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NORTHERN CHEYENNE TRIBE

WATER-RESOURCES INVESTIGATIONS REPORT 95-4093
(Sheet 1 of 2)
Omang, R.J., 1995, Water-surface profile and flood boundaries for the computed 100-year flood, Rosebud Creek, Northern Cheyenne Indian Reservation, Montana

WATER-SURFACE PROFILE AND FLOOD BOUNDARIES FOR THE COMPUTED 100-YEAR FLOOD, ROSEBUD CREEK, NORTHERN CHEYENNE INDIAN RESERVATION, MONTANA

By R.J. Omang

INTRODUCTION

Areas that would be inundated by a peak discharge having a recurrence interval of 100 years (the 100-year flood) along streams in the Northern Cheyenne Indian Reservation are of interest to the Northern Cheyenne Tribe because of the potential for development of the land. Knowledge of the extent of the flood plain also is needed to control flood damage in the Northern Cheyenne Indian Reservation. An area of concern is the flood plain of Rosebud Creek (fig. 1).

One approach for decreasing flood damage is controlling land use adjacent to the stream by planned development and management of flood-hazard areas. Delineation of flood-hazard areas will allow selection of the type of desired development that is compatible with the flood risk.

The U.S. Geological Survey, in cooperation with the Northern Cheyenne Tribe, conducted a hydrologic and hydraulic analysis of Rosebud Creek to identify areas along the creek subject to flooding. The specific objective of the study was to determine the extent of flooding that would result from a 100-year flood. This report presents the results of the study based on conditions in the basin in 1992.

The magnitude of the 100-year flood was determined using techniques described in reports by Omang (1992) and by Parrett and others (1987). Channel and flood-plain elevations were surveyed at 149 cross sections along a 39-mi reach of Rosebud Creek. An additional 33 cross sections along the same reach were synthesized. Physical dimensions of hydraulic structures were measured. Manning's roughness coefficients were determined at each cross section. Field survey data and a computer model were used to calculate water-surface elevations for the 100-year flood at each cross section. These elevations were used to determine the inundated area for the 100-year flood.

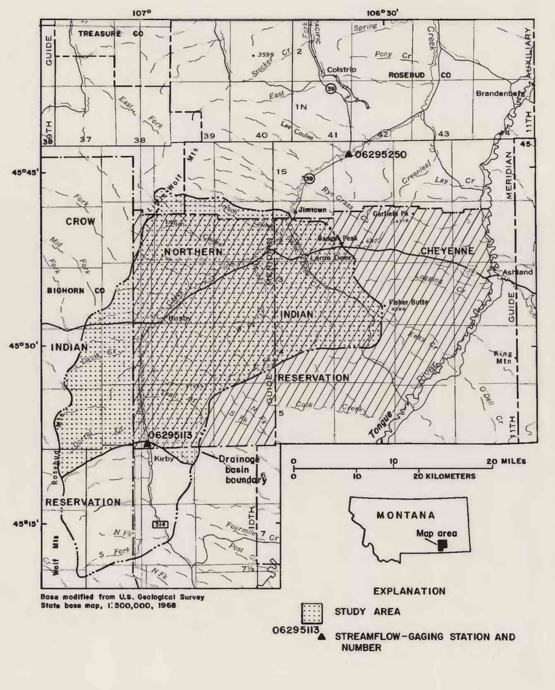

Figure 1. Location of the Rosebud Creek study area, southeastern Montana.

General Description of the Area

Rosebud Creek originates about 20 mi south of Kirby and flows north to the town of Busby and then northeasterly toward the mouth. The study area includes the drainage basin of Rosebud Creek from the southern boundary of the Northern Cheyenne Indian Reservation downstream to the northern boundary, near Jimtown. The headwaters of Rosebud Creek drain the eastern slopes of the Wolf and Rosebud Mountains, which generally are steep and tree covered. The study area consists of gently rolling hills and broad valleys. Areas of the valley adjacent to the stream are densely vegetated with bushes and trees. The elevations of the land surface range from about 3,140 to 5,220 feet in the study area.

The climate is semiarid with cold winters and warm summers. Mean daily temperatures in the area range from 73 °F in July to 22 °F in January at Colstrip and 71 °F in July to 18 °F in January at Busby. Average annual precipitation is about 12 in. at Busby with about 45 percent occurring from April through June. June is the wettest month, with an average of about 2.4 in. of precipitation; December, January, and February are the driest, each with an average of 0.4 in. (U.S. Environmental Data Service, 1971, p. 10).

Streamflow Conditions and Flooding

Rosebud Creek is considered to be a perennial stream and all tributaries, with the exception of Lame Deer Creek and Muddy Creek, are intermittent or ephemeral. Most runoff results from snowmelt in the spring and from rainfall from thunderstorms in the summer. Occasionally, snowmelt and rain combine to produce runoff. The U.S. Geological Survey operates a streamflow-gaging station on Rosebud Creek (station 06295250 located 8.4 mi southeast of Colstrip) 10 mi downstream from the study area and another near the upstream end of the study area (station 06295113 located 2.0 mi north of Kirby). These gages have relatively short periods of record, and no large floods have occurred since operation began. The largest recorded flow on Rosebud Creek at station 06295250 was 605 ft³/s on May 21, 1978. A flow of similar magnitude occurred on the same date at streamflow-gaging station 06295113 according to local residents.

METHODS OF ANALYSIS

Standard hydrologic and hydraulic methods were used to analyze the flood hazard for Rosebud Creek. The magnitude of a flood that is expected to be equaled or exceeded once on the average during any 100-year period (recurrence interval) was selected by the Northern Cheyenne Tribe for analysis. The 100-year flood has a 1-percent chance of being equaled or exceeded in any given year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at shorter intervals or even within the same year.

Hydrologic Analysis

Flood-discharge values for Rosebud Creek are based on techniques developed to estimate flood-frequency information using basin characteristics and channel geometry. The 100-year flood discharge was determined for several stream reaches using techniques described by Omang (1992), which relate the 100-year flood discharge to basin characteristics. The 100-year flood discharge also was determined for these stream reaches by using techniques described by Parrett and others (1987), which relate the 100-year flood discharge to channel width. The two discharges were weighted using methods described by Parrett and others (1987, p. 25). The weighted results determined for each stream reach are shown in table 1. The increases in estimated discharge along the stream reach primarily resulted from significant tributary inflow from Lame Deer Creek, Muddy Creek, and Davis Creek. Data from the streamflow-gaging stations on Rosebud Creek were not used in the analysis because the stations had short periods of record.

Table 1. Summary of computed 100-year flood discharges

Flooding source	Drainage area (square miles)	100-year flood discharge (cubic feet per second)
Rosebud Creek from southern boundary of reservation to mouth of Davis Creek	271	2,620
Rosebud Creek below mouth of Davis Creek to mouth of Muddy Creek	428	3,250
Rosebud Creek below mouth of Muddy Creek to mouth of Lame Deer Creek	564	3,690
Rosebud Creek below Lame Deer Creek	642	3,980

Hydraulic Analysis

The hydraulic characteristics of the cross sections along Rosebud Creek were analyzed to determine the water-surface elevations of the 100-year flood. The method used to define hydraulic characteristics requires cross-section geometry data and estimates of the roughness coefficient (Manning's "n").

Cross-section data were obtained from field surveys conducted during the summer of 1992. Field surveys determined elevations for 149 cross sections along a 39-mile reach. An additional 33 cross sections along the same reach were synthesized. The synthesized cross sections (sections 9, 24, 33, 43, 48, 53, 55, 70, 77, 85, 91, 101, 104, 107, 109, 112, 136, 138, 143, 144, 146, 148, 150, 152, 154, 156, 157, 159, 164, 168, 172, 174, 181 on the principal map) were estimated from adjacent surveyed sections and topographic maps. Structural geometry data also were obtained for nine bridges. Cross sections were located upstream and downstream from the bridges to permit computation of the backwater effects of these structures. Cross sections which are examples of channel and flood-plain conditions in the upstream and downstream parts of the study area are shown in figures 2 and 3, respectively. A cross section showing channel conditions at a bridge is shown in figure 4.

The roughness coefficient represents the resistance to flow. Factors that affect the roughness coefficient include the type and size of materials that compose the bed and banks of the channel and flood plain, shape of the channel, variation in dimensions of adjacent cross sections, vegetation, structures, and degree of meandering. Roughness coefficients used in the hydraulic computations were based on engineering judgment of onsite observations. Roughness values used along Rosebud Creek range from 0.035 to 0.090 for the main channel and from 0.035 to 0.110 for the flood-plain areas.

Water-surface elevations for the 100-year flood were computed using a water-surface-profile computation model (WSPRO) developed by the U.S. Geological Survey for the Federal Highway Administration (Shearman and others, 1986; Shearman, 1990). WSPRO is a computer program that is used to analyze one-dimensional, gradually varied, steady flow in open channels based on the assumption of fixed boundaries. With this computer program, the surveyed and synthesized cross-section data were used to define the hydraulic characteristics of the channel. The location of each cross section was selected to represent the hydraulic characteristics of a reach, and each section was surveyed to define average channel shape throughout the reach. The model uses the standard step method (Chow, 1959, p. 265) to determine changes in water-surface elevation from a downstream cross section to an upstream cross section by balancing the total energy head at the sections. The starting water-surface elevation used to compute the 100-year flood profile for Rosebud Creek at cross section 1 was determined by using a slope-conveyance computation to estimate normal depth. Water-surface elevations for the 100-year flood discharge at each cross section are given in table 2.

WATER-SURFACE PROFILE

The water-surface profile for the 100-year flood (fig. 5) was drawn for the entire reach within the study area. The profile shows the computed water-surface elevations, the streambed elevations, and the location of bridges and cross sections used in the hydraulic analysis.

The hydraulic analysis was based on unobstructed flow. The water-surface elevations shown on the profile thus are considered to be valid only if hydraulic structures remain unobstructed and unchanged and do not fail.

For the WSPRO assumption of gradually varied, steady flow to be valid, the distance between cross sections needs to be short. As described by Davidian (1984, p. 20), no cross-section subreach should be longer than about 75-100 times the mean depth for the modeled discharge, nor longer than about twice the width of the subreach flood plain. The cost to survey cross sections for this study limited the number of sections to 149. Therefore, 33 additional cross sections were synthesized and added to the WSPRO input data set to decrease possible step-backwater computation errors. If the synthesized cross-section data are replaced with surveyed data, the computed water-surface elevations at cross sections could change.

Field surveys and elevations are referenced to U.S. Geological Survey or U.S. Coast and Geodetic Survey bench marks and to reference marks established at convenient locations along Rosebud Creek. Reference-mark locations are shown on the principal map and reference-mark descriptions are given in table 3.

FLOOD BOUNDARIES

The flood boundaries along the stream define an area that would be inundated as a result of the 100-year flood. For this study, the 100-year flood boundaries were delineated using water-surface elevations computed at each cross section. Between cross sections, where survey data were unavailable, the flood boundaries were interpolated using the contour lines on topographic maps.

The 100-year flood boundaries are shown on the principal map. Small flood-plain areas within the flood boundaries may lie above the water-surface elevations, but cannot be shown because of limitations of the map scale or lack of detailed topographic data.

SUMMARY

Standard hydrologic and hydraulic methods were used to determine the flood-hazard area for Rosebud Creek. The 100-year flood was selected as having special significance for flood-plain management.

The magnitude of the 100-year flood was determined for the reach of Rosebud Creek extending from the southern boundary of the Northern Cheyenne Indian Reservation downstream to the northern boundary near Jimtown. The 100-year flood discharge was determined to range from 2,620 to 3,980 ft³/s, depending on location.

Data used for 149 channel and flood-plain cross sections were obtained from field surveys of a 39-mi reach of the river. Thirty-three additional cross sections were synthesized from adjacent surveyed sections and topographic maps. These data were used to compute the water-surface elevation for the 100-year flood at each cross section using WSPRO, a computer program.

The water-surface profile was drawn showing computed water-surface elevations of a 100-year flood. The profile also shows the streambed elevations and the location of the bridges and cross sections used in the hydraulic analysis. Flood boundaries were delineated using the water-surface elevations computed at each cross section. Between cross sections, the flood boundaries were interpolated using the contour lines on topographic maps.

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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 2. Water-surface elevations for the computed 100-year flood discharge at Rosebud Creek cross secitions

[Elevations in feet above sea level]

Cross section	Water-surface elevation	Cross section	Water-surface elevation
1	3,148.2	96	3,413.0
2	3,158.9	97	3,415.0
3	3,168.0	98	3,416.5
4	3,171.1	99	3,416.7
5	3,176.5	100	3,422.2
6	3,176.9	101	3,422.4
7	3,178.4	102	3,422.7
8	3,179.1	103	3,423.9
9	3,179.7	104	3,424.5
10	3,181.6	105	3,429.2
11	3,187.2	106	3,433.2
12	3,193.2	107	3,435.0
13	3,196.3	108	3,437.2
14	3,203.8	109	3,437.5
15	3,211.8	110	3,440.2
16	3,219.7	111	3,446.1
17	3,224.6	112	3,447.1
18	3,226.1	113	3,449.6
19	3,226.3	114	3,453.8
20	3,228.4	115	3,454.3
21	3,230.7	116	3,457.7
22	3,231.4	117	3,460.0
23	3,234.6	118	3,462.9
24	3,235.8	119	3,471.8
25	3,240.4	120	3,478.2
26	3,245.0	121	3,481.6
27	3,248.0	122	3,484.7
28	3,249.3	123	3,489.5
29	3,255.5	124	3,495.9
30	3,261.7	125	3,502.0
31	3,262.1	126	3,512.0
32	3,265.7	127	3,523.4
33	3,266.0	128	3,529.2
34	3,268.4	129	3,532.1
35	3,273.3	130	3,535.5
36	3,275.2	131	3,543.0
37	3,275.3	132	3,550.2
38	3,275.4	133	3,555.6
39	3,277.0	134	3,561.6
40	3,282.1	135	3,567.3
41	3,286.2	136	3,571.8
42	3,289.4	137	3,580.0
43	3,290.1	138	3,585.7
44	3,294.6	139	3,592.1
45	3,295.0	140	3,599.1
46	3,301.4	141	3,601.3
47	3,301.6	142	3,612.4
48	3,301.7	143	3,613.6
49	3,302.2	144	3,614.8
50	3,303.4	145	3,617.9
51	3,303.4	146	3,618.6
52	3,304.2	147	3,623.8
53	3,304.7	148	3,627.9
54	3,306.4	149	3,633.9
55	3,306.9	150	3,636.3
56	3,309.0	151	3,640.5
57	3,313.2	152	3,642.2
58	3,317.1	153	3,648.9
59	3,320.7	154	3,651.8
60	3,322.6	155	3,659.8
61	3,324.8	156	3,661.4
62	3,327.2	157	3,667.6
63	3,333.6	158	3,676.4
64	3,336.5	159	3,677.9
65	3,340.4	160	3,683.4
66	3,345.5	161	3,691.7
67	3,347.4	162	3,697.9
68	3,349.1	163	3,705.0
69	3,351.6	164	3,707.6
70	3,353.6	165	3,710.4
71	3,354.9	166	3,710.6
72	3,354.9	167	3,713.4
73	3,355.4	168	3,713.6
74	3,356.6	169	3,715.5
75	3,357.5	170	3,720.5
76	3,361.8	171	3,727.5
77	3,362.7	172	3,730.9
78	3,368.2	173	3,739.2
79	3,369.5	174	3,741.3
80	3,370.5	175	3,748.8
81	3,371.6	176	3,757.8
82	3,374.1	177	3,763.2
83	3,375.1	178	3,768.5
84	3,378.3	179	3,775.9
85	3,379.5	180	3,782.4
86	3,382.0	181	3,783.6
87	3,383.2	182	3,790.4
88	3,388.6		
89	3,393.8		
90	3,396.7		
91	3,398.3		
92	3,400.8		
93	3,403.7		
94	3,406.8		
95	3,409.2		

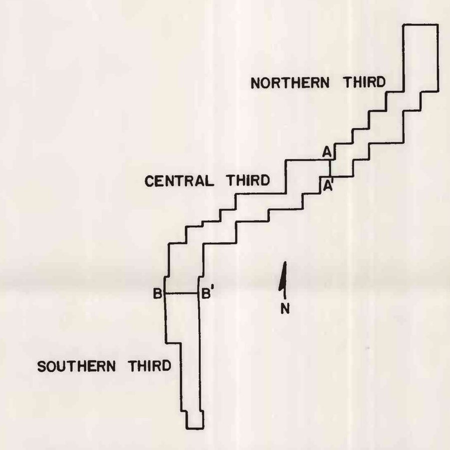
CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
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 (mi^2)	2.59	square kilometer

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

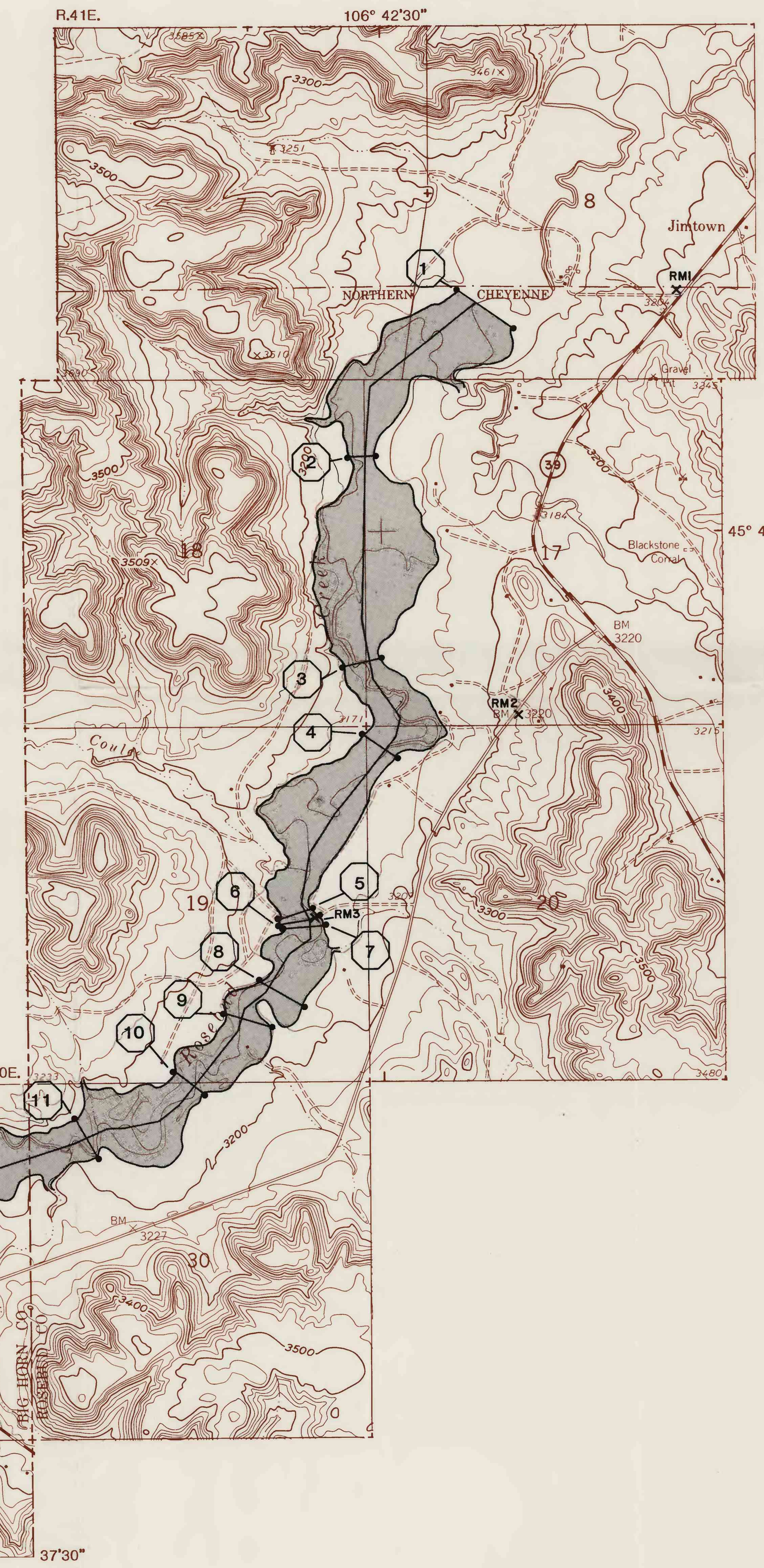
$$°C = 5/9\,(°F - 32)$$

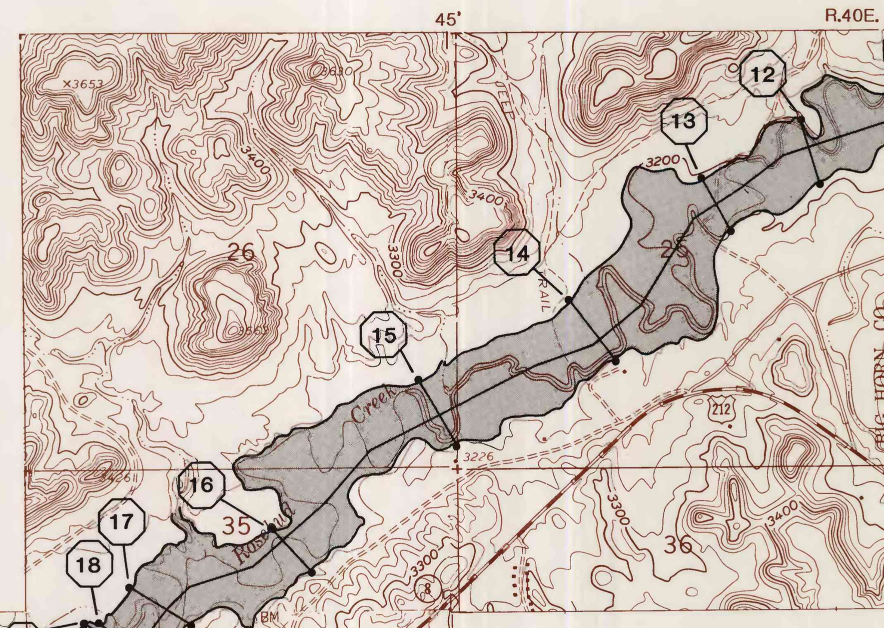
Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

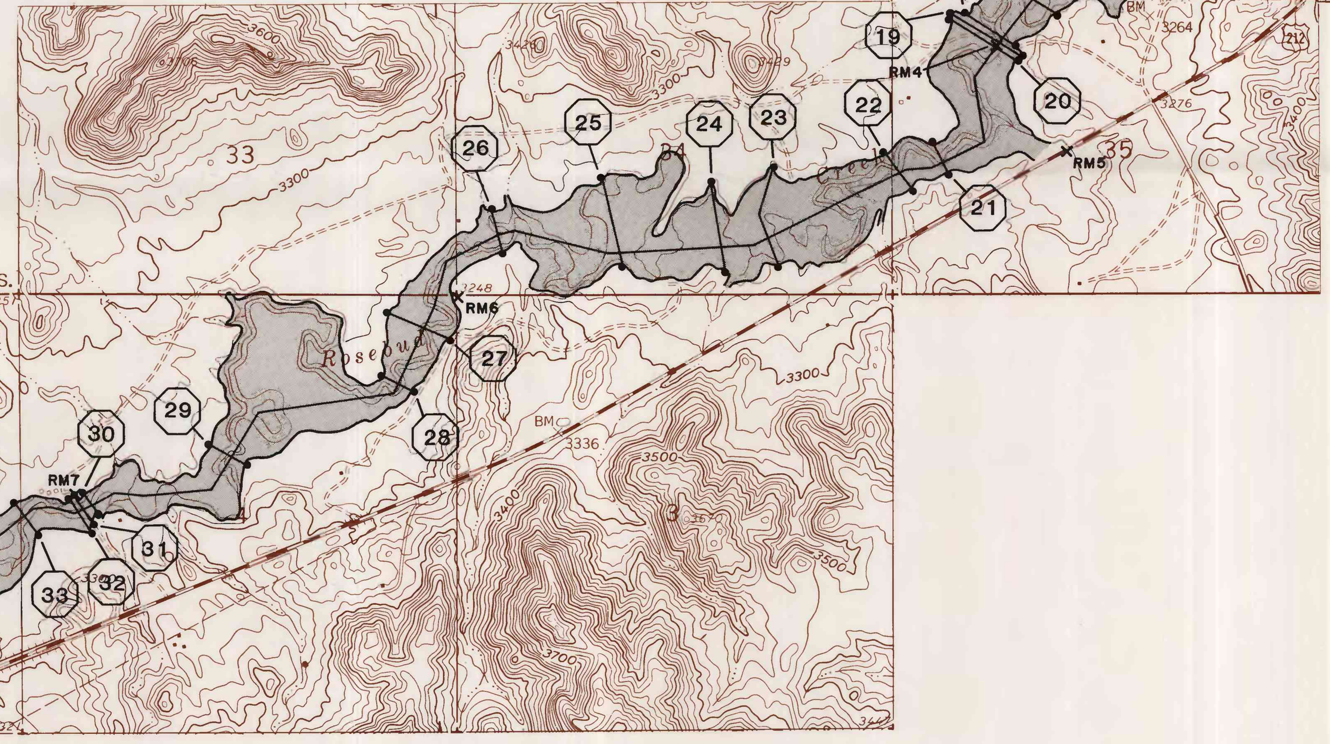


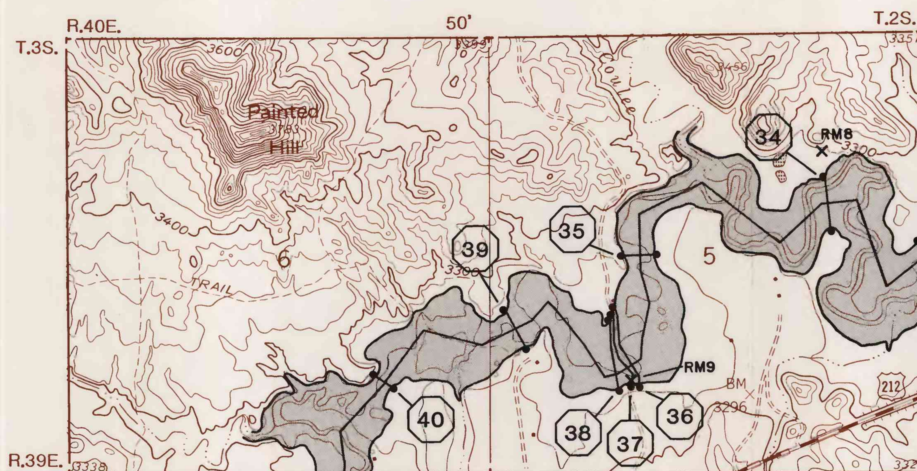
INDEX MAP SHOWING MATCHLINES

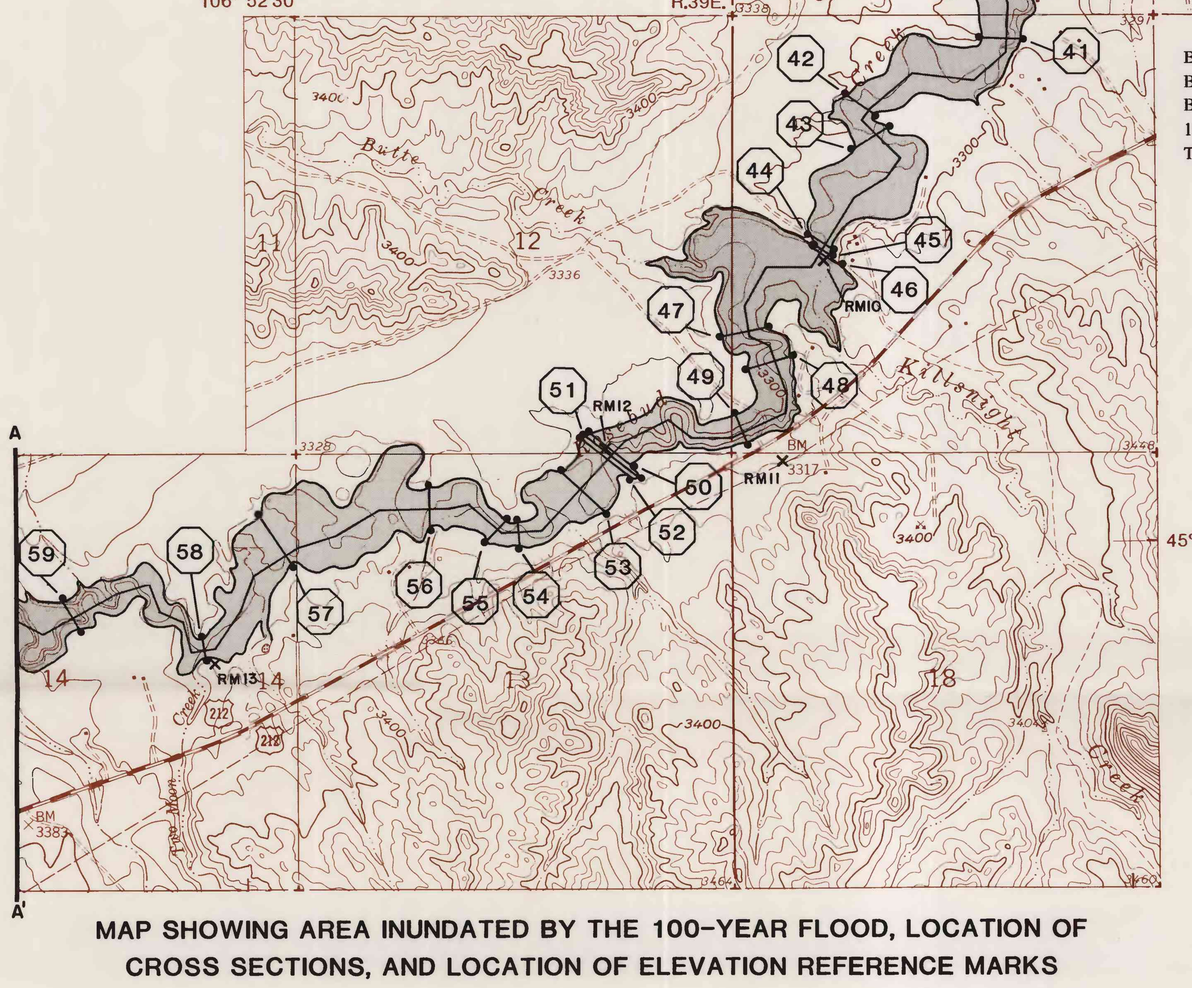
NORTHERN THIRD











Base from U.S. Geological Survey
Birdseye Spring, 1958; Black Spring, 1958; Busby, 1958; Jeans Fork SE, 1967; Jimtown, 1958; Kirby, 1967; Painted Hill, 1958; Thompson Creek, 1967; 1:24,000

SCALE 1:18,000

0 0.5 1 MILE

0 0.5 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DATUM IS SEA LEVEL

MAP SHOWING AREA INUNDATED BY THE 100-YEAR FLOOD, LOCATION OF CROSS SECTIONS, AND LOCATION OF ELEVATION REFERENCE MARKS

EXPLANATION

AREA THAT WILL BE INUNDATED BY THE 100-YEAR FLOOD--Centerline connects approximate centroids of flow areas at cross sections during the 100-year flood

41 CROSS SECTION AND NUMBER

A—A' MATCHLINE--Line separating northern, central, and southern thirds of the study area

RM 2 × ELEVATION REFERENCE MARK AND DESIGNATION

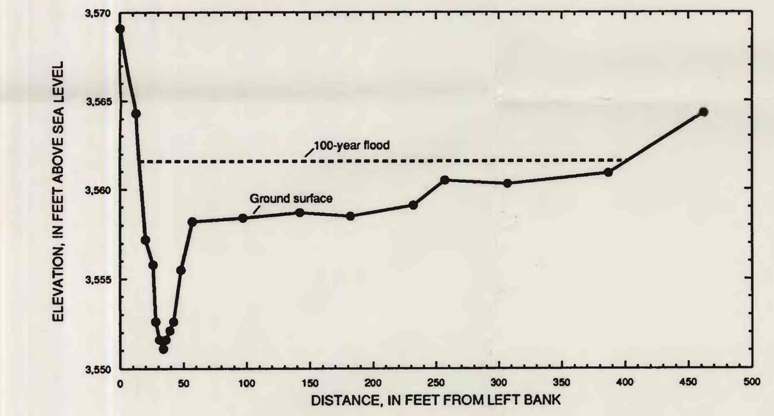


Figure 2. Cross section 134, which is typical of channel and flood-plain conditions in the upstream part of the study reach.

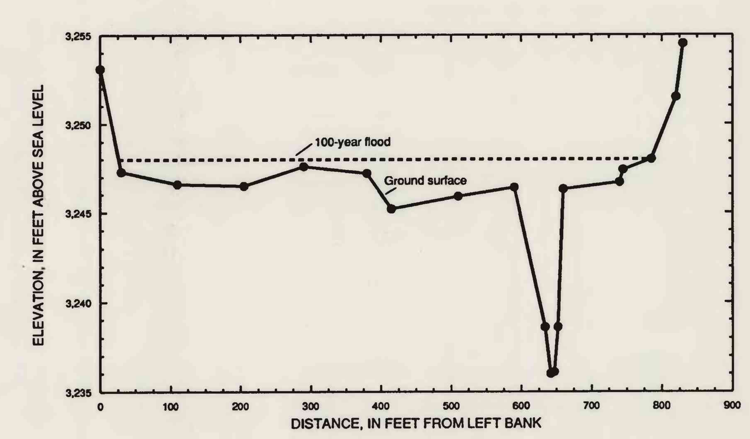


Figure 3. Cross section 27, which is typical of channel and flood-plain conditions in the downstream part of the study reach.

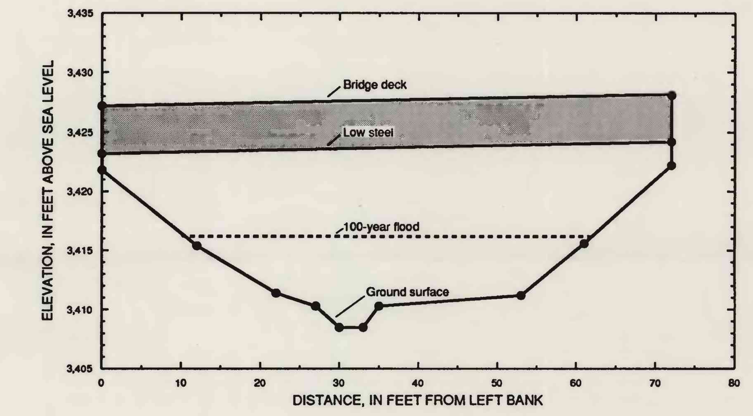


Figure 4. Cross section 99, which is a typical bridge crossing in the study reach.

WATER-SURFACE PROFILE AND FLOOD BOUNDARIES FOR THE COMPUTED 100-YEAR FLOOD, ROSEBUD CREEK, NORTHERN CHEYENNE INDIAN RESERVATION, MONTANA

By
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