FLOODS OF MAY 1981 IN WEST-CENTRAL MONTANA

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 82-33

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No.

4. Title and Subtitle
FLOODS OF MAY 1981 IN WEST-CENTRAL MONTANA

5. Report Date
June 1982

6.

7. Author(s) Charles Parrett, R. J. Omang, J. A. Hull, and John W. Fassler

8. Performing Organization Rept. No.
USGS/WRI 82-33

9. Performing Organization Name and Address
U.S. Geological Survey
428 Federal Building, Drawer 10076
Helena, Montana 59626

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
U.S. Geological Survey
428 Federal Building, Drawer 10076
Helena, Montana 59626

13. Type of Report & Period Covered
Final

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

Extensive flooding occurred in west-central Montana during May 22-23, 1981, as a result of a series of rainstorms. Flooding was particularly severe in the communities of East Helena, Belt, and Deer Lodge. Although no lives were lost, total flood damages were estimated by the Montana Disaster Emergency Services Division to be in excess of $30 million.

Peak discharges were determined at 75 sites in the flooded area. At 25 sites the May 1981 peak discharge exceeded the computed 100-year frequency flood, and at 29 sites, where previous flow records are available, the May 1981 peak discharge exceeded the previous peak of record.

17. Document Analysis a. Descriptors floods, flood peak, flood frequency, peak discharge

b. Identifiers/Open-Ended Terms Missouri River basin, Clark Fork basin, Montana

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
No restriction on distribution	20. Security Class (This Page)	22. Price

25

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

Front cover: Photograph showing flooding of Cottonwood Creek in Deer Lodge, Montana, May 22, 1981. View is east. Photograph by Carl Davaz of the Missoula, Montana, Missoulian newspaper.

FLOODS OF MAY 1981 IN WEST-CENTRAL MONTANA

by Charles Parrett, R. J. Omang, and J. A. Hull, U.S. Geological Survey, with a section on Meteorological setting by John W. Fassler, National Weather Service, National Oceanic and Atmospheric Administration

---

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 82-33

Helena, Montana

June 1982

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For more information write to:

District Chief
U.S. Geological Survey
428 Federal Building
301 S. Park
Drawer 10076
Helena, MT 59626

For sale by:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4600

CONTENTS

ILLUSTRATIONS

TABLES

FACTORS FOR CONVERTING INCH-POUND UNITS TO METRIC UNITS

For use of those readers who may prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound units	By	To obtain metric units
foot (ft)	0.3048	meter (m)
inch (in.)	25.40	millimeter (mm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$)]	0.01093	cubic meter per second per square kilometer $(m^3/s)/km^2$
ton (short)	0.9074	megagram (Mg)

[The National Weather Service uses millibar (mb) as customary unit for atmospheric pressure]

inch of mercury at 32° F (in. Hg)	33.8639	millibar (mb)
degrees Fahrenheit (°F)	5/9(F-32)	degrees Celsius (°C)

FLOODS OF MAY 1981 IN WEST-CENTRAL MONTANA

by Charles Parrett, R. J. Omang, and J. A. Hull

ABSTRACT

Extensive flooding occurred in west-central Montana during May 22-23, 1981, as a result of a series of rainstorms. Flooding was particularly severe in the communities of East Helena, Belt, and Deer Lodge. Although no lives were lost, total flood damages were estimated by the Montana Disaster Emergency Services Division to be in excess of $30 million.

Peak discharges were determined at 75 sites in the flooded area. At 25 sites the May 1981 peak discharge exceeded the computed 100-year frequency flood, and at 29 sites, where previous flow records are available, the May 1981 peak discharge exceeded the previous peak of record.

INTRODUCTION

A series of extensive rainstorms during the month of May culminated in record flooding in west-central Montana during May 22-23, 1981. Precipitation amounts for the first half of May, which were generally well above average at most rainfall recording stations in the area, saturated the ground and raised streamflow levels to near-bankfull stages. The larger storms of May 21-22 then combined with snowmelt to produce the destructive flooding that followed. The flooding was generally centered near Helena and affected both sides of the Continental Divide (fig. 1).

East of the Continental Divide in the upper Missouri River drainage basin, the town of Belt experienced severe flood damage from Belt Creek and East Helena was damaged by flooding of Prickly Pear Creek. Lesser but still significant flood damage occurred near Helena from Tenmile Creek and in and near Bozeman from Rocky Creek, Bridger Creek, and the East Gallatin River. West of the Continental Divide, Cottonwood Creek flooded a large part of Deer Lodge, and flood damage occurred in Elliston, Avon, and Garrison from the Little Blackfoot River and along the Clark Fork near Drummond and Clinton.

Transportation facilities were damaged by the flooding throughout the area as roads and railroad tracks were washed out in numerous places. Six bridges on major State highways were destroyed or extensively damaged by the flooding, and more than 25 road approaches to major bridges were washed out. A 10-county area was declared a national disaster area by Presidential proclamation. No lives were lost in the flooding.

The purpose of this report is to document the meteorological setting and flooding that resulted. The compilation of the pertinent precipitation and streamflow data in a single report is intended to provide a convenient reference for planners and decisionmakers. In addition to streamflow data collected by the U.S. Geological Survey, supplemental data were obtained from the U.S. Soil Conservation Service and the U.S. Forest Service, Gallatin National Forest.

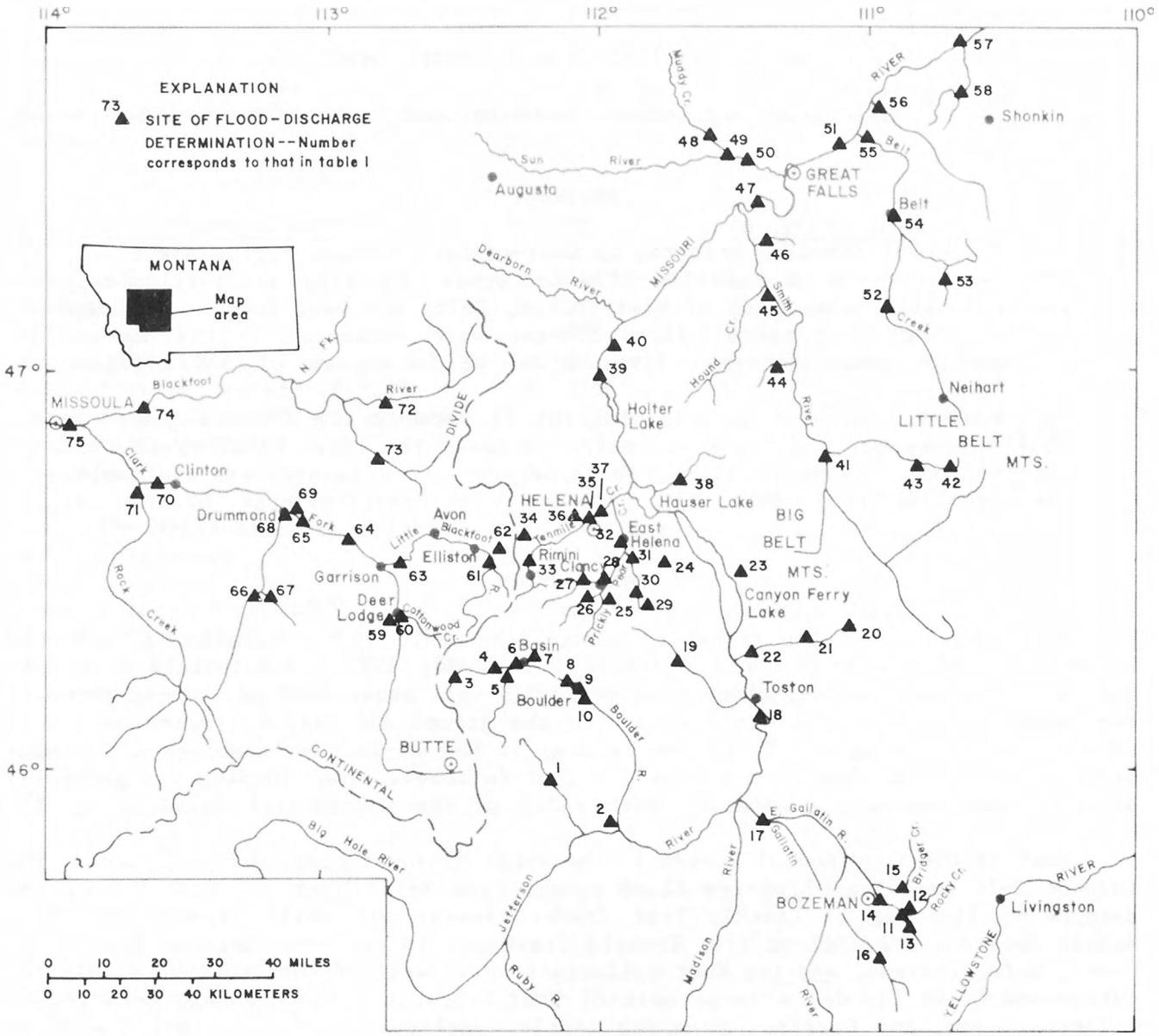

Figure 1.--Location of flood-discharge-determination sites.

METEOROLOGICAL SETTING

By John W. Fassler

National Weather Service

The annual rainy season in Montana normally occurs between May 20 and June 30. Most recorded intense rainstorms have occurred during this period. It is also during this time that significant surface and upper level low-pressure systems (500 mb) develop off the Pacific coast. Their eventual migration across the western United States determines the extent of precipitation in Montana.

The migration of low-pressure systems began during early May 1981 following a dry winter in most of Montana, and a very dry April throughout the State east of the Continental Divide (fig. 2). The first storm system moved eastward along the Montana-Wyoming border on May 7 and 8. The center of greatest precipitation from this system was in central Montana, where the precipitation station near Shonkin (fig. 1) recorded more than 4 in. of rain. By 0600 m.d.t. May 9, the upper level system was in extreme northwestern Kansas.

On May 10 another Low (center of low-pressure system) had formed off the coast of British Columbia. This system moved rapidly into south-central Montana by 0600 m.d.t. May 12. More than 2 in. of rainfall was recorded at many sites in southwestern Montana as a result of this second storm. From Montana the Low moved slowly into southeastern Wyoming by the morning of May 13.

By this time the next upper level low-pressure system was beginning to move southeast out of the Gulf of Alaska toward the west coast. On May 15 this system moved onto the coast near the Washington-Oregon border, farther south than the two previous storms. By 0600 m.d.t. on May 16 the center of the storm was near the Oregon-Idaho-Nevada border. Precipitation in Montana from this storm was also centered in the central part of the State, with Augusta and Great Falls each receiving more than 3 in. of rain.

The fourth and largest storm began to develop off the coast of Oregon at 0600 m.d.t. on May 18. By the next morning the upper level low-pressure system (500 mb) had developed a closed circulation. This Low then moved to southwestern Nevada by 0600 m.d.t. on May 20. A large ridge of high pressure, firmly established over the mid-section of the country, prevented the Low from moving farther southeast. Instead, the Low began moving to the northeast and was near southeastern Idaho on the morning of May 21. At the same time the surface Low was centered in east-central Montana. The clockwise flow around the high pressure over the Midwest began transporting moisture north from the Gulf of Mexico toward the Low. Twenty-four hours later the surface Low had moved about 90 mi northeast, with the center of the upper Low being about 200 mi to the south.

As the storm was ending on the afternoon of May 22, an area of numerous intense showers and thundershowers developed in north-central Montana. Being embedded in the cyclonic upper flow, they moved to the southwest. During the evening the rainfall intensified as the storm was lifted over the mountains. In addition to the measured precipitation at National Weather Service cooperative observer stations, unofficial reports of 4 to 6 in. of rain were received from the Little Belt Mountains, Tenmile Creek near Rimini, and the upstream reaches of Cottonwood Creek

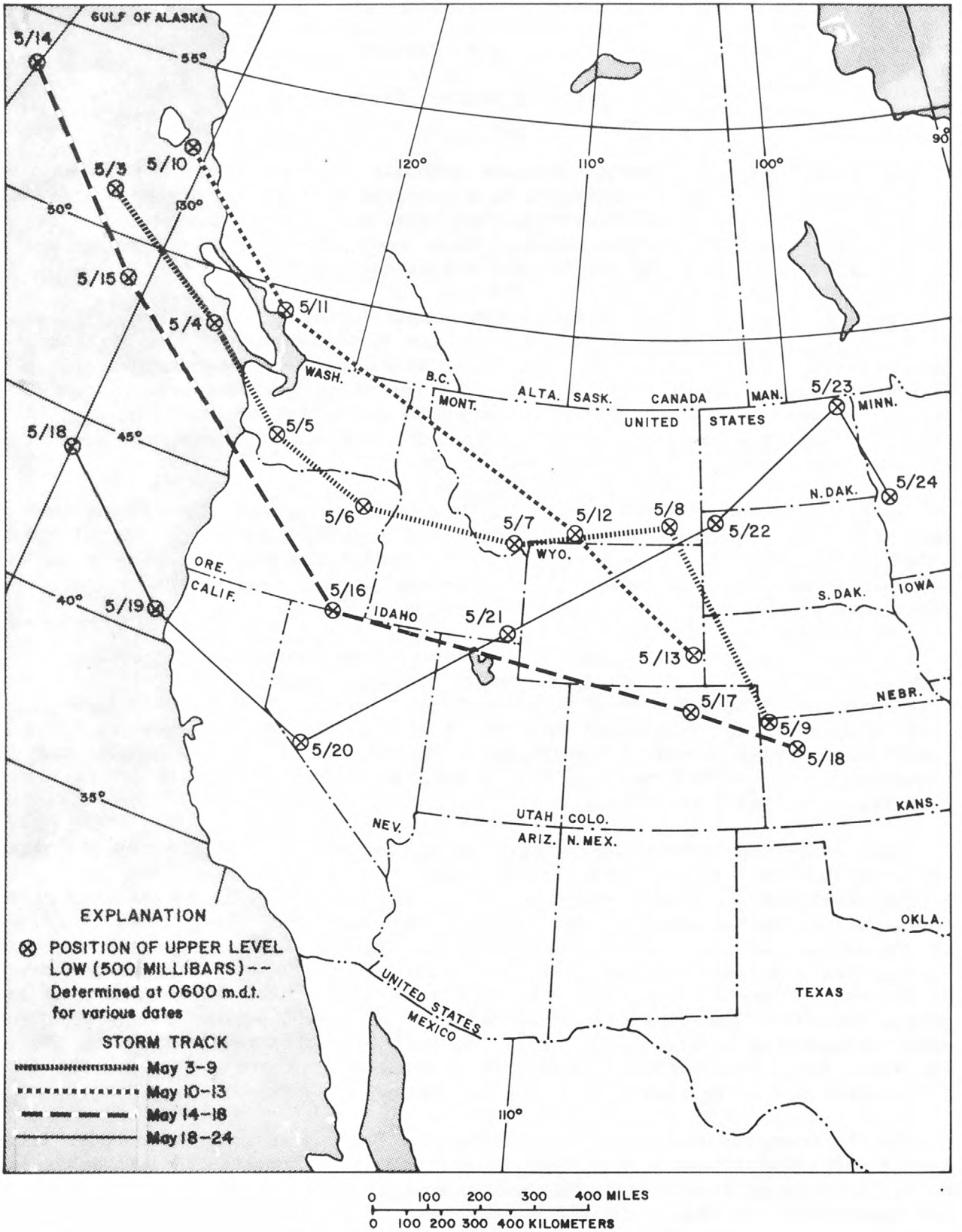

Figure 2.--Track of May 1981 storms in Montana.

near Deer Lodge. Road washouts in many areas prevented bucket surveys by the National Weather Service. The precipitation amounts for the storm of May 21-22 are shown in figure 3.

The frequency of the 500 mb low-pressure systems over Montana during May 1981 produced record or near record rainfall in many areas of central Montana. The almost daily rains of May were similar to those occurring during the 1953 flood year (U.S. Geological Survey, 1957). During 1953 rains continued into June causing additional flooding, whereas the May 1981 rains diminished throughout the State during June with little additional flooding.

DESCRIPTION OF THE FLOODING

Streamflows were generally less than average at the beginning of May. Mountain snowpack was also well below average throughout the area except west of Helena in the upper Tenmile Creek basin where snowpack was about average. Soil moisture was also generally less than average and prospects for record flooding seemed remote as the month of May began.

Area-wide rainfall began on May 5, as the first of the four major storms moved through Montana. Soil moisture increased markedly as a result of the storms of May 5-7 and May 10-12. By the end of the third storm, May 15-17, small streams (less than 100-mi^2 drainage area) were flowing bankfull and soils were saturated. When the fourth and last major May storm moved into the area on May 21, small streams began flooding. Severe overbank flooding was widespread by May 22.

Snowmelt contributed to the flooding in all areas as indicated by snow-measurement (snow-pillow) sites operated by the U.S. Soil Conservation Service. During May 19-23 about 2 in. of snowmelt occurred in the Gallatin River basin; 3 in. occurred along the Continental Divide from Butte to Rogers Pass, northwest of Holter Lake; and about 2.5 in. occurred in the Big Belt and Little Belt Mountains.

Near Helena, Tenmile Creek destroyed five bridges between the small mountain community of Rimini and Helena and forced the evacuation of more than 100 people. The peak discharge of 3,290 ft^3/s for Tenmile Creek near Rimini (site 33) was more than three times the previous peak of record (table 1, at back of report) and probably exceeded the historic flood discharge of 1908; the unit peak discharge was 100 $(ft^3/s)/mi^2$ (table 1). Farther downstream near Helena (site 35), the peak discharge was 3,770 ft^3/s, but the unit peak discharge decreased to 37 $(ft^3/s)/mi^2$. The 1981 peak discharge near Helena was also almost three times the previous peak of record, and was at least as great as the 1908 historic flood. Damage in and downstream from Helena was also extensive as floodwaters left the main channel of Tenmile Creek and coursed northward through residential areas in the valley.

Prickly Pear Creek near Helena also flooded extensively and caused considerable flood damage as it passed through East Helena. The peak discharge of Prickly Pear Creek near Clancy (site 28) was 2,300 ft^3/s--almost twice the previous peak of record. At East Helena (site 32), the peak discharge of Prickly Pear Creek was 4,030 ft^3/s, as McClellan Creek (site 31), a major tributary to Prickly Pear Creek, contributed a peak discharge of 1,730 ft^3/s. The unit discharge for Prickly Pear Creek near Clancy was 12 $(ft^3/s)/mi^2$, whereas the unit discharge for Prickly Pear Creek at East Helena increased to 16 $(ft^3/s)/mi^2$ as a result of the large contribution from McClellan Creek.

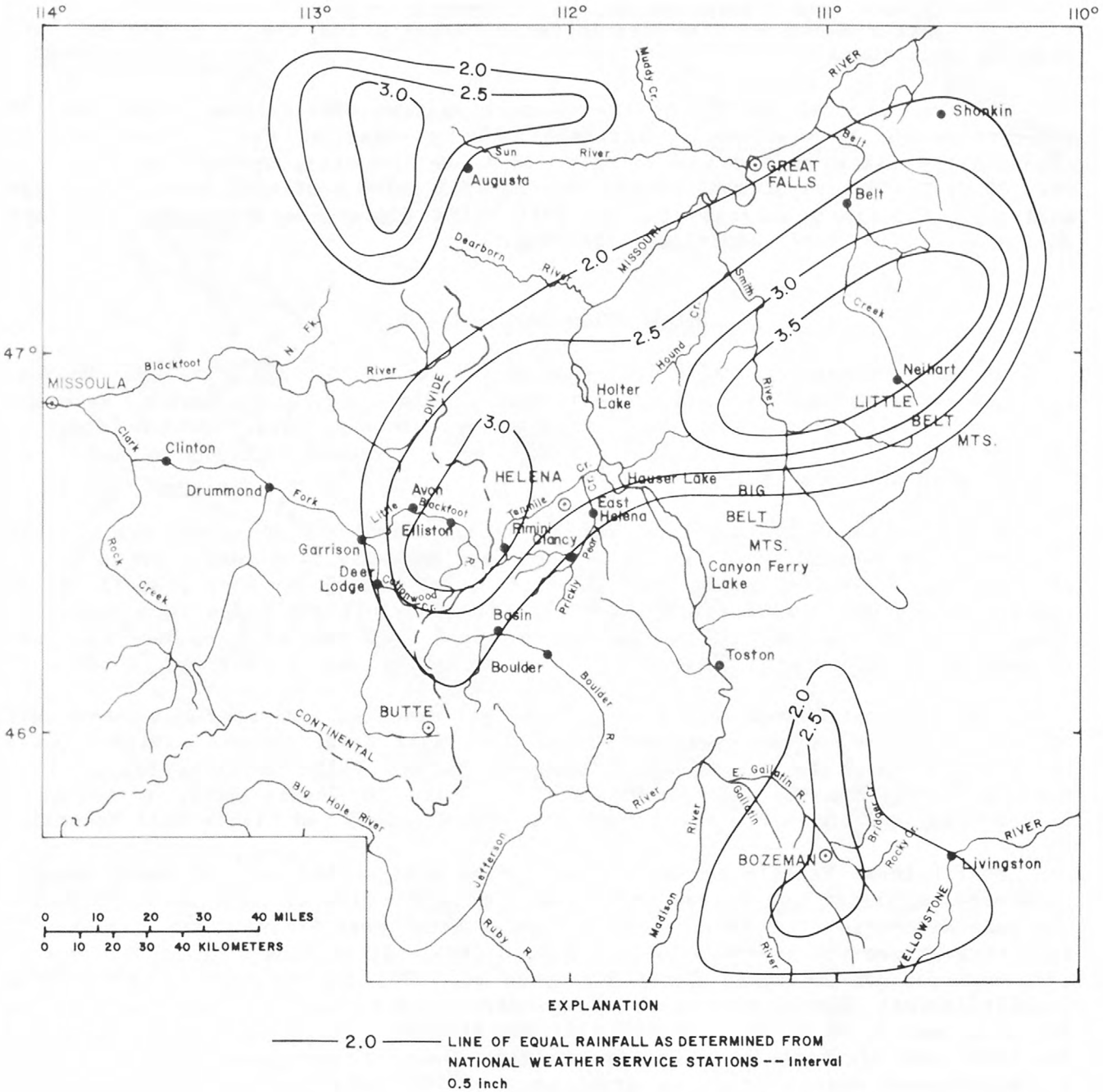

Figure 3.--Total storm rainfall in excess of 2 inches in west-central Montana, May 21-22, 1981.

A flood-discharge hydrograph for Tenmile Creek near Rimini is shown in figure 4 and for Prickly Pear Creek near Clancy in figure 5. Both hydrographs show a

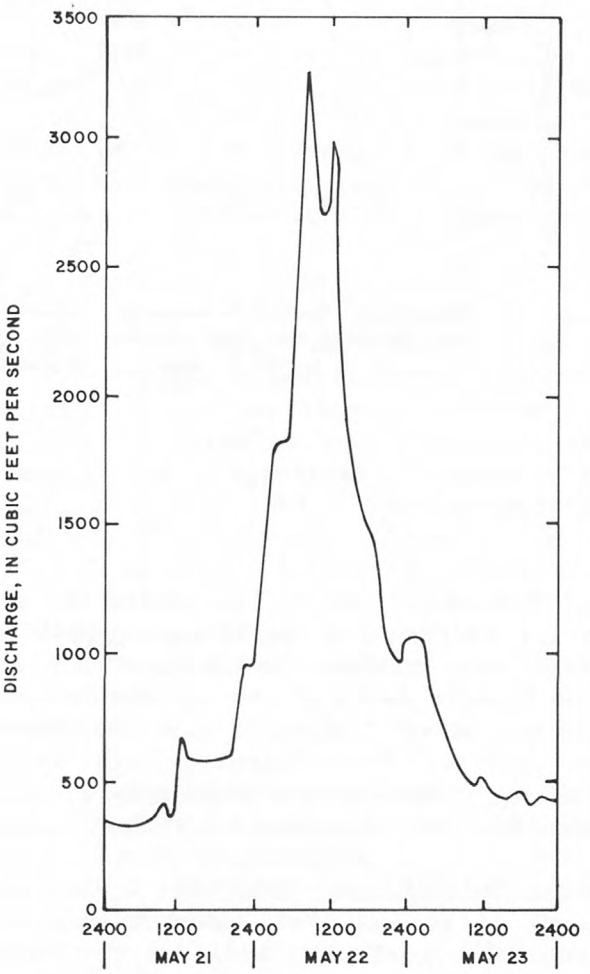

Figure 4.--Flood hydrograph of Tenmile Creek near Rimini, Montana (site 33), May 21-23, 1981.

double peak on May 22, apparently the result of two separate major storm periods. In addition, the hydrograph for Tenmile Creek shows minor peaks on May 21 that apparently are the result of several separate storm bursts on May 21. The hydrographs for both streams exhibit the rapid rise associated with rain-caused floods.

South of Helena, the Boulder River and its major tributaries reached record flood levels and washed out several bridges. Cataract Creek near Basin (site 7), which originates in the same mountainous area as Tenmile Creek, had a unit peak discharge of 103 $(ft^3/s)/mi^2$, the largest unit discharge determined for the flooded area. Cataract Creek washed out a bridge approach on U.S. Highway 91, the major

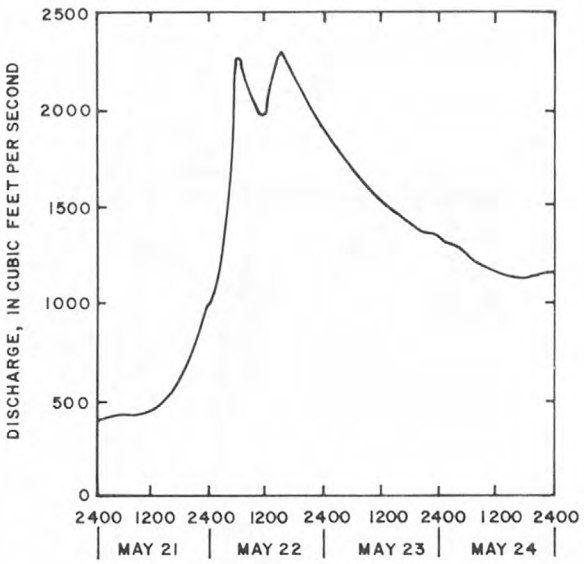

Figure 5.--Flood hydrograph of Prickly Pear Creek near Clancy, Montana (site 28), May 21-23, 1981.

route between Butte and Helena. Basin Creek (site 6) also caused considerable flood damage as it coursed through the small mining community of Basin. Swollen by the large inflows from Cataract Creek and Basin Creek, the Boulder River washed out two major bridges in Boulder (site 8) and caused the evacuation of part of the State Hospital in Boulder. Near Boulder (site 10), the peak discharge of the Boulder River was 7,000 ft^3/s. This discharge was exactly twice the previous peak of record and probably exceeded the historic flood (discharge unknown) of 1908. The unit discharge for the Boulder River near Boulder was 18 $(ft^3/s)/mi^2$.

Near Great Falls, the Smith River, Muddy Creek, Belt Creek, and the main stem Missouri River upstream from the Sun River reached their highest stages since the flood of 1953. The peak discharge in May 1981 for the Smith River near Eden (site 45) was 11,800 ft^3/s as compared to the June 1953 peak discharge of 12,300 ft^3/s. Flooding on the Smith River upstream from Hound Creek may have been more severe in 1981 than in 1953, as evidenced by the severe channel erosion and deposition on upstream tributaries noted by observers after the flood. Property damage in the Smith River basin was limited because the area is sparsely populated.

On the Missouri River, a peak discharge of 28,500 ft^3/s occurred near Ulm (site 47) on May 24. Only the 1948 peak discharge of 32,000 ft^3/s and the 1953 peak discharge of 35,000 ft^3/s exceeded the 1981 peak discharge. Much of the May 1981 peak flow on the Missouri River came from the Smith River. The Dearborn River, the only sizeable unregulated tributary, did not flood. Upstream from the Dearborn River, flood flows of the Missouri River were largely controlled by Holter and Canyon Ferry Lakes.

Although the May 1981 peak discharge on Muddy Creek at Vaughn (site 49) was the second largest in more than 40 years of streamflow record, little flood damage occurred. The 1953 peak discharge of 7,600 ft^3/s on Muddy Creek was considerably

larger than the May 1981 peak discharge of 4,000 ft^3/s. Muddy Creek contributes substantial amounts of sediment to the Sun River, particularly during periods of high runoff. A summary of sediment data collected during the May 1981 flood on Muddy Creek (sites 48 and 49) is given in table 2, which also includes sediment data collected on Belt Creek (site 55), Highwood Creek (site 56), and the Missouri River (sites 18, 57).

Belt Creek flooded from Neihart to its mouth on the Missouri River, causing substantial damage to the town of Belt. The 1981 peak discharge near Monarch (site 52) was 8,450 ft^3/s. This discharge was exceeded by the 1953 peak discharge of 11,000 ft^3/s and perhaps by the historic flood (discharge unknown) of 1908. Downstream at Belt (site 54), the 1981 peak discharge was 9,610 ft^3/s as compared to the 1953 peak discharge of 15,600 ft^3/s. Although the 1981 flood inundated more than 40 homes in Belt, the damage was much more severe during the 1953 flood. The unit peak discharge was 23 $(ft^3/s)/mi^2$ for Belt Creek near Monarch and 15 $(ft^3/s)/mi^2$ for Belt Creek at Belt.

Unlike the 1953 flood, the May 1981 flood extended as far south as Bozeman, where record or near record flood peaks were measured on Rocky Creek (site 11), Bear Canyon Creek (site 13), Bridger Creek (site 15), Hyalite Creek (site 16), and the East Gallatin River (site 14). Some local roads and bridges were closed as a result of the flooding, and one trailer court was evacuated near Rocky Creek. Flood severity and destruction were generally less in the Bozeman area than in the Helena and Belt areas, however. The largest unit peak discharge determined for streams near Bozeman was 61 $(ft^3/s)/mi^2$ from the relatively small drainage area (2.33 mi^2) of Pitcher Creek (site 12). The 1981 peak discharge was substantially larger than the previous known maximum only on the East Gallatin River at Bozeman (site 14). The 1981 peak discharge at this site was 2,460 ft^3/s, which is almost twice the previous known peak discharge of 1,240 ft^3/s. The 1981 peak discharge was reported by local residents to be considerably larger than the two historic peaks of undetermined magnitude which occurred during 1970 and 1971.

West of the Continental Divide, the most damaging flooding occurred in Deer Lodge as Cottonwood Creek inundated nearly one-half the town. The headwaters of Cottonwood Creek are in the same mountainous area as the headwaters of Tenmile Creek and Cataract Creek, where the unit peak discharges equaled or exceeded 100 $(ft^3/s)/mi^2$. The unit peak discharge for Cottonwood Creek at Deer Lodge (site 60) was 40 $(ft^3/s)/mi^2$. The center of the May 21-22 storm was apparently just east of the headwaters part of the Cottonwood Creek drainage basin. The 1981 flood on Cottonwood Creek at Deer Lodge was nevertheless the largest known flood in the memory of local residents. The peak discharge of 1,820 ft^3/s was almost four times the largest flood peak previously measured (1975) and almost twice the estimated 1964 peak discharge of 1,100 ft^3/s.

Destructive flooding west of the Continental Divide also occurred on the Little Blackfoot River from Elliston to its mouth near Garrison. Two bridges on U.S. Highway 12, the main east-west route between Helena and Missoula, were destroyed as was the Burlington Northern Railroad track in several locations.

The headwaters of the Little Blackfoot River are adjacent to the headwaters of Tenmile Creek and just east of the headwaters of Cottonwood Creek. The unit peak discharge of the Little Blackfoot River near Elliston (site 61) was 48 $(ft^3/s)/mi^2$. Although considerably less than the 100-$(ft^3/s)/mi^2$ unit-peak discharge of Tenmile Creek near Rimini, the drainage area for the Little Blackfoot

River near Elliston is more than three times the drainage area at the Tenmile Creek site. At the gaging site near Garrison (site 63), the peak discharge of the Little Blackfoot River was 8,650 ft^3/s. The previous known maximum discharge at this site was 3,650 ft^3/s in 1975. According to a long-time resident, the 1981 flood was slightly larger than the historic 1908 flood, but the duration of flooding was not as long.

As a result of the large inflows from Cottonwood Creek and the Little Blackfoot River, the Clark Fork flooded from Garrison to Clinton. Although some roads and two major bridges were extensively damaged, the severity of flooding was considerably less on the main stem Clark Fork than on the upstream tributaries. Flooding was not appreciable on the Clark Fork tributaries downstream from the mouth of the Little Blackfoot River. At Drummond (site 68), the 1981 peak discharge of the Clark Fork was 15,700 ft^3/s on May 23. This discharge is almost twice the maximum known discharge, but the length of streamflow record at the Drummond gaging station is only 8 years. The 1908 flood reportedly reached a stage 3.1 feet higher than the 1981 flood at the Drummond station. At the long-term gaging station on Clark Fork above Missoula (site 75), the 1981 peak discharge was 29,700 ft^3/s. Previous peak discharges (1975, 1964, 1948, and 1908) exceeded the 1981 peak, as inflows from major tributaries Rock Creek and the Blackfoot River were relatively minor in 1981.

PEAK DISCHARGE AND FREQUENCY

Peak discharges were determined at 75 selected sites in the flooded area (fig. 1). At most active and discontinued streamflow-gaging sites, maximum discharges were determined from existing stage-discharge relationship curves defined by discharge measurements with logarithmic extensions as required. Indirect measurements of peak discharges were made at 25 miscellaneous or otherwise unrated sites. Peak stages, discharges, and recurrence intervals for all measurement sites are listed in table 1. Previous peak stages and discharges are shown where records are available. At 29 sites the May 1981 peak discharge exceeded the previous peak of record.

Recurrence interval, as applied to floods, is the average number of years within which a given flood peak will be exceeded once. The frequencies of the May 1981 peak discharges were estimated for recurrence intervals of 100 years (1-percent chance of occurrence each year) or less. Discharges having recurrence intervals greater than 100 years are noted only as "greater than 100 years." Similarly, discharges having intervals less than 2 years are noted as "less than 2 years." At 25 sites the May 1981 peak discharge exceeded the computed 100-year frequency flood. Recurrence intervals were determined for sites with 10 or more years of record in accordance with guidelines provided by the U.S. Water Resources Council (1977). Recurrence intervals for all other sites were determined by procedures described in the flood-frequency study by Parrett and Omang (1981).

FLOOD DAMAGE

The May 1981 flood was particularly damaging to transportation facilities and urban properties. Agricultural damage was relatively minor because the small mountainous streams that flooded most severely do not traverse large tracts of agricultural land. Some of the road damage and urban flooding is shown in figures 6 through 9.

Figure 6.--Flooding of Prickly Peak Creek at East Helena, Montana, May 22, 1981. View is downstream (north) from U.S. Highway 12 crossing.

Figure 7.--Aftermath of flooding of Cottonwood Creek at Deer Lodge, Montana.

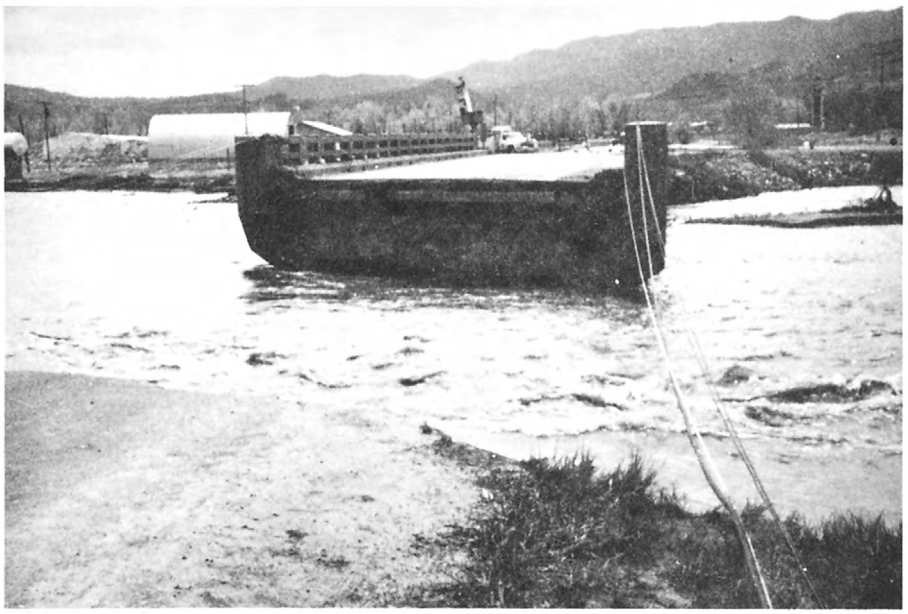

Figure 8.--Washed-out road approach on State Highway 69 as a result of flooding of the Boulder River at Boulder, Montana. View is south.

Figure 9.--Aerial view of road damage between Helena and Rimini, Montana, as a result of flooding of Tenmile Creek. View is east. Photograph by Gene Fischer of the Helena, Montana, Independent Record newspaper.

From a monetary standpoint, the flood of May 1981 was one of the most costly in Montana's history. Preliminary estimates compiled for the application for Federal disaster assistance indicate that the total damages exceeded $30 million (J. Anderson, Montana Disaster Emergency Services Division, oral commun., 1981). Private-property damage was particularly large, with business damage estimated at $7.5 million and homes and personal-property damage estimated at $9.5 million. Road and highway damages exceeded $7 million, and damages to public and private utilities exceeded $4 million. Unlike the Montana floods of 1978, 1975, and 1964, agricultural damages for the 1981 flood were relatively minor and were about $2 million.

REFERENCES

Parrett, Charles, and Omang, R. J., 1981, Revised techniques for estimating magnitude and frequency of floods in Montana: U.S. Geological Survey Open-File Report 81-917, 66 p.

U.S. Army Corps of Engineers, 1972, Special flood hazard information, Cottonwood Creek, Deer Lodge, Montana: Seattle District, 11 p.

U.S. Geological Survey, 1957, Floods of May-June 1953 in Missouri River basin in Montana: U.S. Geological Survey Water-Supply Paper 1320-B, p. 69-153.

U.S. Water Resources Council, 1977, Guidelines for determining flood flow frequencies: U.S. Water Resources Council Bulletin 17A, 26 p.

Table 1.--*Summary of peak stages and discharges for floods of May 1981*

[ft, feet; ft^3/s, cubic feet per second; $(ft^3/s)/mi^2$, cubic feet per second per square mile; mi^2, square miles; <, less than; >, greater than]

Map number	Permanent station number	Site of flood-discharge determination	Drainage area (mi^2)	Period of record
1	06029000	Whitetail Creek near Whitehall	30.8	1950-53; 1955-68
2	06030300	Jefferson River tributary No. 2 near Whitehall	4.50	1957-81
3	06030500	Boulder River above Rock Creek near Basin	23.9	1947-57; 1975
4	------	Boulder River above Bison Creek near Basin	113	-----
5	------	Bison Creek near Basin	77.5	-----
6	------	Basin Creek at Basin	41.3	-----
7	06031950	Cataract Creek near Basin	30.6	1973-81
8	------	Boulder River at Boulder	346	-----
9	------	Muskrat Creek near Boulder	33.9	-----
10	06033000	Boulder River near Boulder	381	1929-32; 1934-72; 1975
11	06046500	Rocky Creek near Bozeman	50.5	1952-81
12	06046700	Pitcher Creek near Bozeman	2.33	1960-75
13	06047000	Bear Canyon Creek near Bozeman	17.0	1952-73; 1975
14	06048000	East Gallatin River at Bozeman	148	1940-61
15	06048500	Bridger Creek near Bozeman	62.5	1946-69; 1972
16	06050000	Hyalite Creek at Hyalite Ranger Station near Bozeman	48.2	1898-99; 1902; 1935-81
17	06052500	Gallatin River at Logan	1,795	1895-1900; 1902-1905; 1929-81
18	06054500	Missouri River at Toston	14,669	1890; 1910-16; 1941-81
19	06055500	Crow Creek near Radersburg	76.6	1901; 1920-29; 1966-71; 1975
20	06056200	Castle Creek tributary near Ringling	2.51	1960-74
21	06045300	Cabin Creek near Townsend	12.6	1960-81
22	06056600	Deep Creek below North Fork Deep Creek near Townsend	87.7	1959-73; 1975
23	------	Confederate Gulch near Townsend	38.6	-----

Maximum previously known			Maximum during flood of May 1981				
Date	Gage height (ft)	Discharge (ft^3/s)	Day	Gage height (ft)	Discharge (ft^3/s)	Recurrence interval (years)	Unit discharge [$(ft^3/s)/mi^2$]
5-18-51	4.22	126	22	4.40	142	20	5
6-24-58	4.45	169	22	-1.34	4.7	<2	1
6-19-48	3.72	582	22	5.31	1,020	>100	43
--	--	---	22	--	1,250	100	11
--	--	---	22	--	853	100	11
--	--	---	22	--	1,550	>100	38
6-19-75	--	623	22	6.88	3,160	>100	103
--	--	---	22	--	6,700	>100	20
--	--	---	22	--	270	5	8
6-19-75	10.90	3,500	22	12.3	7,000	>100	18
4-24-71	3.11	1,230	22	4.91	1,140	95	23
5-11-75	3.54	70	22	4.45	142	50	61
5-21-70	3.90	370	22	--	489	>100	29
6-04-53	6.09	1,240	22	--	2,460	>100	17
6-03-53	4.90	902	22	7.11	1,140	100	18
6-14-1898	--	956	22	3.70	948	>100	20
6-21-1899	--	9,840	23	8.45	7,570	9	4
6-06-48	11.77	32,000	24	11.34	29,500	14	2
5-11-75	5.97	1,300	22	8.14	3,640	>100	48
5-19-70	3.70	47	22	2.93	27	5	11
6-04-60	2.00	70	24	2.13	42	5	3
5-19-70	4.88	445	22	5.10	740	55	8
--	--	--	22	--	1,460	>100	38

Table 1.--*Summary of peak stages and discharges for floods of May 1981*--Continued

Map number	Permanent station number	Site of flood-discharge determination	Drainage area (mi^2)	Period of record
24	06058700	Mitchell Gulch near East Helena	8.09	1959-81
25	06059500	Warm Springs Creek at Alhambra	20.6	1921-24
26	06060000	Clancy Creek at Clancy	33.1	1921-24
27	06061000	Lump Gulch near Clancy	43.4	1909-13
28	06061500	Prickly Pear Creek near Clancy	192	1911-16; 1922-33; 1946-69; 1975
29	06061700	Jackson Creek near East Helena	3.44	1961-75
30	06061800	Crystal Creek near East Helena	3.77	1961-75
31	06061900	McClellan Creek at city diversion dam near East Helena	33.2	1960-75
32	06062000	Prickly Pear Creek at East Helena	251	1909-13
33	06062500	Tenmile Creek near Rimini	32.7	1914-81
34	06062700	Little Porcupine Creek tributary near Helena	.39	1959-73
35	06063000	Tenmile Creek near Helena	102	1909-54; 1975
36	------	Sevenmile Creek near Helena	59.0	-----
37	------	Tenmile Creek at I-15 crossing near Helena	161	-----
38	------	Trout Creek near York	37.2	-----
39	06066500	Missouri River below Holter Dam near Wolf Creek	17,149	1946-81
40	06071600	Wegner Creek at Craig	35.7	1960-81
41	06076690	Smith River near Fort Logan	846	1977-81
42	06076700	Sheep Creek near Neihart	5.23	1960-81
43	06077000	Sheep Creek near White Sulphur Springs	5.44	1942-72; 1975
44	06077300	Trout Creek near Eden	13.2	1974-81
45	06077500	Smith River near Eden	1,594	1951-69
46	06077800	Goodman Coulee near Eden	22.1	1959-81
47	06078200	Missouri River near Ulm	20,941	1948; 1953 1957-81
48	06088300	Muddy Creek near Vaughn	282	1968-81
49	06088500	Muddy Creek at Vaughn	314	1925; 1934-68; 1971-81
50	06089000	Sun River near Vaughn	1,854	1934-81
51	06090300	Missouri River near Great Falls	23,292	1952-81

Maximum previously known			Maximum during flood of May 1981				
Date	Gage height (ft)	Discharge (ft^3/s)	Day	Gage height (ft)	Discharge (ft^3/s)	Recurrence interval (years)	Unit discharge [$(ft^3/s)/mi^2$]
9-07-73	.51	139	22	.23	68	7	8
6-17-22	2.20	71	22	--	972	>100	47
6-7,8-22	1.70	61	22	--	356	25	11
6-09-09	--	106	22	--	1,130	>100	26
6-19-75	6.56	1,200	22	8.90	2,300	>100	12
6-19-75	2.98	25	22	4.11	111	>100	32
6-19-75	3.33	80	22	3.04	72	40	19
6-08-64	2.59	390	22	--	1,730	>100	52
6-19-09	2.5	535	22	--	4,030	>100	16
6-19-75	4.89	995	22	6.20	3,290	>100	100
5-14-72	3.31	16	22	--	20	100	51
6-19-75	--	1,360	22	--	3,770	>100	37
-----	--	---	22	--	170	3	3
-----	--	---	22	--	[a]1,200	--	--
-----	--	---	22	--	717	>100	19
6-08-48	11.70	34,800	[b]	9.46	25,300	12	1
7-01-66	4.64	1,020	22	2.68	360	7	10
3-22-78	5.46	1,930	22	7.8	4,350	8	5
6-16-65	2.40	138	23	1.86	95	5	18
6-04-53	--	460	22	4.48	310	5	6
6-30-75	4.70	430	22	4.73	275	25	21
6-03-53	10.46	12,300	22	10.2	11,800	>100	7
6-07-75	7.43	1,340	22	5.76	238	5	11
6- -53	17.00	35,000	24	14.99	28,500	9	1
5-07-75	13.46	3,110	22	14.72	3,560	60	13
6-04-53	16.70	7,600	22	12.78	3,910	60	13
6-09-64	23.4	53,500	24	15.45	13,700	6	7
6-10-64	--	72,000	24	9.02	43,700	14	2

Table 1.--*Summary of peak stages and discharges for floods of May 1981*--Continued

Map number	Permanent station number	Site of flood-discharge determination	Drainage area (mi^2)	Period of record
52	06090500	Belt Creek near Monarch	368	1951-81
53	06090550	Little Otter Creek near Raynesford	39.5	1974-81
54	------	Belt Creek at Belt	626	-----
55	06090610	Belt Creek near Portage	799	1981
56	06090720	Highwood Creek near Portage	122	1981
57	06090800	Missouri River at Fort Benton	24,749	1980-81
58	06090810	Ninemile Coulee near Fort Benton	16.9	1972-81
59	12324200	Clark Fork at Deer Lodge	1,005	1979-81
60	12324250	Cottonwood Creek at Deer Lodge	45.4	1975-81
61	------	Little Blackfoot River near Elliston	100	-----
62	------	Dog Creek near Elliston	54.8	-----
63	12324590	Little Blackfoot River near Garrison	398	1973-81
64	12324680	Clark Fork at Gold Creek	1,704	1977-81
65	12324700	Clark Fork tributary near Drummond	4.61	1958-81
66	12329500	Flint Creek at Maxville	208	1941-81
67	12330000	Boulder Creek at Maxville	71.3	1939-81
68	12331600	Clark Fork at Drummond	2,378	1973-81
69	12331700	Edwards Gulch at Drummond	4.69	1960-62; 1974-81
70	12331900	Clark Fork near Clinton	[e]2,629	1979-81
71	12334510	Rock Creek near Clinton	885	1972-81
72	------	Blackfoot River at Lincoln	225	-----
73	12335500	Nevada Creek above reservoir near Finn	116	1939-81
74	12340000	Blackfoot River near Bonner	2,290	1899-1905; 1940-81
75	12340500	Clark Fork above Missoula	5,999	1929-81

[a] Does not include about 2,600 ft^3/s bypass flow.

[b] Peak discharge occurred June 13, 1981.

[c] Flood of June 1964 had an estimated peak discharge of 1,140 ft^3/s (U.S. Army Corps of Engineers, 1972).

[d] Flood of June 1908 had a stage of about 15.5 ft, from information by local residents.

[e] Revised.

[f] From floodmark.

[g] Flood of 1927 had a stage of about 9.5 ft, from information by local residents.

Maximum previously known			Maximum during flood of May 1981				
Date	Gage height (ft)	Discharge (ft^3/s)	Day	Gage height (ft)	Discharge (ft^3/s)	Recurrence interval (years)	Unit discharge [$(ft^3/s)/mi^2$]
6-04-53	10.12	11,000	22	10.32	8,270	>100	23
5-08-75	8.90	245	22	4.30	66	<2	2
6- -53	--	15,600	22	--	9,610	50	15
-----	--	---	22	12.13	14,200	>100	18
-----	--	---	22	7.95	2,040	30	17
6-06-08	--	140,000	24	10.57	51,100	11	2
5-07-75	9.24	1,570	22	7.56	335	8	20
5-26-80	4.58	1,710	22	5.32	2,500	2	2
6-19-75	4.10	[c]497	22	9.75	1,820	>100	40
-----	--	---	22	--	4,840	>100	48
-----	--	---	22	--	1,090	100	20
6-19-75	7.50	3,650	22	8.79	8,650	>100	8
5-25-80	8.25	5,640	23	10.98	12,200	40	7
6-09-58	1.64	133	22	.58	10	<2	2
3-28-43	6.79	1,680	22	5.73	847	--	4
6-19-75	4.55	1,460	22	4.50	1,350	30	19
6-20-75	[d]10.60	8,490	23	12.44	15,700	40	7
6-20-74	--	318	22	<0	<.5	<2	<1
5-26-80	8.92	6,410	23	[f]10.9	16,000	30	6
6- -72	[g]8.5	6,500	22	7.53	5,140	8	6
-----	--	---	22	--	2,300	20	9
6-02-53	6.00	1,800	22	5.45	1,750	32	15
6-10-64	10.89	19,200	24	9.20	12,400	4	5
6- -08	--	48,000	24	13.38	29,500	15	5

Table 2.--*Sediment data collected in flooded area, May 1981*

[°C, degrees Celsius; ft^3/s, cubic feet per second;
mg/L, milligrams per liter; T/day, tons per day; mm, millimeter]

May 1981	Time	Temperature (°C)	Streamflow, instantaneous (ft^3/s)	Suspended sediment		Suspended sediment, percent finer than						
				Concentration (mg/L)	Discharge (T/day)	0.004 mm	0.016 mm	0.062 mm	0.125 mm	0.250 mm	0.500 mm	1.00 mm
Site 18 - Missouri River at Toston - 06054500												
25...	1100	13.5	24,900	491	33,000	20	31	49	73	95	100	--
Site 48 - Muddy Creek near Vaughn - 06088300												
20...	1310	18.0	190	1,010	518	53	73	91	98	100	--	--
22...	1730	11.5	913	7,120	17,600	49	66	88	97	100	--	--
Site 49 - Muddy Creek at Vaughn - 06088500												
17...	1520	9.5	323	2,560	2,230	42	63	87	97	100	--	--
22...	1630	8.5	1,570	20,600	87,300	41	57	86	94	95	97	100
28...	1750	17.5	270	1,560	1,140	36	48	74	93	100	--	--
Site 55 - Belt Creek near Portage - 06090610												
23...	1130	8.0	11,200	7,780	235,000	34	61	83	93	99	100	--
Site 56 - Highwood Creek near Portage - 06090720												
23...	1945	14.5	700	4,080	7,710	29	48	75	88	96	100	--
Site 57 - Missouri River at Fort Benton - 06090800												
24...	1800	12.5	50,300	1,940	263,000	34	59	82	89	97	100	--