INTRODUCTION

The objective of this report is to describe the results of a study in which flood-flows on Swift Creek near Afton, Wyoming, were analyzed. Peak discharge with an average recurrence interval of 100 years was computed and used to determine the flood boundaries and water-surface profile in the study reach. The study was done in cooperation with Lincoln County and the Town of Afton to determine the extent of flooding in the Town of Afton from a 100-year flood on Swift Creek. The reach of Swift Creek considered in the analysis extends upstream from the culvert at Allred County Road No. 12-135 to the U.S. Geological Survey streamflow-gaging station located in the Bridger National Forest, a distance of 3.2 miles (fig. 1).

DESCRIPTION OF SWIFT CREEK

Swift Creek originates in the Bridger National Forest, flows west through the north part of the Town of Afton, and discharges into the Salt River, about 2 miles downstream from the Town of Afton (fig. 1). The streambed bottom material in the main channel of Swift Creek consists of cobble and gravel in the upstream part of the study reach, but generally becomes finer-grained in a downstream direction. Along the study reach upstream of Afton, the floodplains are vegetated with grass, willows, aspen, and pine trees. Cottonwood trees are predominant along the channel in the Town of Afton. Downstream from Afton, the bordering vegetation is mainly cottonwoods and grass.

Development of water in Swift Creek for uses other than irrigation has had only limited success. Several attempts were made to develop hydroelectric plants along Swift Creek upstream from Afton. These developments were short-lived because of the large quantity of sediment deposited in the reservoirs. Aqueducts built along the channel have been destroyed by channel shifting and bed-material deposition. Several homes are located along the stream banks in Afton. Land along the downstream reaches is used for agriculture. Numerous headgate structures have been built along Swift Creek, both upstream and downstream from Afton, for diverting streamflow for irrigation.

DATA AVAILABLE

In May, June, and October of 1986, personnel of the U.S. Geological Survey visited Swift Creek to survey channel cross sections, bridges, and a culvert. Twenty-three cross sections were surveyed in the 3.2-river mile reach, and structure details were obtained for four bridges, a culvert, and a diversion dam. Channel roughness coefficients, Manning's "n" values, were selected for each cross section at the time of the survey.

Vertical-elevation control for the survey was obtained from the U.S. Coast and Geodetic Survey bench mark located on one of the front steps of a church on the corner of 4th Avenue and Jefferson Street in Afton. The bench mark is stamped "V-67". The elevation of the bench mark is 6,264.856 feet above the National Geodetic Vertical Datum of 1929. Two temporary bench marks (TBM) were established during the survey--a square chiseled in the left downstream wingwall of the Madison Street bridge (elevation 6,270.40 feet) and a white circle on top of the right upstream abutment of Swift Creek Lake dam (elevation 6,392.82 feet).

The U.S. Geological Survey maintained a streamflow-gaging station on Swift Creek, at the upstream end of the study area, during water-years 1943 through 1980. A water year is October 1 through September 30. A continuous record of stage was collected at the streamflow-gaging station from which annual peak discharges, low flow, and mean daily flows were computed. The drainage area of Swift Creek at the streamflow-gaging station is 27.4 square miles.

MAGNITUDE AND FREQUENCY OF FLOODS

The theoretical 100-year flood discharge at the streamflow-gaging station was computed using 37 years of annual peak-flow data. The 100-year flood discharge, 900 cubic feet per second, was computed using methods outlined in "Guidelines for Determining Flood Flow Frequency" by the U.S. Water Resources Council (1981). The relation between peak discharge and frequency of occurrence is presented in figure 2.

Dams and irrigation diversions were assumed to have negligible effects on the peak discharge for the 100-year flood as the flood wave travels downstream. Storage in Swift Creek Lake, between cross-sections 20 and 21, has been reduced by deposition of sediment in the reservoir. In addition, the annual peak discharge is not much larger than the annual daily maximum discharge; therefore, at the time of peak discharge, the reservoir would be nearly full and would have little additional storage capacity to reduce the peak discharge. Because the opening of headgates at irrigation diversions is not part of a flood-control plan for the creek, it is assumed that the headgates are closed at the time of the 100-year flood.

The largest flood on Swift Creek, during the period (water years 1943-80) that the streamflow-gaging station was in operation, occurred July 6, 1975. The flood, a result of snowmelt runoff, had a discharge of 793 cubic feet per second. No known damage occurred. A longtime resident reported that in the 1930's, an intense thunderstorm occurred at the mouth of the Canyon and caused local flooding. The magnitude of the flood or the extent of the damage is not known.

HYDRAULIC ANALYSIS AND WATER-SURFACE PROFILE

Four types of hydraulic computations were used to compute the elevation of the theoretical 100-year flood--computation of flow through culverts and bridges (width contractions), flow through open channels, and flow over dams. Methods to compute flow through a culvert are described in "Measurement of Peak Discharge at Culverts by Indirect Methods" by Bodhaine (1968). Methods for computing water-surface elevations at bridges and open-channel water-surface profile and elevations are described in "Bridge Waterways Analysis Model/Research Report," by Shearman and others (1986). The elevation of the 100-year flood at the diversion dam was computed using methods outlined in "Measurement of Peak Discharge at Dams by Indirect Methods," by Hulsing (1968).

The step back-water method used to compute the open-channel water-surface profile requires a series of cross sections to be surveyed across the river valley to define the hydraulic characteristics of the channel. Each cross-section location was selected to represent the hydraulic characteristics of a reach and was surveyed to define the cross-section shape. In order for an assumption of gradually varied steady-state flow to be valid within a reach, the distance between cross sections has to be short. The cost to survey sufficient cross sections to satisfy the step back-water computation is prohibitive in a steep-sloped valley such as Swift Creek. To accomplish the computation, template cross sections were placed between the surveyed cross sections. A template cross section is a surveyed cross section which has been moved upstream or downstream and adjusted for channel slope. Template cross sections are not shown on the map.

The water-surface elevations for the 100-year flood were computed at surveyed cross sections and hydraulic structures. Cross-section numbers begin at the most downstream point in the 3.2 river-mile study reach and increase in the upstream direction. The types of hydraulic computation used to compute the water-surface elevation are discussed below for the following cross sections and hydraulic structures:

1. Culvert on Allred County Road No. 12-135 and cross-sections 1 and 2. Elevations of the 100-year flood at cross-sections 1 and 2 were determined from the elevation of the 100-year flood at the tailwaters and headwaters of the culvert. The elevations were computed using hydraulic methods for culverts described by Bodhaine (1968).

2. Cross-sections 2 through 10, including the computation of flow through the bridge on U.S. Highway 89. The shape, slope, and roughness of the channel are the principal factors that determine the elevation of the 100-year flood, except at the bridge where the water surface is determined by the geometry of the bridge. The elevations were computed using hydraulic methods described by Matthai (1967) and Shearman and others (1986).

3. Madison Street bridge and cross-section 11. The elevation of the 100-year flood at cross-section 11 is determined by the geometry of the bridge and the shape and roughness of the channel. Culvert computations (Bodhaine, 1968) were used instead of computations for a bridge opening because the Froude number in the control section exceeds 1.0.

4. Cross-sections 11 through 15. The elevation of the 100-year flood is determined by the shape, slope, and roughness of the channel. The elevations of the 100-year flood were computed using hydraulic methods for open-channel analysis described by Shearman and others (1986).

5. Diversion dam. The elevation of the 100-year flood is a function of geometry of the channel and the dam. The elevation of the 100-year flood was computed using hydraulic methods for indirect measurements at dams described by Hulsing (1968).

6. Swift Creek Canyon County Road No. 12-138 and cross-section 16. The elevation of the 100-year flood at cross-section 16 is determined by the geometry of the Swift Creek Canyon County Road No. 12-138 bridge. Because the flow through the bridge was supercritical, Froude number greater than 1.0, the elevation of the 100-year flood at cross-section 16 was computed using hydraulic methods for culverts described by Bodhaine (1968).

7. Cross-sections 16 through 20. Elevation of the 100-year flood is determined by the shape, slope, and roughness of the channel except at cross-section 17 where the elevation of the 100-year flood is determined by the geometry of a private bridge. The elevations of the 100-year flood were computed using hydraulic methods for open-channel analysis described by Shearman and others (1986).

8. Swift Creek Lake Dam. The elevation of the 100-year flood at the Swift Creek Lake Dam is a function of the number of planks in the control section and the geometry of the control section. Because the elevation of the spillway is variable, the elevation of the 100-year flood was not determined.

9. Cross-sections 21 through 23. Elevation of the 100-year flood at cross-section 21 is determined by the geometry of the National Forest Service bridge. The water-surface elevations for sections 22 and 23 are determined by the shape, slope, and roughness of the channel. The elevation of the 100-year flood was converted to the datum used for the streamflow-gaging station and plotted on the stage-discharge relation curve (fig. 3). The stage-discharge relation verifies the theoretical water-surface elevation computed in this study which helps substantiate the validity of the hydraulic methods used.

Strip maps showing location of 23 cross sections and two dams are on sheet 1, and the configuration of the cross sections with the elevation of the computed 100-year flood and channel-roughness coefficients are on sheet 2. The cross sections are identified with cross-section numbers and section reference distances. A summary of hydraulic properties are listed in table 1 (sheet 2) and the water-surface profile of the 100-year flood is shown in figure 4.

MAP OF FLOOD BOUNDARIES

Boundaries of the 100-year flood were delineated using the computed elevation of the flood at each cross section, survey data, and a 1983 aerial photograph. The computed water-surface elevation for the 100-year flood was plotted at each cross section, then the lateral extent of the flood was transferred to the flood map. Boundaries between cross sections were sketched using information taken from the aerial photograph. Areas that are inundated, but not part of the active flow, are designated on the cross sections.

Contour lines on the Afton Quadrangle used for the strip maps do not always agree with the elevations shown on the surveyed cross sections. The standards for vertical accuracy of topographic maps require that no more than 10 percent of the elevations of test points interpolated from contours shall be in error more than half the contour interval. The Afton Quadrangle has a contour interval of 40 feet; therefore, differences of up to 20 feet between the contour lines and surveyed cross sections can be expected.

Based on survey data, the channel between cross-sections 15 and 18 was relocated on the topographic map. The maximum distance that the channel was moved on the topographic map was 40 feet, which is the tolerance allowed in horizontal distance for the Afton Quadrangle.

No overflow channel exists where Swift Creek flows out of the canyon onto the Salt River valley floor; that is, the reach between the Swift Creek Canyon County Road No. 12-138 bridge and cross-section 15. If flow at this location should exceed the elevation of the the road, then the flow would follow Swift Creek Canyon County Road No. 12-138 into Afton and the irrigation system to the north. However, the theoretical 100-year flood would be confined by the present channel. The computed elevation of the 100-year flood is 0.9 foot below the top of the headgate diversion structure and 0.3 foot below the top of Canyon Road at cross-section 15.

The hydraulic analysis and elevations of the 100-year flood are based on the condition and configuration of the Swift Creek channel at the time of the survey. Channel changes and encroachment on the channel and floodplain will result in different flood elevations. Bridges and culverts were considered free of debris and fences. Blockage of hydraulic structures will result in increased backwater and higher water-surface elevations than computed in this study.

SELECTED REFERENCES

Benson, M.A., and Dalrymple, Tate, 1967, General field and office procedures for indirect discharge measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A1, 30 p.

Bodhaine, G.L., 1968, Measurement of peak discharge at culverts by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A3, 60 p.

Hulsing, Harry, 1968, Measurement of peak discharge at dams by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A5, 29 p.

Matthai, H.F., 1967, Measurement of peak discharge at width contraction by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A4, 44 p.

Matthai, H.F., Stull, H.E., and Davidian, Jacob, 1972, Preparation of input data for automatic computation of stage-discharge relations at culverts: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 7, Chapter C3, 25 p.

Shearman, J.O., Kirby, W.H., Schneider, V.R., and Flippo, H.N., 1986, Bridge waterways analysis model/Research report: U.S. Geological Survey, and Federal Highway Administration, Office of Research and Development, FHWA/RD-86/108, 112 p.

U.S. Water Resources Council, Hydrology Committee, 1981, Guidelines for determining flood flow frequency: Washington, D.C., Bulletin No. 17b, 183 p.

CONVERSION FACTORS

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

Multiply inch-pound unit	By	To obtain metric unit
foot	0.3048	meter
foot per second	0.3048	meter per second
mile	1.609	kilometer
square foot	0.09290	square meter
cubic foot per second	0.02832	cubic meter per second

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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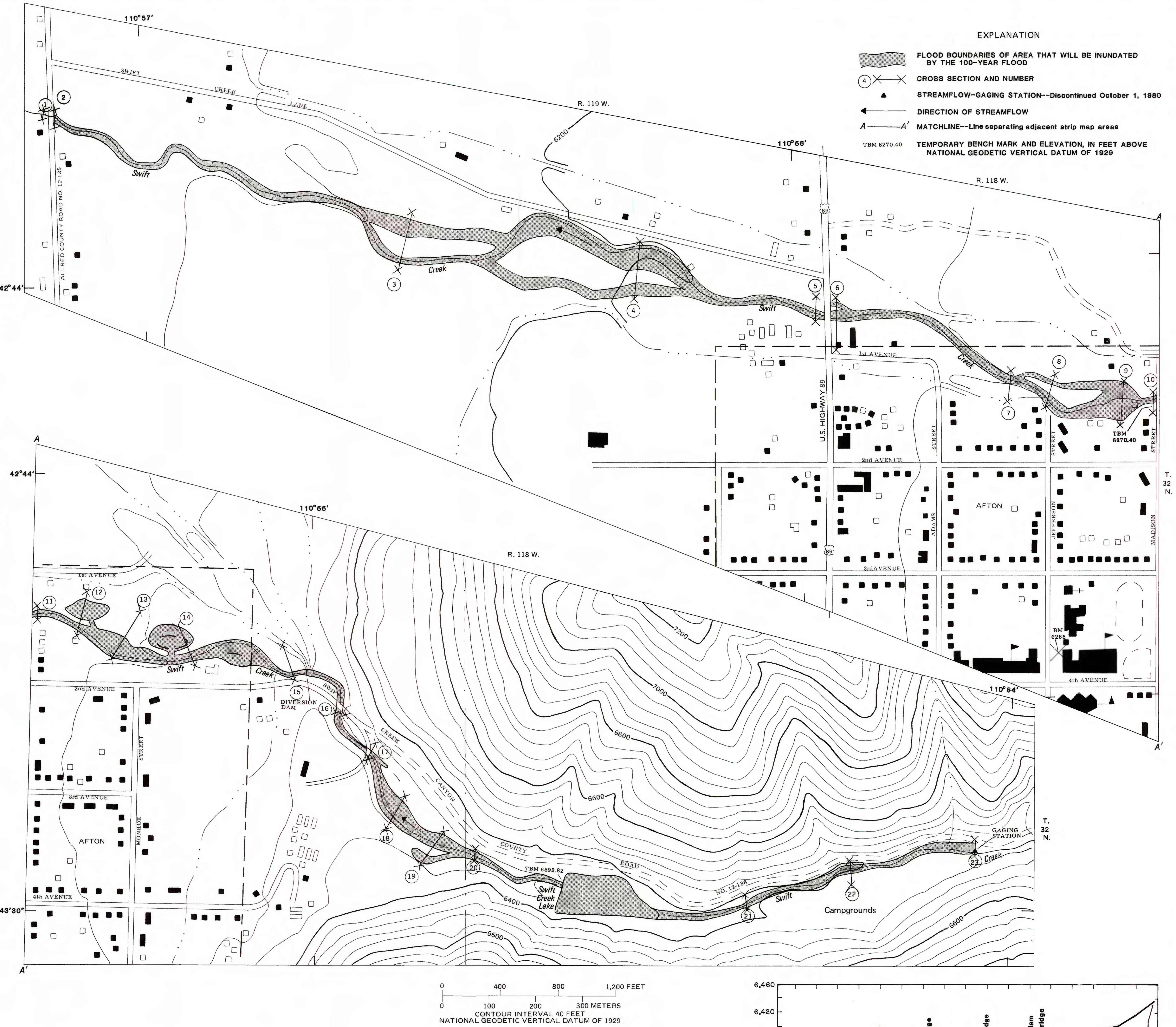

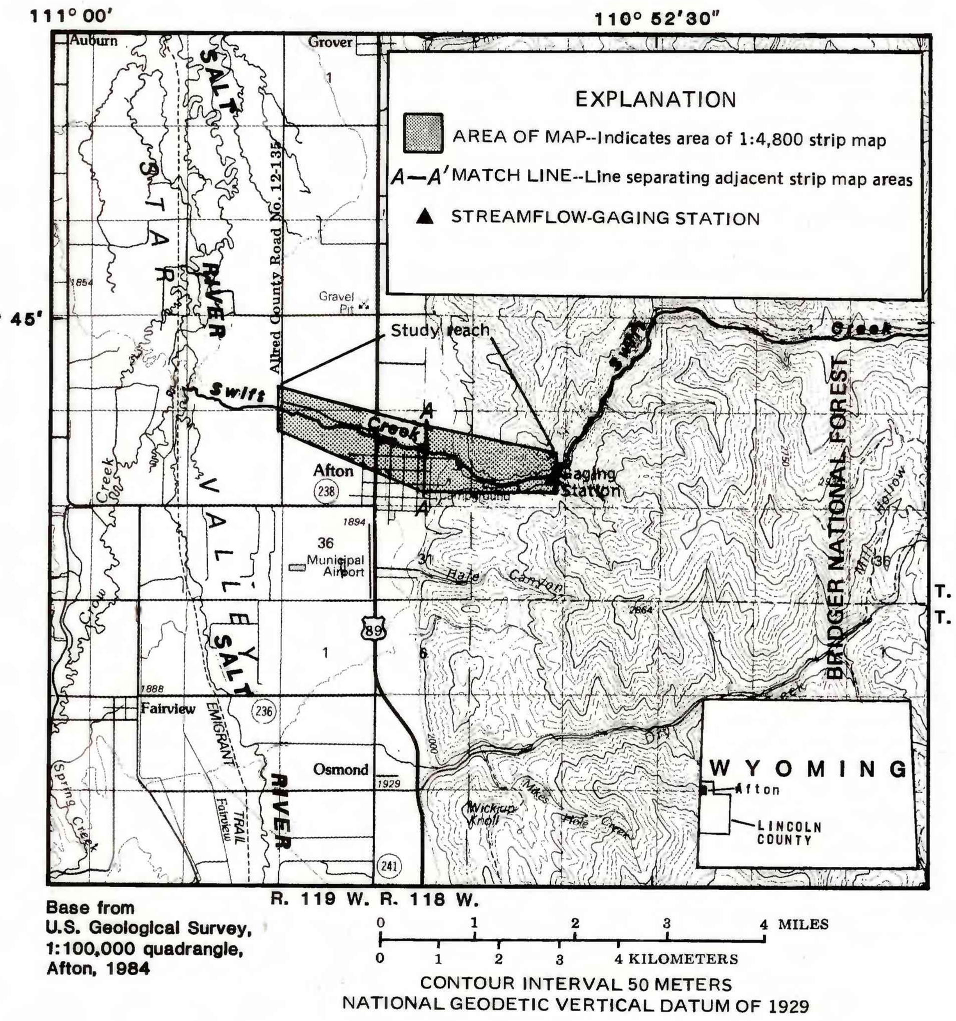

Figure 1.--Reach of Swift Creek considered in the flood analysis.

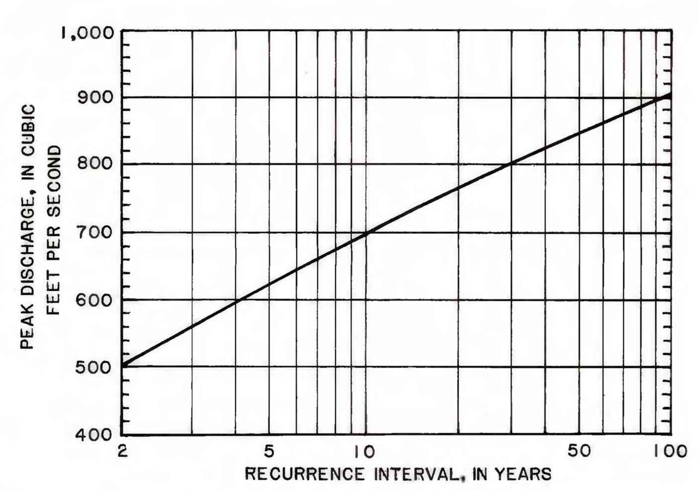

Figure 2.--Discharge-frequency relation, Swift Creek near Afton.

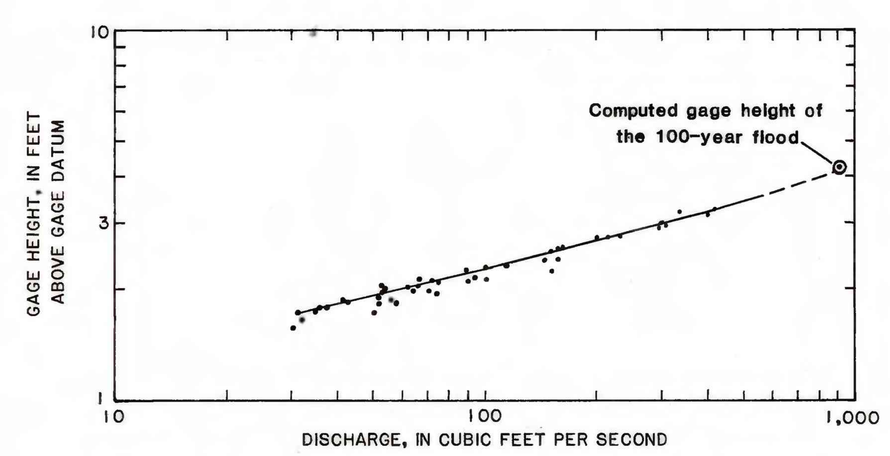

Figure 3.--Stage-discharge relation at streamflow-gaging station, Swift Creek near Afton.

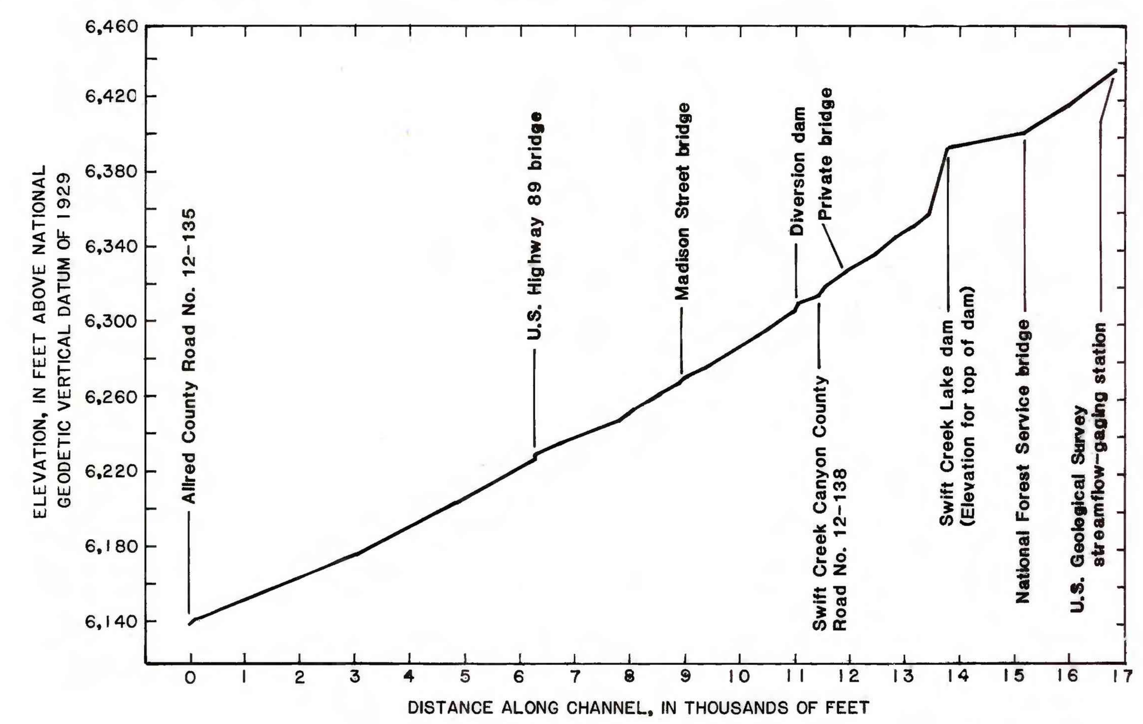

Figure 4.--Water-surface profile for 100-year flood on Swift Creek.

FLOOD BOUNDARIES AND WATER-SURFACE PROFILE FOR THE COMPUTED 100-YEAR FLOOD, SWIFT CREEK AT AFTON, WYOMING, 1986

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