. and Henrylyn Irrig. District. Decrees of 1885-1909 for 33,010 acre-feet. Fed by O'Brian Canal, cap. 600 s.f. off-Channel reservoir, earth fill dam, water depth 34 ft., length 7,000 ft. water surface area 1,900 acres. Original Barr Res. constructed in 1887-1888. Oasis Res. annex constructed 1888-1889, Both enlarged to present capacity in 1909. Its outlets are Beebe Canal, Speer and Neres Canals and Brighton Lat.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water Dis-trict	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
2 Cont.	Horse Creek Res. (Henrylyn Irrigation District)	South Platte R.	20,700	Storage for Henrylyn Irrig. District. Priority of 1911 for 17,000 Ac. Ft., also enlargement priority of 1922 to store from "48 ft. depth to 51 ft. depth." Earth-fill dam on branch of Boxelder Cr. length 5,400 ft., area water surface 800 acres. Filled through Denver-Hudson Canal of 350 Sec.Ft. capacity. Constructed in 1911. Partially failed in 1914 but has been repaired and enlarged since.
	Prospect Res. (Henrylyn Irrig. District).	South Platte R.	5,970	Storage for Henrylyn Irrig. Dist. Priority of 1910 for 5,970 Ac. Ft. Has conditional decree of 1922 for enlargement to 7,660 ac.ft. not yet enlarged. Earth-fill dam, depth of water 36 ft., length dike 5,370 ft., area water surface 400 acres. Filled through Denver-Hudson Canal, an extension of O'Brian Canal. Completed in 1911.
	Sand Creek Res. (Henrylyn Irrig. Dist.)	South Platte R.	1,800	Storage for Henrylyn Irrig. Dist. Priority of 1911 for 1,804 Ac. Ft. Earth-fill dam, depth water 23 ft., length dike 1,680 ft. Filled through Denver-Hudson Canal. In channel Sand Creek. Area water surface is 187 acres. Completed in 1911.
	Milton Lake Res. (Farmer's Res. and Irrig. Co.)	South Platte R. and seepage from Beebe Draw.	24,390	Storage for irrigation. Priority of 1909 for 26,733 Ac. Ft, and conditional decree for 16,374 Ac. Ft. of 1909 water that has not been fulfilled. Earth-fill dam, depth of water 36 ft. length dikes is 4,750 ft., area water surface 2,364 acres. Off-channel res. in Beebe Draw. Fed by Evans No. 2 Canal of 225 Sec. Ft. cap. and Beebe Canal from Barr Lake. Completed in 1909 to present capacity.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
2 cont.	Lower Latham Res. (Lower Latham Res. Co.)	South Platte R.	6,212	Storage for Lower Latham Ditch. Priorities of 1898 & 1900 for 5,755 Ac. Ft. Off-channel res. earth-fill dam, depth water 15 ft., length dike 9,000 ft., area water surface 987 acres. Fed by Union Ditch of 150 Sec. Ft. capacity. Construction started in 1898 and completed by enlargement in 1900.
	Standley Lake Res. (Farmer's Res. and Irrig. Company.)	Clear Creek, Ralston Cr. and other tributaries	18,500 (Present safe cap.)	Storage for lands of the Farmer's Res. and Irrig. Co. under Niver Canal. Derives its water supply from Dist. 7. Off-channel reservoir on Woman's Creek. Earth-fill dam, present max. height 90 ft., length dam about 8,000 ft., area 1,600 acres. Safe storage depth 72 ft. above outlet. Has no decrees. Filing claims date of 1869 for 940 Ac.Ft. for Kinnear Lake, included in Standley Lake, and 1902 for start of surveys for enlargement to 101,200 acre-feet by dam 113 ft. high and 9,000 ft. long. Construction started on 113 ft. dam in 1909 but work suspended in 1910 before completion. Dam repaired in 1922 and cut down to present height of 90 ft. Main supply is derived from Clear Creek through Croke Canal inlet and Church Ditch. Material of dam is blue clay which becomes unstable on being saturated. Several slides have occurred on downstream face.
7	Tucker Reservoir (Denver View Ditch Co.)	Ralston Creek	1,800	Storage for Denver View Ditch. Fed by Haines and Piquette Ditch of 20 Sec.Ft. capacity. Priority of 1869 (date of construction) to fill res., capacity not given in decree. Inlet ditch and res. enlarged 1900 & 1901 to dike 33 ft. H't., length 2,800 ft., area water surface 80 acres, capacity 1,800 enlargement not decreed. Fills once each year.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
7 cont.	Hyatt Lake. (Farmer's Highline Canal and Res. Co.)	Clear Creek	1,200	Storage for water users under Farmer's Highline. Fed by Farmer's Highline. Priorities covered by those for Golden Canal. First constr. in 1863. Enlargement completed in 1890. Earth fill dike, depth of water 18 ft. area of water surface 111 acres. Temp. storage of natural flow rights.
	Sloan and Cooper Lake Res. (Rocky Mountain Water Company.)	Clear Creek	1,400	Storage for lands under Rocky Mtn. Ditch. Fed by branch of Rocky Mt'n Ditch. Priority No. 1 under ditch priority, no amount specified. Water surface covers about 150 acres. Low earth dike. Serves as regulator of natural flow rights in feeder. Constructed in 1873.
	Broad Lakes Res. (Farmer's Highline Canal & Res. Company.)	Clear Creek	1,710	Storage for Farmer's Highline or Golden Canal. Fed by some canal. Stores decreed water of canal, has no separate storage decree. Natural depression supplemented by long low earth dike. Constructed in 1887, enlarged in 1890.
	Leyden Reservoir (Farmer's Highline Canal and Res. Co.)	Clear Creek and Leyden Cr.	1,330	Storage for Farmer's Highline Canal Fed by Golden City & Ralston Cr. or Church Ditch. Has no decree for storage. Off-channel res., earth-fill dam 48 ft. high, 1500 ft. long area water surface 70 acres. Completed in 1908.
	Agricultural Res. (Agricultural Ditch and Res. Co.	Clear Creek	1,125	Storage under Agricultural Ditch. Has no storage decree. Off-channel reservoir. Includes Main Res., Smith Lake and East res., 3 small lakes. Earth dikes, total length 4,700 ft. height 8' to 40', total area water surface 120 acres. Work started by survey in 1903, constructed 1904.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
6	Barker Meadow Res. (Public Service Co. of Colorado.) (Also called Nederland Lake.)	Main Boulder Cr.	11,700	Operated by Public Service Co. as storage for power purposes. Concrete dam. Height 170 ft. length 660 ft. area water surface 200 acres. Channel res. completed in 1910 by Colo. Power Co., assignee of Eastern Colo. Power Co., acquired by Public Service Co. of Colo. Priority of 1906 for 11,700 acre-feet.
	Marshall Lake Res. (Farmer's Res. and Irrigation Co.)	South Boulder Cr.	10,300	Storage for lands under Community Canal and Standley Lake System. Off-channel reservoir fed by Community Canal. Earth fill dam, H't. 72 ft., length dike 2,350 ft. area water surface 420 acres. Priorities of 1885 and 1902 for 10,600 acre-feet. Conditional decree of 1921 for 1,550 acre-feet additional. It is intended to store in this res. also, transmountain water brought through Moffatt Tunnel from Fraser River. Original construction in 1885,- enlarged in 1902.
	Panama Res. No. 1 (Boulder and White Rock Ditch Co.)	Main Boulder Cr.	7,000	Storage for Boulder and White Rock Ditch et. al. Off-channel reservoir Earth-fill dike, H't. dike 14 ft. cut to outlet pipe 31 ft., depth water 40 ft., length dike 2,000 ft. area water surface 400 acres. Fed by White Rock & Leggett Ditches. Priority of 1904 for 7,000 acre-feet. Constructed 1904.
	Hillcrest Res. (Public Service Co. of Colo.)	Main Boulder Cr. and South Boulder Cr.	1,800	Storage for Leggett ditch and other users from So. Boulder Cr. Off-channel reservoir fed by Wellman and Hillcrest ditches. Earth-fill dike, H't. 27.5 ft. length 2,550 ft., area water surface 100 acres. Priority of 1917 for 1800 acre-feet. Constructed in 1917. Exchanges water with So. Boulder Cr. to increase head at Public Service Co.'s power plant.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
6 cont.	Base Line Res. (Base Line land and Res. Co., controlled by share holders in Lower Boulder Ditch Co.)	Main Boulder, So. Boulder & Bear Creeks	4,600	Storage for Lower Boulder Ditch. Off-channel reservoir fed by New Anderson Ditch and New Dry Creek Ditch. Total length feeder 6.4 miles, capacity 50 to 300 Sec.Ft. Earth-fill Dam, H't. 37 Ft., length 2,100 ft., area water surface 380 acres. Priority of 1904 for 3,000 acre-feet. Enlarged to present capacity in 1922-1923. Decree for enlargement not yet issued.
	Silver Lake Res (City of Boulder and Silver Lake Ditch and Res. Co.)	North Boulder Cr.	800	Storage for City of Boulder domestic water supply and for irrigation under Silver Lake Ditch. Allowed to fill twice each year. Irrigation priority of 1887 for 800 Ac.Ft. for one filling each year and priority of 1906 for 800 Ac.Ft. to allow re-filling for domestic use. Channel reservoir on a branch of North Boulder Cr. Rock-fill dam, height 35 ft., length 1,140 ft., area water surface 65 acres. Originally constructed in 1887-1888, completed by enlargement in 1906.
	Lake Albion Res. (City of Boulder.)	North Boulder Cr.	1,100	Storage for Boulder domestic use. Channel reservoir. Concrete dam. Height 60 ft., length 620 ft., area water surface 40 acres. Priority of 1910 for 1,100 ac. ft. Completed in 1911.
	Goose Lake Res. (City of Boulder)	North Boulder Cr.	1,035	Storage for Boulder domestic use. Channel reservoir. Rock-fill timber crib dam, height 28 ft., length 383 ft., area water surface 45 acres. Priority of 1901 for 200 Ac. Ft. (date of original construction) and of 1906 for 260 Ac. Ft. additional. Completed to present capacity in 1907.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water Dis-trict	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
6 cont.	Six Mile Res. (Boulder and White Rock Ditch Co.)	Main Boulder Cr.	1,150	Storage for Boulder & White Rock Ditch. Off-channel res. Earth-fill dam, height 28 ft., length 1,200 ft., area water surface 320 acres. Has no decree. Is on Dry Creek and fed by Boulder & White Rock Ditch.
5	Pleasant Valley Res. (Pleasant Valley Res.Co.)	St. Vrain Creek	3,080	Storage for Rough & Ready Ditch. Off-channel res. fed by Rough & Ready Ditch. Earth-fill dam, height 20 ft., length 2,640 ft. Area water surface 336 acres. Priority of 1871 for 1,610 Ac. ft. (date of original construction). Priority of 1904 for 930 Ac.Ft. additional. Enlarged to present capacity in 1907.
	Oligarchy No. 1 Res. (Oligarchy Ditch No.)	St. Vrain Cr.	2,000	Storage for Oligarchy Ditch. Off-channel, res. fed by St. Vrain and Palmerton Ditch. Earth-fill dam, height 36 ft., length 4,400 ft., Area water surface 106 acres. Priorities of 1889-1911 for 2,130 Ac.Ft. Originally constructed in 1889. Has been enlarged 3 times. Final enlargement in 1911.
	Beaver Park Res (Highland and Supply Ditch Co's.)	Beaver Cr. (A trib. of So.St. Vrain Cr.)	2,200	Storage for Highland and Supply Ditches. Channel res. in channel at Beaver Cr. Earth-fill dam, height 30 ft., length 1,540 ft. area water surface 120 acres. Priorities of 1892-1905 for 2,180 Ac.Ft. Originally constructed in 1892, has been enlargod 3 times, last enlargement in 1907.
	Foot Hills Res. (Highland Ditch Co.)	St. Vrain Creek	4,250	Storage for Highland Ditch. Off-channel reservoir filled through feed canal from St. Vrain Cr. Length feed canal 9,400 ft., capacity 400 Sec.Ft. Earth-fill dam, height 52 ft., length 3,150 ft., area water surface 173 acres. Priority of 1910 for 4,246 Ac. Ft. Constructed in 1910 by Chas. Kistler.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
5 cont.	Union Reservoir (Union Res.Co.)	St. Vrain Cr. & Spring Gulch	12,740	Storage for South Platte R. ditches in districts 2 & 1. Off-channel res. filled through Oligarchy Ditch & Spring Gulch Feeder. Earth-fill dike, height 17 ft., length 6,900 ft., area water surface 736 acres. Priority of 1902 for 13,200 Ac.Ft. Constructed in 1902 to hold 5,900 Ac.Ft. by cut in rim of lake. Present dike built in 1909.
	McIntosh Lake Res. (Highland Ditch Co.)	St. Vrain Cr.	2,460	Storage for Highland Ditch. Off-channel res. fed by Oligarchy Ditch. Earth-fill dike. Depth of water 13 ft. area water surface 263 acres. Priority of 1902 for 2,460 Ac.Ft. Construction started in 1890 but not completed until 1902. Decree dated 1902 on account of lack of diligence in completing construction.
	Highland Lake No. 1 Res. (Highland Ditch Co.)	St. Vrain Cr.	1,035	Storage for Highland Ditch. Off-channel res. fed by Highland Ditch. Long, low, earth-fill dike, water area 80 acres. Priority of 1879 for 780 Ac. Ft. Original construction in 1879.
	Highland Lake No. 2 Res. (Highland Ditch Co.)	St. Vrain Cr.	2,700	Storage for Highland Ditch. Off-channel res., fed by Highland Ditch. Earth-fill dike 22 ft. high 6,600 ft. long, area water surface 151 acres. Water drawn down 15 ft. below base of dikes by cut in rim of lake. Priorities of 1881-1889 for 2,700 acre-feet. Has enlargement filing of 1926 also.
	Highland Lake No.3 Res. (Highland Ditch Co.)	St. Vrain Cr.	1,650	Storage for Highland Ditch. Off-channel res. fed by Highland Ditch. Earth-fill dike, depth water 16 ft. area water surface 180 acres. Priorities of 1881 and 1902 for total of 1,560 Ac.Ft. Original construction 1881, enlarged 1902.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
4	Welch Lakes (5) (Handy Ditch Co.	Big Thompson R.	4,550	Storage for Handy Ditch. Off-channel reservoirs fed by Handy Ditch. Low earth dikes around small depressions. The reservoirs were constructed and enlarged at various times between 1881 and 1904. Decrees were issued in 1923 for the full capacity of lakes but cancelled in 1925. The lakes are now storing about 2,000 Ac.Ft. annually.
	Loveland Res. (Loveland Lake & Ditch Co.)	Big Thompson R.	2,150	Storage for Lake Ditch. Off-channel res. fed by Handy ditch. Earth-fill dam, 25 ft. high, 3,400 ft. long, area water surface 160 acres. Priority of 1898 for 2,150 Ac. Ft. issued in 1923, but cancelled in 1925. Res. stored only 410 ac. Ft. in 1930.
	Boulder and Larimer Co.Res. (Boulder & Larimer Co.Res. Co.)	Little Thompson Creek	7,340	Storage for Boulder and Lar. Co. Ditch. Off-channel res. fed by B. & Lar. Co. D. Earth-fill dike, depth water available 35 ft., area water surface 380 acres. Priorities of 1875 to 1904 issued for full capacity but contested and cancelled. Res. stored only 2,000 Ac.Ft. in 1930. Originally built as small res. in 1875. Has been enlarged 3 times, the 3rd being in 1904.
	Mariano Reservoir (Consolidated Home Supply Ditch & Res. Co.)	Big Thompson R.	5,360	Storage for Home Supply Ditch. Off-channel res., fed by Geo. Rist Ditch. Earth-fill dam, low dike about 1,000 ft. long. Originally constructed in 1888, enlarged in 1893. Priority of 1888 for 4,130 Ac.Ft. About 500 Ac.Ft. in bottom of res. Cannot be drawn off. Stored 4,800 Ac.Ft. in 1930.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (CONT'D.)

Water District	Namo and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
4 cont.	Seven Lakes Res. (Loveland and Greeley Irr. Co.)	Big Thompson R. and Dry Creek	8,440	Storage for Loveland & Greeley Canal. Off-channel Res. fed by Barnes and Louden Ditches. Low earth dikes. Area water surface 717 acres, depth water 17 ft. Adjoins Boyd Lake. Priority of 1902 for 8,440 Ac. Ft. Constructed originally in 1899 by small earth dam across Dry Creek, enlarged in 1902.
	Loveland and Greeley Res. or Lake Loveland (Loveland and Greeley Irr. Co.)	Big Thompson River	14,250	Storage for Loveland & Greeley Canal. Off-channel res., fed by old Barnes Ditch. Earth dike, 49 ft. high, 1,600 ft. long, area water surface 472 acres. Priority of 1893 for 14,250 Ac. Ft. Constructed in 1893.
	Boyd Lake Res. (Loveland and Greeley Irr. Co.)	Big Thompson River	44,100	Storage for Loveland & Greeley Canal and Big Thompson R. Off-channel res. fed by old Barnes Ditch enlarged and Loveland & Greeley Canal. Has low earth dikes on rims of 2 natural lakes. Tunnel outlet can draw water down a depth of 38 ft. Priority of 1902 for 44,100 Ac. Ft. Constructed in 1902. Total area of high water surface 2,000 acres.
	Home Supply Res. (Consolidated Home Supply Ditch and Reservoir Co.)	Big Thompson River	9,180	Storage for Home Supply Ditch lands. Off-channel res., filled through Home Supply Ditch. Low earth dike, area water surface 536 acres. Priority of 1881 for 9,180 Ac. Ft. Completed in 1882 by Farwell Res. Co. No maps on file in State Eng'r. Office. Fills usually to full capacity.
3	Long Draw Res. (Water Supply & Storage Co.)	Grand or Upper Colorado River	4, 400	Storage for trans-mountain waters diversion by Grand River Ditches, in channel of Long Draw. Earth-fill dam 63 ft. high 820 ft. long, area water surface 264 acres. Constructed in 1929 & 1930. No decree.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
3 cont.	Chamber's Lake Res. (Water Supply & Storage Co.)	Laramie River & Joe Wright Cr. & Upper Poudre R.	6,700	Storage for Larimer County Canal. In channel Cache la Poudre R. at Junction of Joe Wright Cr. Sky Line Ditch is feeder from Laramie R. Earth-fill dam, 57 ft. high, 1,290 ft. long, area water surface 264 acres. Priorities of 1882 & 1910 for 6,670 Ac.Ft. Originally constructed in 1882, and enlarged by raising and repairing dam in 1910.
	Worster Res. (Divide Canal and Res. Co.)	Sheep Creek, trib. of N. Fork Cache la Poudre River	3,740	Storage for Larimer and Weld Canal. In channel Sheep Creek. Earth-fill dam, 68 ft. high, 700 ft. long, area water surface 120 acres. Priorities of 1907-1910 for 3,740 Ac.Ft. Originally constructed in 1907 and enlarged in 1908 and 1910.
	Halligan Res. (North Poudre Irrig. Co.)	North Fork of Cache la Poudre River	6,400	Storage for North Poudre Canal. Channel res. concrete arch dam, height 80 ft., length 333 ft., 10 ft. freeboard, 110 ft. Spillway over crest of dams area water surface 253 acres. Priorities of 1894-1900 for 6,900 Ac. Ft. by transfer from No. Poudre Res.'s Nos. 5 and 6. Completed in 1910.
	No. Poudre Res. No. 15. (No. Poudre Irrig. Co.)	North Fork of Cache la Poudre River	5,500	Storage for North Poudre Canal. Off-channel res. fed.by No. Poudre Canal. Earth-fill dam, 45 ft. high, 3,500 ft. long, area 312 acres. Priority of 1909 for 5,470 Ac. Ft. Constructed in 1909.
	Dowdy Lake Res. (Laramie-Poudre Irrig. Co.)	Lone Pine Cr. (Trib. of N. Fork.	2,300	Storage for Poudre Valley (Laramie Poudre) Canal. Off-channel res. fed by canal from South Fork of Lone Pine Cr. Earth-fill dam about 50 ft. high and 3,400 ft. long, area 160 acres. Feeder from So. Pine has cap. of about 100 Sec. Ft. and is 8,000 ft. long. Plans have been made and some work has been done to enlarge this res.to practically double its present capacity.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
3 cont.				Has decrees for 2,100 Ac.Ft. dated 1899, 1906 & 1919 for original construction and 2 enlargements. Also has a conditional decree of 1919 for 3,450 Ac.Ft. additional but this enlargement (3rd) has not been made. Res. stores usually about 1/10 of its capacity.
	Douglas Lake Res. Laramie-Poudre Irrig. Co.	Cache la Poudre River	6,000	Storage for Greeley-Poudre Irrig. Dist. Off-channel res. supplied by Poudre Valley Canal. Earth-fill dam, 33 ft. high, 3600 ft. long, area 580 acres. Supplies Poudre Valley Canal by exchange with river. Has priority of 1901 for 10,580 Ac. Ft. but cannot hold this amount. Usually stores about 5,000 Ac. Ft. Originally constructed in 1901 and enlarged in 1908.
	North Poudre No. 2 Res. (Demmel Lake) (No. Poudre Irrig. Co.)	North Fork of Cache la Poudre River	3,880	Storage for North Poudre Canal. Off-channel res. fed by No. Poudre Canal. Earth-fill dike, depth water 24 ft., 2 dikes total length 1,400 ft. Priorities of 1890 & 1901 for 3,880 Ac. Ft. Construction started in 1884 and completed in 1890 to store 6 ft. depth of water, enlarged in 1891 and 1901. Present area water surface 275 acres.
	North Poudre No. 3 Res. (No. Poudre Irrig. Co.)	North Fork of Cache la Poudre River and Boxelder Creek.	2,870	Storage for No. Poudre Canal. Off-channel res. fed by No. Poudre Canal. Earth-fill dike, depth water 30 ft., area 160 acres. Priorities of 1884 to 1904 for 3,620 Ac.Ft. Original construction in 1884, enlarged in 1892 and 1904.
	North Poudre No. 4 Res. (No. Poudre Irrig. Co.)	North Fork of Cache la Poudre R., Boxelder Park & Dry Crs.	1,600	Storage for No. Poudre Canal. Off-channel res. fed by No. Poudre Canal. Earth-fill dike, depth water 22 ft., dike about 1,300 ft. long, area 100 acres. Priorities of 1889 and 1903 for 1,780 Ac. Ft. Original construction in 1889, enlarged in 1903.
	No. Poudre No. 5 Res. (Bee Lake) (No. Poudre Irrig. Co.)	Cache la Poudre River	5,750	Storage for Larimer Co. Canal by exchange with river. Off-channel res. fed by Poudre Valley Canal. Earth-fill dike, depth water 20 ft. length dike about ½ mile, area 500 acres. Priorities of 1894 and 1903 for 5,750 Ac.Ft. Original construction 1894, enlarg. 1903. 1,380 Ac.Ft. transferred to Halligan Res. in 1910.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
3 cont.	No. Poudre No. 6 (No. Poudre Irrig. Co.)	North Fork of Cache la Poudre River	10,200	Storage used by Larimer Co. Canal by river exchange. Off-channel res. fed through No. Poudre No. 2 Res. Earth-fill dike depth 26 ft., area 600 acres. Had priority for constr. of 1900 for 10,200 Ac.Ft. but transferred 7,800 Ac.Ft. to Halligan Res. in 1910 leaving present rights of only 2,400 Ac. Ft.
	McGrew Res. (Greeley-Poudre Irrig. Dist.)	Cache la Poudre R. & tributaries	21,500	An impractical storage scheme for Greeley-Poudre Irrig. district lands. A good reservoir site in a natural depression known as Eastman Basin. Present dike is 20 ft. in max. height and 10,000 ft. long, water depth that can be withdrawn is 38.5 ft., area filled 1,270 acres. The res. was to be supplied by the Laramie-Poudre Canal from the Poudre River, about 85 miles long through a Sandy Country. No water has ever reached the reservoir through the canal. The res. dike was constructed in 1906 & 1907 and connected with the feed canal. It was repaired in 1925 and a conditional decree of this date for 21,600 Ac.Ft. was issued in 1930 although the Res. is still dry.
	Clark's Lake (Coal Cr. Res's) (Nos. 12 & 13 Res.'s) (No. Poudre Irrig. Co.)	No. Fork of Cache la Poudre River, Boxelder and Coal Crs.	4,090	Storage for No. Poudre Canal. Off-channel res. fed by No. Poudre Canal. Low earth dike about 1,800 ft. long, area 346 acres. Two reservoirs connected. Priority of 1901 for 4,090 Ac. Ft., constructed in 1901. Greatest depth 25 ft.
	Reservoir No. 1 (Rocky Ridge Res.) (Water Supply & Storage Co.)	Cache la Poudre River	4,700	Storage for Larimer & Weld Canal on river exchange. Off-channel res. fed by Larimer County Canal. Earth-fill dike, water depth 30 ft. area 226 acres. Priority of 1891 (year of construction) for 4,700 Acre-Feet.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
3 cont.	Kluver Res. (Water Supply & Storage Co.)	Cache la Poudre River	1,150	Storage for Larimer & Weld Canal on river exchange. Off-channel res. fed by Larimer Co. Canal. Earth dike, 25 ft. high 3,370 ft. long, area 85 acres. Has no decree. Constructed in 1911.
	Windsor Res. (Windsor Res.& Canal Co.)	Cache la Poudre River.	18,600	Storage delivered to Cache la Poudre (or Greeley No. 2) canal in exchange for river water diverted above by Larimer & Weld Canal. Off-channel res. fed by feeder from Larimer & Weld Canal, (also known as Eaton Ditch). Earth-fill dam, depth water 37 ft., length dike about 4,600 ft., area 1,000 acres. Priorities of 1890 and 1901 for 17,700 Ac.Ft. Originally constructed in 1890, enlarged in 1893 and 1901.
	Windsor No. 8 Res. (Windsor Res. and Canal Co.) (Includes Annex No. 8.)	Cache la Poudre River	11,250	Storage for Larimer and Weld Canal. Off-channel res. fed by Poudre Valley Ditch. Consists of 2 natural depressions connected by a cut 350 ft. long and supplemented by earth dikes. No. 8 dike 23 ft. high, 4,430 ft. long, Annex dike 18 ft. high, 1,420 ft. long, total area water surface 540 acres, greatest depth is 50 ft. Priority of 1903 for total of 15,400 Ac. Ft. Originally constructed by No. Poudre Irrig. Co. in 1901, enlarged by B. H. Eaton, in 1903. Later acquired by Divide Canal & Res. Co. whose successors are the Windsor Res. and Canal Co.
	Black Hollow Res. (Water Supply & Storage Co.)	Cache la Poudre River	8,000	Storage for Larimer Co. Canal. Off-channel res. fed by Larimer Co. Canal. Earth dike 42 ft. high, 1,300 ft. long, area 500 acres. Priority of 1906 for 6,400 Ac.Ft. (date of constr.) enlarged to present capacity in 1918.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
3 cont.	Warren Lake Res. (Warren Lake Res. Co.)	Cache la Poudre	2,900	Storage for Warren Lake Outlet Canal. Off-channel res. fed by Larimer Co. No. 2 Ditch. Earth dike, depth water 20 ft., length dike 3,600 ft., area 200 acres. Priorities of 1875-1908 for 2,430 Ac. Ft. Original construction in 1875, enlarged in 1893 and in 1908.
	Larimer & Weld Res. (Terry Lake) (Larimer & Weld Res. Co.)	Cache la Poudre River and Dry Creek	9,770	Storage for Larimer and Weld Canal. Off-channel res. filled by Little Cache la Poudre Ditch. Earth-fill dike, depth water 35 ft., length dike 4,000 ft., area 530 acres. Priorities of 1890-1905 for 9,770 Ac. Ft. Original construction in 1890, enlarged in 1895 and 1905.
	Long Pond Res. (or Res. No. 5) (Water Supply and Storage Co.)	Cache la Poudre River	4,040	Storage for river exchange with Larimer & Weld Canal. Off-channel res. fed by Larimer Co. Canal. Earth dike, depth water 30 ft., length dike 2,800 ft., area 240 acres. Priority of 1891 for 4,040 acre-feet (date construction). Enlarged in 1908.
	Cache la Poudre Res. (Timnath Lake) (Cache la Poudre Res.Co.)	Cache la Poudre River and small tribs.	9,540	Storage for Cache la Poudre or Greeley No. 2 Canal. Off-channel res. fed by inlet canal from river, about 6 mi. long, cap. 140 sec. ft., Earth dike, depth water 34 ft., length dikes 4,400 ft., area 700 acres. Decrees of 1892 & 1902 for 10,100 acre-feet. Original construction in 1892, enlarged in 1902.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
3 cont.	Wood Reservoir (Divide Canal & Res. Co.)	Cache la Poudre River	3,200	Storage for Wood Outlet Canal. Off-channel res. fed through a draw by the Larimer and Weld Canal. Earth dike, depth water 25 ft., length dike 1,300 ft., area 200 acres. Priorities of 1892 and 1903 for 3,200 Ac.Ft. Built in 1892 and enlarged in 1903.
	Windsor Lake Res. (Lake Supply Co.)	Cache la Poudre River	1,800	Storage for Lake Supply Ditch and sugar factory of Windsor. Off-channel res. supplied by Cache la Poudre Canal. Earth dike, depth water 9 ft., area 200 acres. Priority of 1882 for 1,800 Ac. Ft. Has not been enlarged.
	Fossil Cr.Res. (No. Poudre Irrig. Co.)	Cache la Poudre River and Fossil Cr.	11,560	Storage for river exchange by North Poudre Canal. Off-channel res. fed by Fossil Cr. Inlet Canal, about 4.5 miles long with capacity of 400 Sec.Ft. Earth-fill dam 45 ft. high, 2,500 ft. long, area 800 acres. Priorities of 1901 and 1904 for 13,600 Ac.Ft. Constructed in 1901.
	Big Beaver Res. (Mountains and Plains Irrig. Co.)	Big Beaver Cr. a trib. of So. Fork of Poudre R.	1,220	Storage water for sale. Off-channel res. fed by inlet canal from Big Beaver Cr. Earth-fill dam, height 40 ft., length about 500 ft., area 70 acres. Priorities of 1898 and 1901 for 1,590 Ac. Ft. Constructed in 1898 and outlet lowered in 1901.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
3 cont.	Barnes Meadow Res. (Mountains & Plains Irrig. Co.)	Upper Cache la Poudre R.	1,630	Storage for sale. Off-channel res. fed by inlet canal diverting below Chambers Lake. Canal 2,760 ft. long, cap. 650 s.f. Earth-fill dam 52 ft. high, 1,400 ft. long, area 65 acres. Has no decrees as yet. Constructed in 1927.
	Richards Res. (Water Supply & Storage Co.)	Cache la Poudre River	1,050	Storage for exchange with Larimer & Weld Canal. Off-channel res. fed by Larimer County Canal. Earth-fill dike 20 ft. high, 1,900 ft. long, area 68 acres. Has no decrees. Constructed in 1906.
	Curtis Lake Res. (Water Supply & Storage Co.)	Cache la Poudre River	1,500	Storage for river exchange by Larimer Co. Canal with Larimer & Weld Canal. Off-channel res. fed by Larimer Co. Canal. Earth dike, 20 ft. high, 2,775 ft. long, area 150 acres. Has no storage decree. Fills mostly during irrig. season from excess water in Larimer Co. Canal. Built in 1906.
	Cobb Lake Res. Laramie-Poudre Irrig. Co.	Cache la Poudre River	8,000	Storage water sold to Larimer and Weld Canal. Off-channel res. filled through Poudre Valley Canal and Laramie-Poudre (or Greeley-Poudre) Canal, which is an extension of the first mentioned canal. Earth-fill dam 40 ft. high, 800 ft. long, area high water line 440 acres. Has a decree dated 1919 for 1,000 Ac. Ft. Also has a conditional decree of 1919 to store a total of 9,100 Ac.Ft. (decree to become absolute if this amount is stored within a reasonable time). Greatest amount of water stored so far is 5,200 Ac.Ft. in 1927. Work was done on this reservoir, intermittently, by several owners between 1901 and 1919, when it was finally completed to its present capacity.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
1	Empire Res. (Bijou Irrig. Dist.)	South Platte R.	37,700	Storage for Bijou Canal. Off-channel res. fed by Empire Inlet Can., 20 miles long, cap. 600 Sec. Ft. Long earth-fill dikes about 5 miles long (res. is about 2/3 surrounded by dikes), max. height 38 ft., area high water line 2,900 acres. Decree of 1905 for 37,700 Ac. Ft. Originally constructed in 1905-1906, enlarged in 1910. Part of inside slope of dike washed out and was repaired in 1917.
	Bijou No.2 Res. (Bijou Irrig. Co.)	South Platte R. & Bijou Cr.	9,200	Storage for Bijou Can. and other ditches in Bijou Irrig. Dist. Off-channel res. filled through Bijou Can. and inlet from Bijou Cr. Earth-fill dike, 18 ft. high, 2,880 ft. long, 8 ft. storage below base of dike, making available depth of water 26 ft., area water surface 916 acres. Priority of 1909 for 9,200 Ac. Ft. Originally constructed as small res. by Fort Morgan Land & Res. Co. in 1889. Enlarged to present capacity by Bijou Irrig. Co. in 1909.
	Owl Creek Res. (Owl Creek Ditch & Res. Co.)	Owl Creek	1,100	Storage for 1,200 acres under res. Off-channel res., feed can. 4,700 ft. long, cap. 600 Sec. Ft. Low earth dike, depth water 15 ft., length dike 4,600 ft., area water surface 219 acres. Priorities of 1891 & 1896 for 1,100 Ac.Ft. Original construction in 1891, enlarged 1896.
	Hereford Irrig. Sys. Res. or Lovella Res. (Lovella D. Res. (Irrig. Co.)	Crow Creek	6,770	Storage for lands under reservoir. Off-channel res. fed by feed canal from Crow Cr., 7.4 miles long, cap. about 100 Sec. Ft., diverts in Wyoming. Long earth dike, depth water 27 ft., length dike about 1 mile, area water surface 562 acres. Conditional decree of 1910 for 6,770 Ac.Ft. were issued in 1914 but no evidence is on record of actual use of this amount of water. Res. constructed in 1912, present condition not known.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
1 Cont.	Riverside Res. (Riverside Res. and Land Co.)	South Platte R.	57,500	Storage for Riverside Outlet Canal and other canals in Riverside Irri. Dist. Off-channel res. fed by Riverside Inlet Canal, 11½ miles long, cap. 1,000 Sec. Ft. Long earth dike, depth water 32 ft., length dike 4.4 miles, area water surface 3,595 acres. Priorities of 1902 and 1907 for 57,500 Ac. Ft. Original construction in 1902 for 16,000 Ac. Ft., enlargement completed to present capacity in 1908.
	Jackson Lake Res. (Jackson Lake Res. & Irr. Co.)	South Platte River	35,400	Storage for Fort Morgan Canal and other canals of Fort Morgan and Hillrose Irrig. Dist's. Off-channel res. fed by Jackson Lake Inlet Canal 11 miles long, cap. 400 Sec. Ft. Priority of 1901 for 35,629 Ac. Ft. Earth-fill dike, water depth 30 ft., length dike 3.8 miles area water surface 2,546 acres. Outlet ditch to river 2 miles long, cap. 600 s.f. Completed in 1903.
	Jack Pot Res. (North Fort Morgan Res. Co.)	Wild Cat Cr.	1,770	Storage for Jack Pot No. 1 and No. 2 ditches. Channel res. on Wild Cat Cr. Earth-fill dam, depth water 31 ft., length dam 1,830 ft., area water surface 132 acres. Priority issued in 1914 for 160 acre-feet of date 1908. Dam completed in 1911. Evidently the project is not a success due to lack of water in Wild Cat Cr.
	Prewitt Reservoir (Prewitt Res. and Land Co., Logan and Iliff Irr. Dist's.	South Platte River	32,800	Storage for Logan and Iliff Irr. Dists. Off-channel res. fed by Prewitt Inlet Canal, 25,400 ft. long, cap. 695 Sec. Ft. Earth-fill dam, 36 ft. high, 18,400 ft. long, area 2,430 acres. Priority of 1910 for 32,300 Ac. Ft. Work was started on this res. in 1906 but was not in active operation until completed by its present owners in 1912

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
1 cont.	Noonen No. 2 Res. (Agate Land and Irr. Co.)	Deer Trail Cr.	2,660	Storage for about 300 acres under res. On channel of Deer Trail Cr. Earth-fill dam, depth water 25 ft. length dike 2,500 ft. Area 160 acres. Priority of 1907 for 2,660 Ac. Ft. Conditional decree of 1912 for enlargement to 6,100 Ac.Ft. Not yet enlarged. Constructed in 1907 by John T. Noonen.
	Agate No. 1 (Agate Land and Irr. Co.)	East Bijou Cr.	5,600	Storage for lands under Agate Ditch. Off-channel res. supplied by Agate Ditch, 9,400 ft. long, cap. 2,250 s.f. Earth dam, 26 ft. high, 6,600 ft. long, area about 500 acres. Has no decree Constructed 1905-1906. (not storing water in late years.)
	Heart Res. (Andy Ross).	Little Crow & Willow Crs.	1,300	Storage for Seven Cross Ditch, Channel res. on Little Crow Cr. Earth-fill dam 26 ft. high, 1,200 ft. long area 160 acres. Priority of 1906 for 1,300 Ac. Ft. Built in 1906.
	Adams Res. (Nile Irrig. Dist.) (Daugherties)	East Bijou Creek	5,400	Storage for Nile Irrig. Dist. Off-channel res. fed by intake canal. Earth-fill dikes 23 ft. high, 13,800 ft. long, area 448 acres. Decree of 1908 for 11,000 acre-feet. Conditional on beneficial use of water. Inlet diversion washed out and reservoir has not been used for a number of years. Originally constructed in 1912.
	Bootleg Res. (Henrylyn Irrig Dist.)	Boxelder Cr.	6,200	Storage for Henrylyn Irrig. Dist. Channel res. Earth-fill dam, 46 ft. high 2,600 ft. long, area water surface 432 acres. Conditional priority of 1909 for 6,200 Ac.Ft. Dam completed in 1909. Res. is operating but no record of storage is kept.

PRINCIPAL CONSTRUCTED RESERVOIRS
IN SOUTH PLATTE AREA (Cont'd.)

Water District	Name and Owner	Source of Water Supply	Capacity in Acre-Feet	Description
64	Point of Rocks Res. (North Sterling Res.) (North Sterling Irrigation Dist.)	South Platte R. & Pawnee Cr., & Cedar Cr.	81,000 (Safe cap)	Storage for No. Sterling Irrig. Dist. Away from channel of main supply but across bed of Cedar Creek. Earth-fill dam 85 ft. high, 5,080 ft. long, area 3,080 acres. Has feed canal about 50 miles long. Cap. 405 Sec.Ft., outlet extends 65 miles beyond reservoir. Priority of 1908 for 73,920 Ac. Ft. with 300 Sec.Ft. inlet canal. Conditional decree dated 1915 allows enlargement of inlet canal to 711 Sec. Ft. and res. to store up to 84,000 Ac.Ft. if the necessary work is done within a reasonable time. Enlargement has not been completed. The rip-rap on the water face of the dam was badly damaged by wave action in the spring of 1927. The slope was flattened and the rip-rap restored over the entire face in 1928 and 1929. Originally constructed in 1908. Greatest amount stored during past 5 years is 65,075 Ac. Ft. in 1927. Diverts in District No. 1.
	Julesburg Res. (Jumbo Res.) (Julesburg Irrig. Dist.)	South Platte River	28,200	Storage for Julesburg Irrig. Dist Five earth dams, max.height 58 ft. total length 8,200 ft., area 1,570 acres. Off-channel res. fed by Harmony No. 1 ditch, 20 miles long, cap. 350 Sec. Ft. Priority No. 1 of 1904 for 28,200 Ac. Ft. Constructed in 1904-1905. Storage limited to about 24,000 Ac. Ft. on account of danger from wind action.