EFFECT OF FLOW DIVERSION FOR IRRIGATION ON PEAK RATES OF RUNOFF FROM WATERSHES IN AND NEAR THE ROCKY MOUNTAIN FOOTHILLS OF COLORADO

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Paper No. 8

CSU. Atmospheric Science Technical Paper No. 8

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BIBLIOGRAPHIC DATA SHEET	1. Report No. CER60-36	2.	3. Recipient's Accession No.
4. Title and Subtitle EFFECT OF FLOW DIVERSION FOR IRRIGATION ON PEAK RATES OF RUNOFF FROM WATERSHEDS IN AND NEAR THE ROCKY MOUNTAIN FOOTHILLS OF COLORADO			5. Report Date Mar. 1962
			6.
7. Author(s) Richard A. Schleusener, G.L. Smith and Ming Cheng Chen			8. Performing Organization Rept. No. CER60-36
9. Performing Organization Name and Address Civil Engineering Research Colorado State University Fort Collins, Colorado 80521			10. Project/Task/Work Unit No.
			11. Contract/Grant No.
12. Sponsoring Organization Name and Address U.S. Bureau of Public Roads Hydraulic Research Division Washington, D.C.			13. Type of Report & Period Covered
			14.

15. Supplementary Notes CSU. Atmospheric Science Technical Paper No. 8.
Published in International Assoc. of Scientific Hydrology. Bulletin No. 7, 1962

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17. Key Words and Document Analysis. 17a. Descriptors

Flow diversion
Irrigation
Runoff
Watersheds
Rocky Mountain Foothills
Colorado

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 9
	20. Security Class (This Page) UNCLASSIFIED	22. Price

I.A.S.H. Bulletin No. 7, March 1962

EFFECT OF FLOW DIVERSION FOR IRRIGATION ON PEAK RATES OF RUNOFF FROM WATERSHEDS IN AND NEAR THE ROCKY MOUNTAIN FOOTHILLS OF COLORADO

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ABSTRACT

An investigation was made to determine the effect of flow diversions for irrigation on the magnitude and frequency of peak rates of runoff from selected small watersheds in the Rocky Mountain Foothills in Colorado. A study of seven watersheds smaller than 1,000 square miles indicates that the effect of flow diversion on peak rates of runoff is probably negligible for those watersheds for which peak rates of runoff are caused by rainstorms. Evidence indicates that flow diversions probably become significant for watersheds of 1,000 square miles or more for which snowmelt is a significant contributing factor in producing peak rates of flow.

INTRODUCTION

The effect of flow diversion for irrigation on magnitude and frequency of peak rates of runoff has not yet been definitely established. An investigation was made of this problem for selected small watersheds in the Rocky Mountain Foothills in Colorado and in the region of the High Plains of Colorado adjacent to the Rocky Mountain Foothills. The watersheds studied are considered representative of the conditions under which there is not only a short supply but also a great demand for irrigation water.

Procedure

One of the reasons that little is known of the effect of flow diversions on peak rates of runoff is that most of the basic data are available only in unpublished form — as records of the various Water Commissioners which are on file in the office of the State Engineer. After consulting with the Chief Hydrographer from the office of the State Engineer of Colorado, it was concluded that the quality and quantity of records was adequate to justify detailed analyses of only a limited number of watersheds. The watersheds selected for study are given in Table 1.

The records maintained in the Water Commissioners' Field Books on file in the State Engineer's office include the following information:

1. The daily diversion rate,
2. The first and last date water was used for irrigation,
3. Total days water was diverted,
4. Total volume of water used,
5. Irrigated area, and
6. Dates of the water decrees.

Additional data, such as the names and locations of ditches, the method of operation of the irrigation system, and the location and types of measuring devices, were obtained from individual Water Commissioners.

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TABLE 1

Flow diversions for irrigation as a percentage of peak rates of runoff for selected watersheds in and near the rocky mountain foothills in Colorado

Station	Location: Longitude			Location: Latitude			Elevation of Gauging Sta.	Drainage Area	Period of Record Studied	Flow Diversion for Irrigation in per cent of peak flow: Max.	Median	Min.
	Degree°	Min′	Sec″	Degree°	Min′	Sec″	Ft.	Sq. Mile				
Bear Creek at Morrison, Colo.	105	11	40	39	39	10	5780	165	1938-1957[4]	small [1]		
Bear Creek at Mouth at Sheridan, Colo.	105	01	13	39	39	07	5280	264	1938-1957[4]	95.00	3.40	0.86
Cherry Creek near Franktown, Colo.	104	45	50	39	21	40	6150	172	1940-1958	2.24	0.11	0
Cherry Creek near Melvin, Colo.	104	49	15	39	36	20	5610	369	1940-1958	0.73	0.19	0
Fountain Creek at Pueblo, Colo.	104	35	40	38	16	20	4660	926	1924-25, 1935 1942-58	52.00[2]	1.17	0.28
St. Vrain Creek at Lyons, Colo.	105	15	40	40	13	10	5290	226	1936-1957[4]	small[1]		
St. Vrain Creek at Mouth near Platteville, Colo.	104	52	46	40	15	28	4740	1000	1936-1957[4]	150	6.10	0
Cache la Poudre River near Ft. Collins, Colo.	105	13	10	40	39	55	5240	1048	1936-1957[4]	small[1]		
Cache la Poudre River near Greeley, Colo.	104	38	22	40	25	04	4610	1840	1936-1957[4]	102[3]	54.4	12.6

[1] Information from Water Commissioner indicates effect is probably less than 1 per cent.
[2] Only for the two lowest peak flows have diversions been greater than 10 per cent.
[3] Peak flows also affected by trans-basin, trans-mountain niversion, and diversion for municipal use. Total effect of these artificial control measures is unknown.
[4-5] Highest and 2 lowest peak flow years have been selected for study.

The momentary maximum discharge for each water year and the date of its occurrence for each station was compiled from Water Supply Papers of the U.S. Geological Survey.

The time of flow into each ditch that would produce an effect on the peak rates of runoff was determined by plotting the hydrograph of the gaging station for an isolated storm. Fig. 1 shows that the time required for runoff from an isolated storm to travel from the headwater to the gaging station, both for Cherry Creek and Fountain Creek, is less than 24 hours. Therefore the diversion data were computed as of the date of maximum peak flows, without any adjustment for travel time from the diversion point to the gaging station.

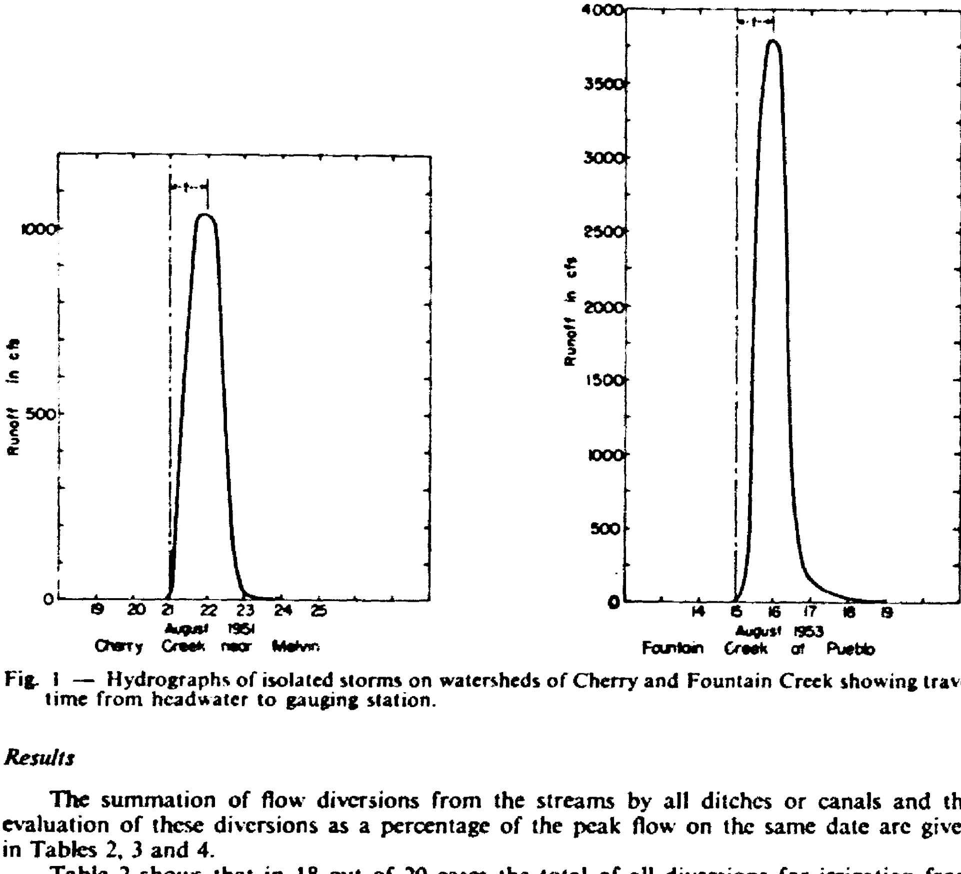

Fig. 1 — Hydrographs of isolated storms on watersheds of Cherry and Fountain Creek showing trave time from headwater to gauging station.

Results

The summation of flow diversions from the streams by all ditches or canals and the evaluation of these diversions as a percentage of the peak flow on the same date are given in Tables 2, 3 and 4.

Table 2 shows that in 18 out of 20 cases the total of all diversions for irrigation from Fountain Creek above Pueblo were less than three (3) per cent of the annual maximum peak flows. Only for the two lowest peak flows were flow diversions greater than ten (10) per cent of the annual maximum peak flows. Hence the effect of flow diversion for irrigation on peak flows may be neglected.

Tables 3 and 4 show that in all cases the total flow diversion for irrigation from Cherry Creek at two locations were also less than three (3) per cent of the annual maximum peak flows. Likewise, the limited sample of Table 5 shows that 8 out of 10 cases were less than 10 per cent. The two highest percentages (for 1939 and 1951) were for low-flow years.

TABLE 2

Summation of diversions for irrigation and/or storage from Fountain Creek above Pueblo as a fraction of the annual maximum peak rates of runoff

Station	Fountain Creek at Pueblo, Colorado			
Water Year	Annual Maximum Peak Flow		Summary of Diversion for Irrigation	
	Rate cfs	Date	Total in cfs	Percent of Peak Flow
1958	3,750	Aug. 5	97.5	2.60
1957	6,180	May 15	91.0	1.47
1956	5,250	Aug. 18	34.5	0.66
1955	11,500	Aug. 6	72,3	0.63
1954	5,800	Aug. 6	25.8	0.45
1953	3,730	Aug. 16	65.0	1.74
1952	5,170	Aug. 28	72.9	1.41
1951	11,600	July 30	57.9	0.50
1950	9,600	July 28	117.2	1.22
1949	1,590	June 5	184.0	11.58
1948	9,290	June 12	142.7	1.54
1947	5,880	July 8	86.9	1.48
1946	16,000	Aug. 26	193.4	1.17
1945	17,800	July 10	112.0	0.63
1944	12,900	Aug. 4	117.5	0.91
1943	324	May 22	168.1	52.00
1942	11,000	Aug. 14	128.0	1.17
1935	35,000	May 30	99.6	0.28
1925	2,500	July 19	84.5	3.38
1924	12,000	Oct. 3	47.0	0.39

Since Cherry Creek and Fountain Creek are intermittent streams, most of the peak rates of runoff were probably caused by intense storms which gave higher rates of flow than the rate of flow used for orrigation. This hypothesis is substantiated by two facts: (1) Fifteen out of nineteen maximum annual events occurred during the summer season when irrigation demands are normally the highest; and (2) the summer season is the period of intense storms of short duration.

A plot of the annual maximum peak rates of runoff *vs* diversions expressed as per cent of peak flow for watersheds smaller than 1000 square miles is given in Fig. 2. A similar plot for watersheds larger than 1000 square miles is given in Fig. 3. Both figures show that the smaller the peak flow, the greater the effect of flow diversion.

Flow diversions for irrigation, in per cent of peak rates of runoff, are given in Table 1. The maximum effect was 150 per cent for the St. Vrain Creek at the mouth near Platteville.

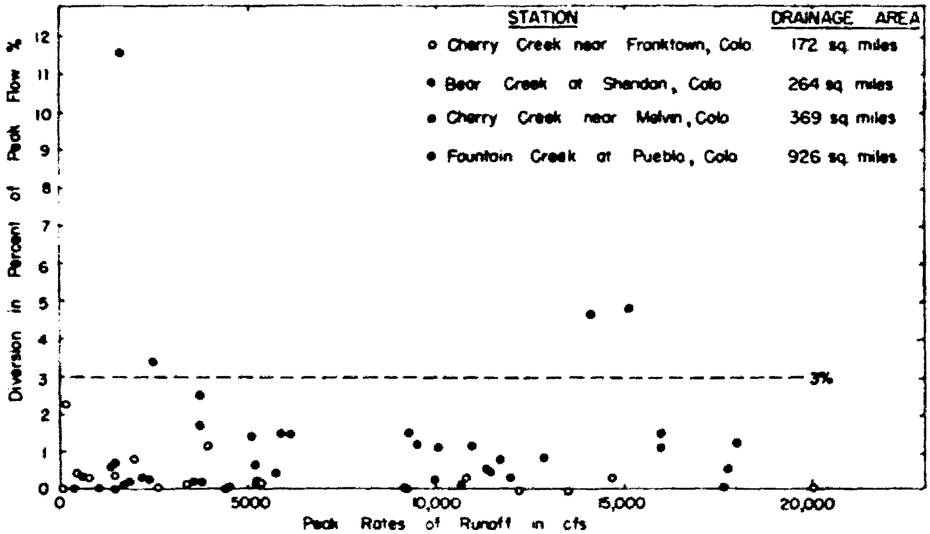

Fig. 2 — Flow diversion for irrigation and/or storage as a per cent of maximum annual peak flow for watersheds less than 1000 sq. mi. in Rocky Mountain Foothills of Colorado.

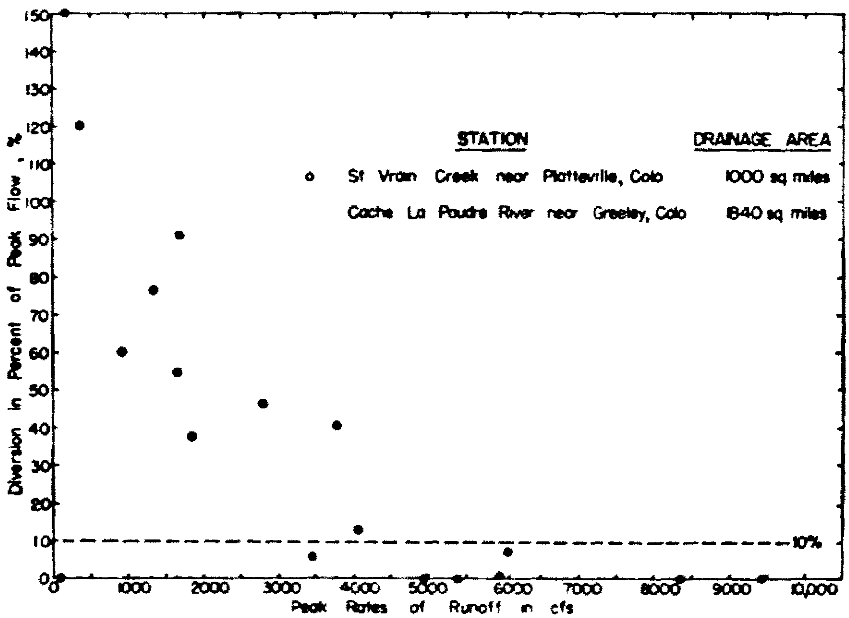

Fig. 3 — Flow diversions for irrigation and/or storage as a per cent of maximum peak flow for watersheds greater than 1000 sq. mi. in Rocky Mountain Foothills of Colorado.

TABLE 3

Summation of diversion for irrigation and/or storage from Cherry Creek above Melvin as a fraction of the annual maximum peak rates of runoff

Station	Cherry Creek near Melvin, Colorado			
Water year	Annual maximum peak flow		Summary of diversion for irrigation	
	Rate cfs	Date	Total in cfs	Per cent of peak flow
1958	5.290	July 18	6.5	0.13
1957	9,950	July 26	23.5	0.24
1956	5,310	July 31	10.2	0.19
1955	4,510	Aug. 5	2.7	0.06
1954	611	Aug. 13	2.0	0.33
1953	1,670	Aug. 27	2.0	0.12
1952	321	Aug. 29	0	0
1951	1,040	Aug. 22	0	0
1950	1,450	July 25	0	0
1949	1,420	June 13	10.4	0.73
1948	3,760	May 30	7.7	0.21
1947	1,790	Mar. 18	3.5	0.20
1946	17,600	July 18	11.5	0.06
1945	10,700	Aug. 5	11.8	0.11
1944	1,380	July 9	8.4	0.61
1943	3,580	Aug. 4	8.0	0.22
1942	2,220	Aug. 3	6.5	0.29
1941	2.390	July 14	6.0	0.25
1940	4,500	Sept. 6	0.5	0.01

Only for this station and for the Cache la Poudre River at Greeley were the median flow diversions for irrigation larger than five (5) per cent.

Discussion

Table 1 shows differences in the amounts of flow diversions for irrigation and storage with changes in agricultural land use. Diversions for irrigation or for storage in reservoirs from the St. Vrain at Lyons and from the Cache la Poudre near Fort Collins are negligible as compared to gaging stations located a short distance downstream. For example, between Lyons and Platteville on the St. Vrain River the amount of irrigable land increases 460 per cent from 20,000 acres to 112,000 acres, and the amount of reservoir storage 840 per cent from 5,000 acre feet to 46.900 acre feet (1,2,3) (*). Likewise between the mouth of the canyon and Greeley on the Cache la Poudre River the amount of irrigable land increases 3,100 per

(*) Numbers theses refero in parent appended regerences.

TABLE 4

Summation of diversion for irrigation and/or storage from Cherry Creek above Franktown as a fraction of the annual maximum peak rates of runoff

Station	Cherry Creek near Franktown, Colorado			
Water year	Annual maximum peak flow		Summation of diversion for irrigation	
	Rate cfs	Date	Total in cfs	Per cent of Peak flow
1958	152	Feb. 18	3.7	2.24
1957	5,380	July 30	9.9	0.19
1956	3,380	July 31	3.7	0.11
1955	790	Aug. 5	2.7	0.34
1954	2,620	Aug. 7	2.0	0.08
1953	455	Aug. 16	2.0	0.44
1952	1,350	Aug. 28	0	0
1951	81	Aug. 3	0	0
1950	146	July 27	0	0
1949	1,080	June 13	3.7	0.34
1948	1,220	Mar. 23	0	0
1947	928	Mar. 18	0.5	0.05
1946	1,470	Aug. 24	5.5	0.37
1945	9,170	Aug. 5	2.2	0.03
1944	390	July 12	4.4	1.15
1943	198	June 28	1.7	0.86
1942	3,620	Mar. 13	1.0	0.03
1941	4,700	July 13	0.5	0
1940	2,000	June 6	2.7	0.13

cent from 700 acres to 225,000 acres and the amount of reservoir storage 410 per cent from 31,800 acre feet to 161,162 acre feet [1,2,3].

The percentage of flow diversion from the Cache la Poudre at Greeley and from the St. Vrain at Platteville are higher than for the other watersheds listed in Table 1. The probable reasons for this are: (*a*) snowmelt is a major cause of annual peak flows, (*b*) land area suitable for irrigation is large, and (*c*) the numerous off-stream storage reservoirs are filled at this time.

With the exception of these two gauging stations, no appreciable error would result from ignoring the effect of flow diversions for irrigation on peak rates of runoff for the watersheds studied.

TABLE 5

Summation of diversions for irrigation and/or storage from bear Creek above Sheridan as a fraction of the annual maximum peak rates of runoff

Station	Bear Creek near Sheridan, Colorado			
Water Year	Annual maximum peak flow[1]		Summation of diversion for irrigation	
	Rate cfs	Date	Total in cfs	Percent of peak flow
1957	2,560	Aug. 21	97	3,79
1955	1,170	Aug. 11	100	0.86
1951	60	June 3	57	95.00[2]
1950	1,510	June 16	73	4.84
1949	1,800	June 5	23	1.28
1947	1,010	June 22	12	1.19
1945	1,410	Aug. 20	66	4.69
1942	1,600	April 19	25	1.56
1939	141	April 16	60	42.50[2]
1938	2,810	Sept. 2	96	3.42

CONCLUSIONS

1. There is no significant effect of diversions for irrigation on peak rates of runoff for watersheds less than 1000 square miles in the Rocky Mountain Foothills of Colorado for which the primary causes of floods are rainstorms.

2. Flow diversions for irrigation become more significant for watersheds greater than 1000 square miles in the Rocky Mountain Foothills for which snowmelt is a primary cause of annual peak rates of runoff.

3. These conclusions are considered probably applicable to adjacent similar areas in Wyoming and New Mexico, in which there is a heavy demand for irrigation and/or storage water.

ACKNOWLEDGEMENTS

The authors wish to thank Mr. L.R. Burgess, Chief Hydrographer for the State of Colorado, and W.G. Wilkinson, Water Commissioner of District Three, for their assistance in compiling the basic data used in this study. This study was performed as a part of larger study on peak rates of runoff sponsored by the Hydraulic Research Division, U.S. Bureau of Public Roads, Carl F. Izzard, Chief.

(1) Eight highest and two lowest peak flow years have been selected for study.
(2) Values not shown on Fig. 2.

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