STREAMFLOW CHARACTERISTICS OF SMALL TRIBUTARIES OF ROCK CREEK, MILK RIVER BASIN, MONTANA, BASE PERIOD WATER YEARS 1983-87

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CONVERSION FACTORS

The following factors can be used to convert inch-pound units in this report to metric (International System) units.

Multiply inch-pound unit	By	To obtain metric unit
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile	2.59	square kilometer

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) by the equation:

$$°C = 5/9\ (°F - 32)$$

Sea Level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929."

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ABSTRACT

Five streamflow-gaging stations--four on small tributary streams and one on Rock Creek--were installed in the Rock Creek basin north of the Milk River near Hinsdale, Montana. Streamflow was monitored at these gaging stations and at an existing gaging station upstream on Rock Creek from May 1983 through September 1987.

On the basis of 9 years of record at the existing gaging station, annual mean streamflow in the study area was substantially less than the long-term (1979-87) mean annual streamflow (17 cubic feet per second) during water years 1983-85 and was greater than the mean annual streamflow during water years 1986-87. Annual mean streamflow for 1983-87 ranged from 2.8 to 57 cubic feet per second in the mainstem and from zero to 0.60 cubic foot per second in the tributaries. Monthly mean streamflow at the six gaged sites ranged from zero to 528 cubic feet per second. Although monthly runoff trends of the four tributary streams were similar to those of Rock Creek, monthly mean flows of the four tributary streams were small, ranging from zero to 5.3 cubic feet per second. Daily mean streamflow data for the six gaged sites indicate similar patterns during periods of large runoff, but substantial individual variations during periods of lesser runoff. During periods of little area-wide runoff, the small streams may have daily mean flow that is several times larger than that at the two Rock Creek sites. Daily mean streamflows of Rock Creek were often less at the downstream site than at the upstream site.

Thus, daily mean streamflow in the tributaries appears to be closely related to daily mean streamflow in mainstem Rock Creek only during periods of substantial area-wide runoff. Streamflow in the tributaries resulting from local storms or local snowmelt may not contribute to streamflow in the mainstem.

INTRODUCTION

In the Milk River basin in Montana north of the mainstem, runoff from small tributary streams has long been used as a source of water for small stockwater reservoirs. Stockwater dams have been constructed with little regard to flow characteristics of the small streams or to the potential cumulative effect of such dams on streamflow in the Milk River.

A major problem in adequately evaluating the effects of stockwater reservoirs on streamflow is the lack of flow data for small streams. This study was undertaken to provide streamflow data that could be used to assist in the effective design and placement of these reservoirs. The study was conducted in cooperation with the U.S. Bureau of Land Management.

Purpose and Scope

This report describes the flow characteristics of four small streams in the Rock Creek basin north of Hinsdale that are considered to be typical of those in the northern part of the Milk River basin in Montana. Streamflow-gaging stations were installed on four tributaries and on Rock Creek downstream from an existing station. Differences in streamflow at the two gaging stations on Rock Creek were used to help describe flow characteristics of the four small streams.

General Description of the Area

The Rock Creek basin (fig. 1) north of Hinsdale is a sparsely populated basin that has rolling hills, flat valleys, and moderately defined drainage systems. The land surface has little relief, with elevations ranging from 2,500 to 2,700 ft above sea level.

The climate is typically continental. Winters are cold and dry and summers are hot and moderately dry. Temperatures at Opheim, about 20 mi east of the study area, range from a mean daily maximum of 80 °F in July to a mean daily minimum of -4 °F in January. Average annual precipitation is about 12 in.; more than 8 in. of the total is received from April through August. June is the wettest month, with an average of about 3 in., and February is the driest, with an average of 0.4 in. (U.S. Environmental Data Service, 1971).

Except for Rock Creek, a major north-side tributary of the Milk River that normally appears to be perennial for most of its length, all streams in the basin are intermittent or ephemeral. Snowmelt produces runoff in most streams each year during the spring, and thunderstorms produce runoff in most streams during the summer. Occasionally, late snowmelt and rain combine to cause runoff.

STREAMFLOW DATA

To obtain flow data on small streams, four gaging stations were installed on tributaries of Rock Creek in May 1983 and operated through September 1987. The gaging stations (fig. 1, sites 2-4, 6) were located on streams where no stockwater dams existed in 1983, but where there was potential for future construction. In addition, one gaging station (site 5) was installed on the mainstem of Rock Creek downstream from three of the small streams. Streamflow data collected at this downstream gaging station, together with data collected at an existing gaging station upstream on Rock Creek near the international boundary (site 1), provided information on streamflow gain and loss between the two sites.

All annual streamflow data are presented on a water-year[1] basis. Streamflows are reported to the nearest hundredth of a cubic foot per second for values less than 1 ft^3/s; to the nearest tenth between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to 3 significant figures for more than 1,000 ft^3/s.

At the five gaging stations (sites 2-6) installed in May 1983, the period of available record is one partial (May-September 1983) and four complete (1984-87) water years. At the upstream Rock Creek gaging station the period of record is 9 complete water years (1979-87).

Drainage area upstream from each gaging station and annual mean flow data for water years 1983-87 are listed in table 1. Monthly mean streamflows are listed in table 2; daily mean streamflows during periods of runoff are listed in table 3.

STREAMFLOW CHARACTERISTICS

All the gaged streams have snowmelt runoff in February or March of most years (table 2). Monthly flows of the four small streams are relatively small, unless

[1]A water year is the 12-month period October 1 through September 30. It is designated by the calendar year in which it ends. Water year 1987, for example, began October 1, 1986, and ended September 30, 1987.

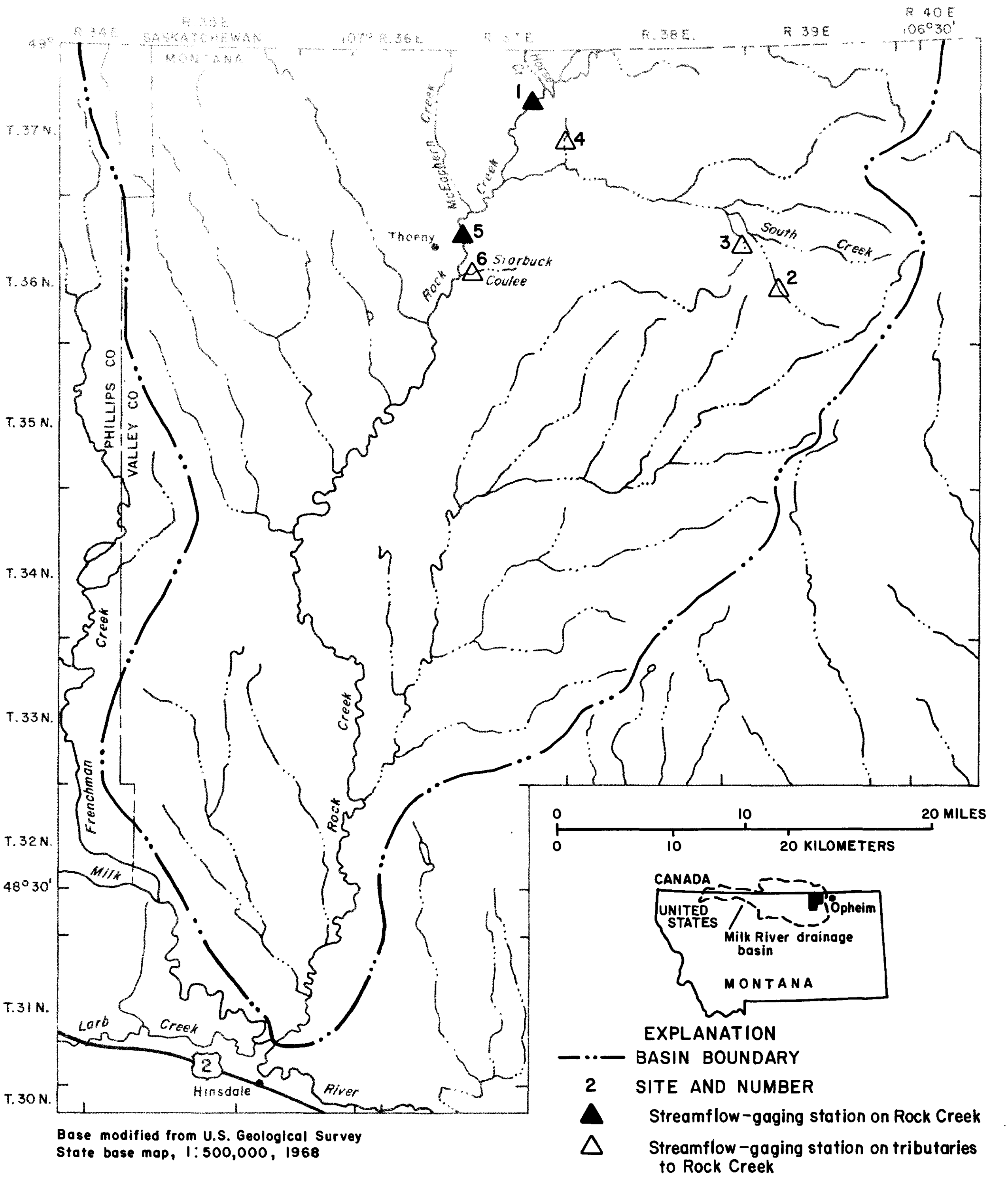

Figure 1.--Location of Rock Creek basin and streamflow-gaging stations.

greater-than-average quantities of snow and warmer-than-average temperatures combine to increase runoff. Area-wide frontal rainstorms in May and June generally produce runoff at all sites. Local rainstorms produce sporadic runoff from July through October.

Long-term mean annual streamflow (the average of a series of annual mean streamflows) for the 9-year period of record at the upstream Rock Creek gaging station (site 1) is 17 ft^3/s (Shields and others, 1988, p. 201). Annual mean streamflow at that site for water years 1983-87 was smallest (2.8 ft^3/s) in 1984 and largest (31 ft^3/s) in 1986 (table 1). Annual mean streamflow was substantially less than the long-term (1979-87) mean annual streamflow during 1983-85 and was greater than the long-term mean annual streamflow during 1986-87.

The annual mean streamflow pattern at the downstream Rock Creek gaging station (site 5) for water years 1984-87 (table 1) was similar to the annual mean streamflow at the upstream Rock Creek gaging station (site 1). The smallest annual mean streamflow at this site was 3.2 ft^3/s in 1984, and the largest was 57 ft^3/s in 1986.

Annual mean flow of the four small streams (table 1) generally was similar in pattern to the annual mean streamflow of Rock Creek. For three of the small streams, the annual mean flow was smallest in 1984 and largest in 1986. The exception was South Creek tributary No. 3 near international boundary (site 4), which had annual mean flows of zero in 1984 and 1985 and near-zero (0.01 ft^3/s) in 1986.

Monthly mean streamflow at the upstream Rock Creek site for water years 1983-87 was largest (288 ft^3/s) in March 1986 (table 2). The smallest monthly mean streamflow was zero, which occurred seven times during the study. The period of no flow occurred in middle to late summer (August-September) and in mid-winter (January-February). Normally, the monthly mean streamflow is largest from March through June, with thunderstorms occasionally creating substantial streamflow from July through September.

Monthly mean streamflow at the downstream Rock Creek site generally was greater than that at the upstream Rock Creek site from February through June (table 2). From July through January, the relative magnitudes commonly were reversed. The smallest monthly mean streamflow at the downstream Rock Creek site was zero, which occurred 11 times during the study.

Monthly mean flow data for the four small streams indicate that runoff trends generally are similar to those of Rock Creek (table 2), with most runoff occurring from March through June. However, the monthly mean flow is fairly small. For example, the largest monthly mean streamflow at any of the four sites during the period of record was 5.3 ft^3/s on South Creek tributary No. 2 near Opheim (site 3); for many months, all the small streams had zero flow.

Daily mean streamflow data for periods of runoff at all six gaged sites for May 1983 through September 1987 are listed in table 3. The six sites have similar patterns of daily mean streamflow during most periods of large runoff. For example, daily mean streamflow during the March 3-8, 1986, period was largest on March 5 at each site. Similarly, the daily mean streamflow resulting from a storm of July 28-August 2, 1987, was largest on July 29 at all sites that had flow. However, individual variations in daily mean streamflow at the sites can be substantial during periods of lesser runoff. For example, daily mean streamflow at the two Rock Creek sites for the runoff of July 8-13, 1986, was largest on July 11; on that date, three of the four small streams were dry and the fourth had a daily mean flow of only 0.07 ft^3/s. Similarly, three of the four small streams were dry on September 22, 1986, when the two Rock Creek sites had maximum daily mean streamflow for the September 20-24 period of runoff.

During periods of little area-wide runoff, the small streams may have substantial daily mean flow, yet the two Rock Creek sites may have small daily mean streamflow. For example, during the runoff period of May 30-June 5, 1985 (table 3), the combined daily mean flow of the four smaller streams on May 30 was 7.2 ft^3/s, while the daily mean streamflow of the downstream Rock Creek site was

3.9 ft^3/s (site 5). A similar situation occurred again during the runoff of July 8-13, 1986. Combined daily mean streamflow for the small-stream sites was about 13 ft^3/s on July 8, while the daily mean streamflow of the downstream Rock Creek site was 2.7 ft^3/s (site 5). In these examples, the daily mean streamflow of the two Rock Creek sites increased substantially a day or two after the large flows occurred in the small streams. Flow in the small streams may have contributed to streamflow in Rock Creek during these runoff periods but the contribution was delayed, perhaps as a result of temporary channel and bank storage, for at least a day.

In two other instances, substantial daily mean flow in the small streams occurred during periods when the daily mean streamflow of Rock Creek decreased downstream. For example, on July 10, 1983, the daily mean streamflow was 1.0 ft^3/s at the upstream Rock Creek site, was 14 ft^3/s for the combined flow of the four small streams, and was 0.39 ft^3/s at the downstream site. Although daily mean streamflow subsequently increased at both Rock Creek sites several days later, the maximum daily mean streamflow at the downstream site (4.9 ft^3/s on July 16) was less than the maximum daily mean streamflow at the upstream site (5.6 ft^3/s on July 13) and significantly less than the combined daily mean streamflow for sites 2, 3, and 4 on July 10. Another example occurred on September 7, 1985, when the daily mean streamflow was 0.27 ft^3/s at the upper Rock Creek site, was about 16 ft^3/s for the combined sites 2, 3, and 4, and was zero at the downstream Rock Creek site. In this example, none of the flow at the upper mainstem site or in the small streams reached the lower site, which had no flow for the entire runoff period. This loss in streamflow between the two Rock Creek sites evidently occurs only when flows in the mainstem are small. Daily mean flow in the small streams may be substantial, but only for a day or two, during these periods of losing flow. The streamflow loss may be due, in part, to diversions of streamflow for stockwatering and minor irrigation, evapotranspiration losses, or ground-water storage. No other reasons for the flow loss are presently known.

On the basis of this study, daily mean streamflow in the tributaries appears to be closely related to daily mean streamflow in the mainstem of Rock Creek only during periods of substantial area-wide runoff. Thus, flow in the small streams resulting from local storms or local snowmelt may not contribute to streamflow in the mainstem.

SUMMARY

Four streamflow-gaging stations were installed on selected small streams in the Rock Creek basin north of the Milk River near Hinsdale to monitor flow characteristics. In addition, one short-term gaging station was installed on Rock Creek downstream from an existing gaging station. The gaging stations were used to obtain information on streamflow changes between the two sites. The gaging stations were operated from May 1983 through September 1987.

Annual mean streamflow of Rock Creek at the upstream site was substantially less than the long-term (1979-87) mean annual streamflow (17 ft^3/s) during 1983-85 and was greater than the long-term mean annual streamflow during 1986-87. In the mainstem, annual mean streamflow ranged from 2.8 to 31 ft^3/s at the upstream site, and from 3.2 to 57 ft^3/s at the downstream site. Annual mean streamflow ranged from zero to 0.60 ft^3/s in the tributaries. At all gaging stations in the study area, the monthly mean streamflow normally is largest from March through June, with thunderstorms occasionally creating substantial streamflow from July through September. The largest monthly mean streamflow of Rock Creek was 528 ft^3/s at the downstream site. The largest monthly mean streamflow recorded at any of the four small-stream sites was 5.3 ft^3/s on South Creek tributary No. 2 near Opheim. All four small streams had times of zero monthly mean streamflow.

The six gaged sites have similar patterns of daily mean streamflow during most periods of large runoff, but individual variations in daily mean streamflow can be substantial during periods of lesser runoff. During periods of little area-wide runoff, the small streams may have substantial daily mean flow, whereas the two Rock Creek sites may have small daily mean streamflow. Daily mean flows of Rock Creek are often less at the downstream site than at the upstream site.

On the basis of this study, daily mean streamflow in the tributaries appears to be closely related to daily mean streamflow in the mainstem of Rock Creek only during periods of substantial area-wide runoff. Thus, streamflow in the tributaries resulting from local storms or local snowmelt may not contribute to streamflow in the mainstem.

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U.S. Environmental Data Service, 1971, Climate of Montana: Department of Commerce, National Oceanic and Atmospheric Administration, Climatography of the United States No. 60-24, 21 p.

Table 1.--*Annual mean streamflow at gaging stations*

[--, no data]

Site No.	Station name	Streamflow-gaging station No.	Drainage area (square miles)	Mean streamflow, in cubic feet per second, for indicated water year 1983	1984	1985	1986	1987
1	Rock Creek below Horse Creek, near international boundary	06169500	328	6.3	2.8	5.6	31	21
2	South Creek tributary No. 1 near Opheim	06169600	2.15	--	.06	.14	.25	.09
3	South Creek tributary No. 2 near Opheim	06169700	1.62	--	.05	.24	.60	.58
4	South Creek tributary No. 3 near international boundary	06169800	.32	--	0	0	.01	.03
5	Rock Creek below McEachern Creek, near international boundary	06170050	650	--	3.2	7.1	57	42
6	Starbuck Coulee near international boundary	06170080	4.16	--	.08	.11	.36	.28

Table 2.--*Monthly mean streamflow at gaging stations*

[--, no data; <, less than]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
	Mean streamflow, in cubic feet per second											
Site 1--Rock Creek below Horse Creek, near international boundary												
1983	2.2	1.8	1.0	1.1	2.7	25	24	15	2.1	1.1	0	0
1984	.28	.81	.47	0	.02	10	13	2.5	6.6	.38	0	0
1985	.36	.96	.31	0	0	40	16	3.8	4.6	.02	.02	1.0
1986	2.3	.92	.38	.45	.93	288	10	35	1.9	9.0	.07	13
1987	9.3	2.4	1.6	1.1	17	141	54	2.1	.84	17	6.4	.66
Site 2--South Creek tributary No. 1 near Opheim												
1983	--	--	--	--	--	--	--	.12	0	.01	0	0
1984	0	0	0	0	.01	.63	.01	0	.01	0	0	0
1985	0	0	0	0	0	.95	.14	.23	.11	0	.21	.01
1986	.03	0	0	0	0	2.3	0	.50	0	.09	0	.09
1987	0	0	0	0	.84	.26	0	0	0	0	.04	0
Site 3--South Creek tributary No. 2 near Opheim												
1983	--	--	--	--	--	--	--	.97	0	.55	0	0
1984	0	0	0	0	.06	0	0	0	0	0	0	0
1985	0	0	0	0	0	1.1	.01	.22	0	0	1.0	.54
1986	.32	0	0	0	0	3.1	0	2.9	0	.34	0	.33
1987	.09	0	0	0	.88	.61	0	0	0	5.3	.05	0
Site 4--South Creek tributary No. 3 near international boundary												
1983	--	--	--	--	--	--	--	<.01	0	0	0	0
1984	0	0	0	0	0	<.01	0	0	.02	0	0	0
1985	0	0	0	0	0	.01	0	0	0	0	0	0
1986	0	0	0	0	0	.03	0	.09	0	0	0	.03
1987	.01	0	0	0	.13	.13	0	0	0	.09	0	0
Site 5--Rock Creek below McEachern Creek, near international boundary												
1983	--	--	--	--	--	--	--	15	1.5	1.0	<.01	0
1984	0	.93	.28	0	.70	13	13	1.8	8.4	.17	0	0
1985	0	.53	.24	0	0	52	20	3.4	8.3	0	0	0
1986	1.5	1.1	.01	.25	1.8	528	16	92	2.9	12	.51	17
1987	13	2.5	1.3	.76	42	275	79	3.5	1.5	62	24	.97
Site 6--Starbuck Coulee near international boundary												
1983	--	--	--	--	--	--	--	.08	0	0	0	0
1984	0	0	0	0	0	.65	0	0	.34	0	0	0
1985	0	0	0	0	0	.30	.02	.02	.02	0	.61	.30
1986	.03	0	0	0	0	2.3	0	1.5	0	.01	0	.36
1987	.31	0	0	0	1.1	1.5	0	0	0	.52	0	0

Table 3.--*Daily mean streamflow during periods of runoff at gaging stations*

Period of runoff		Mean streamflow, in cubic feet per second					
		Rock Creek (site 1)	South Creek tributary No. 1 (site 2)	South Creek tributary No. 2 (site 3)	South Creek tributary No. 3 (site 4)	Rock Creek (site 5)	Starbuck Coulee (site 6)
Water year 1983							
May	13	11	0	0	0	6.8	0
	14	14	.32	9.5	.02	7.9	0
	15	25	.55	9.0	0	9.0	.68
	16	62	.64	5.7	0	42	.49
	17	49	.64	4.9	0	68	.47
	18	50	.54	.86	0	67	.51
	19	42	.43	.14	0	59	.33
	20	30	.25	.02	0	48	.12
July	9	.64	0	0	0	0	0
	10	1.0	.39	14	0	.39	0
	11	1.3	.01	3.0	0	.87	0
	12	2.9	0	0	0	.99	0
	13	5.6	0	0	0	1.2	0
	14	4.1	0	0	0	1.1	0
	15	2.4	0	0	0	3.6	0
	16	1.8	0	0	0	4.9	0
	17	1.5	0	0	0	3.6	0
	18	1.2	0	0	0	2.3	0
	19	1.1	0	0	0	1.8	0
	20	.80	0	0	0	1.4	0
Water year 1984							
March	24	25	1.1	.18	0	30	.50
	25	30	1.2	.08	0	35	.25
	26	35	.40	0	0	45	.10
	27	40	.16	0	0	50	0
	28	45	.03	0	0	60	0
	29	40	.02	0	0	50	0
	30	35	.05	0	0	40	0
	31	33	.02	0	0	35	0
June	19	2.4	0	0	0	1.4	0
	20	7.0	.26	0	.50	4.3	9.8
	21	48	0	0	0	12	.36
	22	29	0	0	0	96	.04
	23	14	0	0	0	40	0
	24	11	0	0	0	19	0
Water year 1985							
March	15	10	4.6	5.0	0	.10	1.0
	16	100	6.0	10	0	.50	.96
	17	70	5.5	5.0	.20	5.0	1.1
	18	190	2.5	3.0	0	180	.65
	19	230	.70	1.0	0	250	.47
	20	150	.65	.20	0	280	.35
	21	100	.61	.10	0	350	.17
	22	90	.25	.05	0	150	.13
April	1	16	2.4	.10	0	11	.36
	2	37	1.5	0	0	30	.13
	3	68	.16	0	0	70	.04
	4	73	.08	0	0	100	.02
	5	59	.04	0	0	101	.04
	6	38	.04	.10	0	68	.04
May	30	4.7	3.1	3.8	0	3.9	.35
	31	27	4.1	3.0	0	5.0	.14
June	1	38	3.1	.08	0	60	.43
	2	27	.16	0	0	60	.11
	3	17	.04	0	0	42	.04
	4	11	0	0	0	23	.01
	5	8.1	0	0	0	13	0

Table 3.--*Daily mean streamflow during periods of runoff at gaging stations*--Continued

Period of runoff		Rock Creek (site 1)	South Creek tributary No. 1 (site 2)	South Creek tributary No. 2 (site 3)	South Creek tributary No. 3 (site 4)	Rock Creek (site 5)	Starbuck Coulee (site 6)
		Mean streamflow, in cubic feet per second					
Water year 1985--Continued							
September	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	.06	0	0	0	0	0
	6	.09	0	0	0	0	0
	7	.27	.36	16	0	0	5.0
	8	.12	.01	0	0	0	2.0
	9	.09	0	0	0	0	1.0
	10	3.4	0	0	0	0	.50
	11	2.6	0	0	0	0	.10
	12	2.4	0	0	0	0	0
	13	1.7	0	0	0	0	0
	14	1.2	0	0	0	0	0
Water year 1986							
March	3	800	5.0	10	0	1,500	2.0
	4	650	7.5	15	.10	1,250	4.0
	5	1,000	10	20	.10	2,000	14
	6	850	5.0	2.0	0	1,600	.30
	7	350	3.5	1.0	0	700	0
	8	450	1.0	.70	0	500	.15
May	8	62	0	1.3	.54	124	1.1
	9	183	4.5	27	1.3	276	20
	10	292	.21	22	.06	638	3.3
	11	92	2.9	31	.19	305	1.4
	12	56	7.8	8.9	.26	326	8.4
	13	39	.01	.08	0	285	.45
July	8	1.0	2.7	10	0	2.7	0
	9	1.9	.21	.50	.14	2.2	0
	10	68	0	0	0	3.1	0
	11	111	0	0	0	158	.07
	12	36	0	0	0	73	.03
	13	23	0	0	0	40	.01
September	20	7.4	0	0	.69	6.7	5.0
	21	82	.07	.50	.16	25	3.8
	22	88	0	0	0	181	.34
	23	31	0	0	0	67	.13
	24	13	0	0	0	24	.08
Water year 1987							
March	4	70	3.5	11	2.0	60	21
	5	500	1.9	2.3	.10	800	5.1
	6	700	.06	0	0	1,200	2.8
	7	900	.01	0	0	1,400	1.3
	8	450	0	0	0	1,110	.50
	9	200	0	0	0	523	.10
	30	90	0	0	0	200	.10
	31	130	0	0	0	178	.01
April	1	330	0	0	0	398	0
	2	320	0	0	0	495	0
	3	259	0	0	0	365	0
	4	159	0	0	0	220	0
July	28	.85	0	0	0	7.6	0
	29	233	0	8.7	2.9	1,060	15
	30	181	0	.13	0	568	.91
	31	76	0	.03	0	222	.11
August	1	88	0	0	0	282	0
	2	30	0	0	0	133	0

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