UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

POTENTIAL HAZARDS FROM FLOODFLOWS IN WILDROSE CANYON, DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA AND NEVADA

By John R. Crippen

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CONVERSION FACTORS

The inch-pound system of units is used in this report. For readers who prefer metric units, the conversion factors for the terms used in this report are listed below.

Multiply	By	To obtain
ft (feet)	0.3048	m (meters)
ft/s (feet per second)	0.3048	m/s (meters per second)
ft^3/s (cubic feet per second)	0.02832	m^3/s (cubic meters per second)
inches	25.4	mm (millimeters)
mi (miles)	1.609	km (kilometers)
mi^2 (square miles)	2.590	km^2 (square kilometers)

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 mean sea level.

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ABSTRACT

Wildrose Canyon, in the western slope of the Panamint Mountains, is a well-traveled route in Death Valley National Monument and is a scenic area often visited for its own sake. It is an arid region that is subject to flash flooding. Although such flooding is infrequent, when it occurs in the steep, narrow canyon within which the road lies, the flow of water and accompanying debris may be hazardous to life and to any obstacle in its path. Historical records of amounts of rainfall and floodflow in the area are sparse, but data from the basin and from similar areas in the desert mountains of southern California are sufficient to provide a basis for estimates of the degree of hazard. Potential hazards from floodflows are defined for Wildrose Canyon and its nearby approach routes.

INTRODUCTION

Death Valley National Monument includes areas of geologic, historic, and scenic interest that are not within Death Valley proper. Among these areas is Wildrose Canyon, in the western slope of the Panamint Mountains. Like other desert areas of southern California, Wildrose Canyon, despite its arid climate, is subject to infrequent but sometimes intense storms that can result in flash flooding. When such floods occur, roads and other works of man in their paths may suffer severe damage and visitors can be endangered.

Wildrose Canyon is narrow, steep, and winding. Throughout much of the canyon the road occupies almost the entire width of the canyon floor. When flow occurs here the road itself may become the channel. In many other places the road and the channel may be separated during low flows, but at higher flows the two may become indistinguishable. Because of these conditions the Water Resources Division of the Western Regional Office, National Park Service, requested and funded a study by the Geological Survey of the flood-hazard potential in Wildrose Canyon. This summary of extent and severity of flood hazards is intended to assist the National Park Service by providing a basis for planning visitor activities and selecting structure sites.

GEOGRAPHIC SETTING

Wildrose Canyon lies in the steep western slope of the Panamint Mountains, about 25 mi by air southwest of Death Valley National Monument headquarters and about 35 mi by air or road northeast of the community of Trona. Because of the relatively easy gradients and the presence of several springs, Wildrose Canyon served as an important route westward from Death Valley for many early emigrants. There have been sporadic mining enterprises in the canyon and the nearby mountains, and in the late 19th century the canyon route was used to carry charcoal from kilns in the upper basin above the head of the canyon to a smelter in the Argus Range to the west across Panamint Valley. During the period 1870 to about 1915 the canyon was also the principal route for freight wagons serving the mines in the vicinity of Harrisburg and Skidoo, north of the Wildrose basin. The paved Park Service road through Wildrose Canyon is now a popular tourist route. At the head of the canyon is a Ranger Station, with residences and service buildings that are an outlying base for Park operations. Figure 1 is a sketch map of the canyon and vicinity.

The shape and extent of the Wildrose basin is shown in figure 2. Nemo basin (27.4 mi^2) and upper Wildrose basin (23.7 mi^2) are the largest sub-basins. Upper Wildrose basin is shaped somewhat like a broad amphitheatre, with high steep slopes at the east side leading downward to a broad sloping alluvial fill east of point Z on the map. At point Z the channel enters a narrow gorge, Wildrose Canyon. About 4.1 mi downstream at point X, the canyon opens as it enters the "Wildrose graben," a downfaulted trench wherein Wildrose and other much smaller contributing channels lose their identity as they leave the steep slopes of the Panamint Range. At point Y, 0.8 mi upstream from point X and still within the canyon, Nemo Canyon enters Wildrose from the north. Much of the eastern part of Nemo Canyon is a broad alluvial fill similar to upper Wildrose but with gentler slopes. Between points Y and Z many smaller drainages enter Wildrose Canyon; their total contributing area is about 9.9 mi^2. Thus the total area at point Y is 61.0 mi^2; at point X, where flow enters the braided channels that follow Wildrose graben, drainage area is 61.9 mi^2.

Altitudes in Wildrose basin range from about 2,500 ft near the monument entrance (fig. 1) to 9,994 ft at Rogers Peak (fig. 2). The canyon bottom itself is at about 4,300 ft at the head near point Z; 3,130 ft near point Y; and 2,800 ft near point X. Of the 61.9 mi^2 total area tributary to point X, about 97 percent lies above 4,000 ft, 70 percent above 5,200 ft, 14 percent above 7,200 ft, and 4 percent above 8,200 ft.

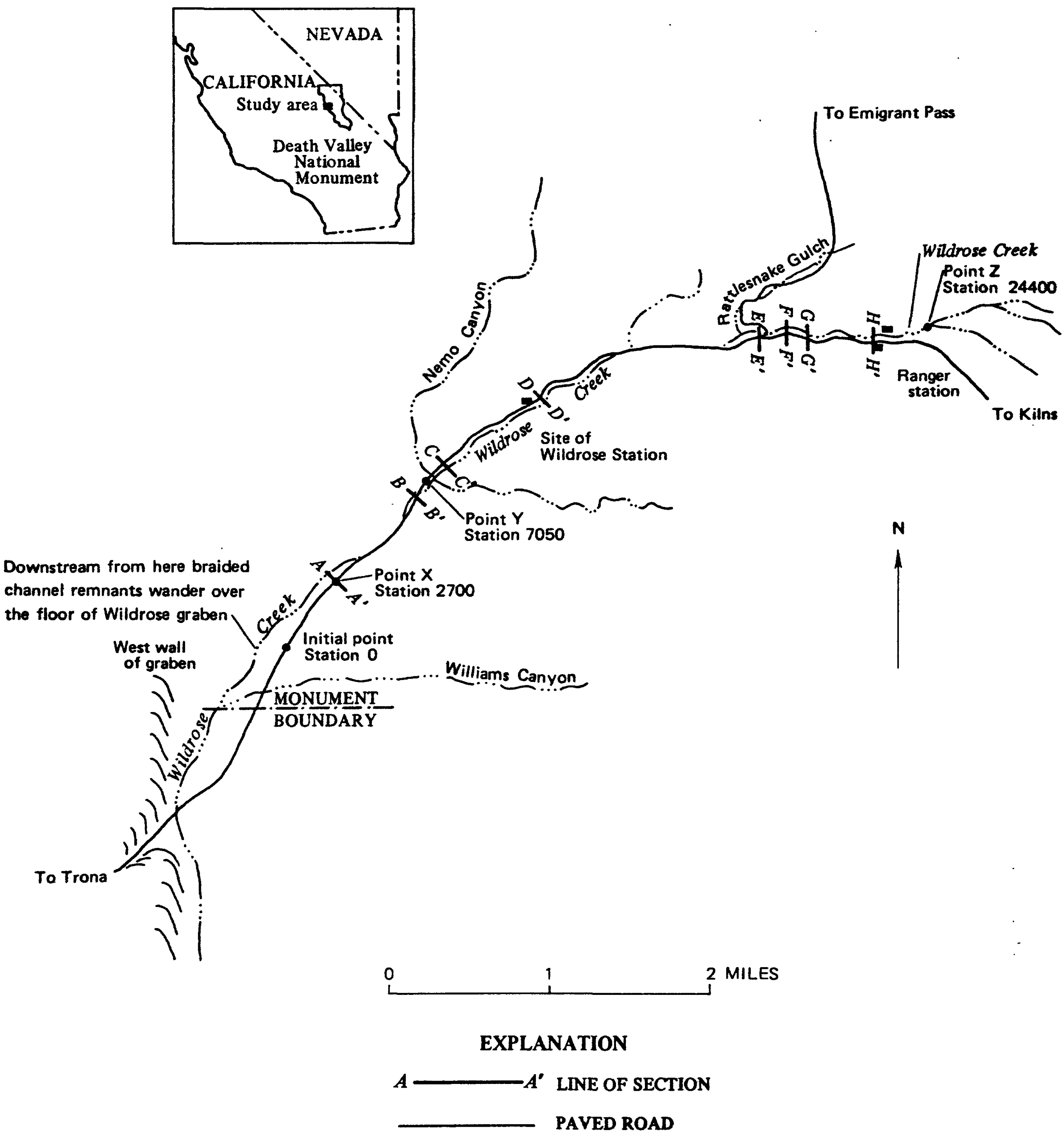

FIGURE 1.--Wildrose Canyon and vicinity.

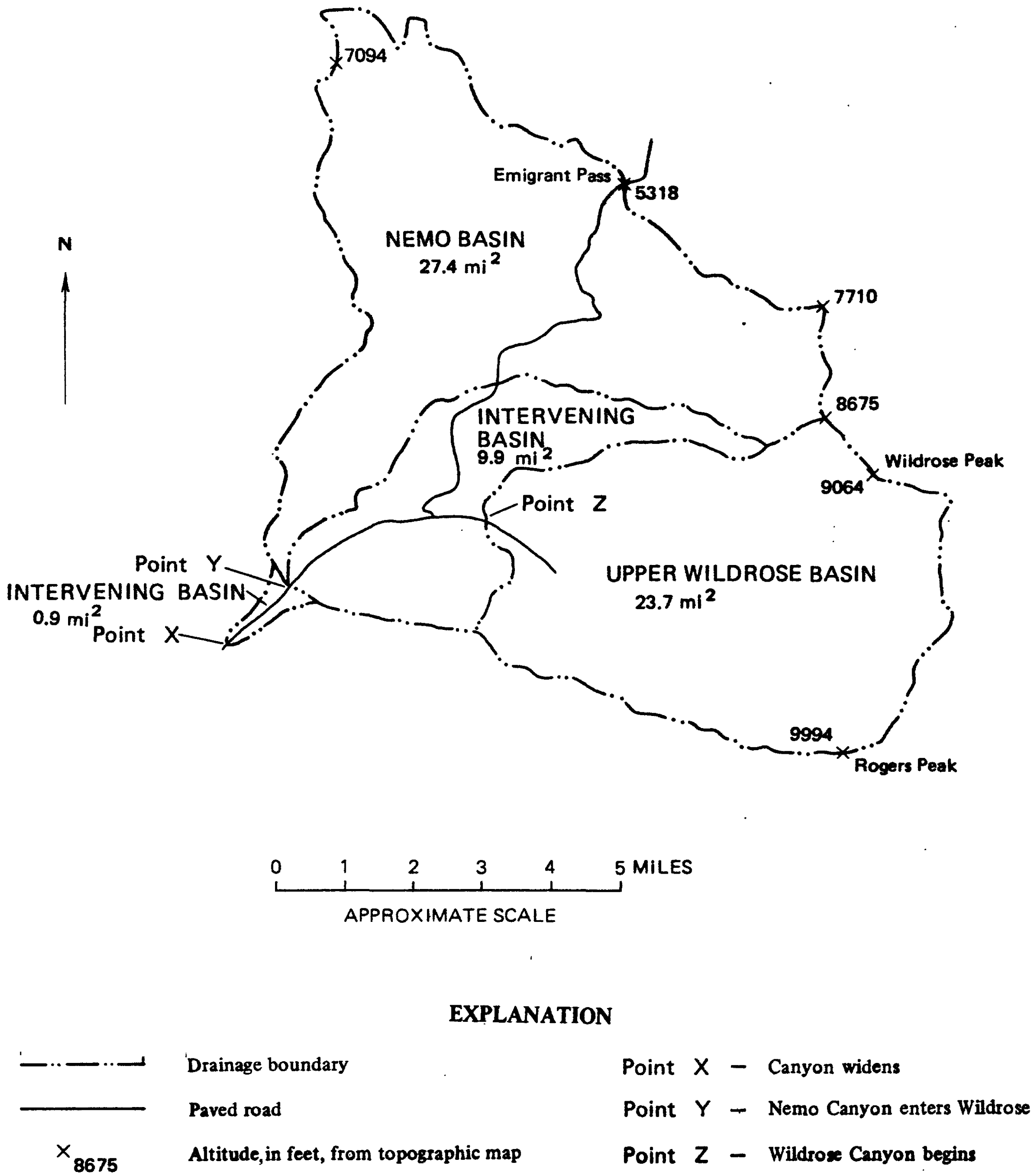

FIGURE 2.--Wildrose basin.

As this study is concerned with flood hazard in Wildrose Canyon itself, a baseline was established for locational reference, with stationing along the highway in feet. After the base for stationing was selected in the field, distances were measured on a set of topographic contour maps, prepared for the Park Service by Aero Service Corp. and dated July 1970. The maps are at a scale of 1 inch equals 100 ft with a contour interval of 2 ft. Stationing started with zero at the location of "gate," shown on the Park Service map to be at a pavement altitude of 2,619 ft, and progressed upgrade (roughly northeasterly). The zero station is estimated from odometer readings and by the topographic map to be about 2,200 ft upgrade from the southern boundary of the monument.

Eight cross sections were surveyed using the datum of the Park Service maps. Data pertinent to the locations mentioned are shown in table 1.

TABLE 1. - Data for points of interest in Wildrose Canyon

Station (fig. 1)	Point	Cross section	Altitude of road, in feet	Miles	Remarks
0	--	--	2,619	0	Gate.
2700	X	A	2,806	0.51	Canyon opens into graben.
6340	--	B	3,075	1.20	--
7050	Y	--	3,130	1.34	Mouth of Nemo Canyon.
7530	--	C	3,154	1.43	--
12180	--	D	3,478	2.31	Site of Wildrose Station.
19700	--	E	3,995	3.73	--
20700	--	F	4,065	3.92	--
21600	--	G	4,114	4.09	Wildrose Campground.
22500	--	H	4,173	4.26	Ranger Station.
24400	Z	--	4,300	4.62	Site of Geological Survey gage at head of canyon.

PRECIPITATION

Rainfall is scanty throughout Wildrose basin, and varies greatly with altitude. As is common throughout the interior of southern California, the general wide-area storms that over many years bring most of the precipitation occur during the winter months, November to March. Such storms are likely to be relatively gentle, and each winter sees moderate accumulation of snow at altitudes higher than 8,000 ft. However, the more rare but often more intense rainfall of summer storms, from July through September, are the cause of most damaging floodflows. The distribution in time of precipitation is similar to that of the Furnace Creek basin (Crippen, 1979, p. 4).

Maps prepared by Rantz (1969) provide the most detailed representation available of average annual precipitation in the southern California desert region. Rantz shows precipitation to range from less than 5 inches in the Panamint Valley (altitude about 1,200 ft) to more than 10 inches near the crest of the Panamint Range, which forms the eastern boundary of Wildrose basin. Data collected during the years 1965 to 1975 at several sites in the upper Wildrose basin are in reasonable agreement with these amounts and also with the crude but useful rule-of-thumb equation that can be applied in the region:

$$P=2.0+0.85A,$$

where

P=the mean annual precipitation, in inches, and
A=the altitude of the specified site, in thousands of feet.

However, differences in exposure together with the great fluctuation from year to year cause great variation in the observed data.

FLOOD HYDROLOGY

Floods in desert regions are the product of intense rainfall, often over relatively small areas. As mentioned before, such floods are by far most frequent during the summer months. A record of flow at the head of the canyon (point Z) obtained at a Geological Survey gaging station during the period October 1960 to September 1975 illustrates the occurrence of floods from the upper Wildrose basin. Peak flows and all other daily flows during the 15 years of record are shown in table 2.

Of the six peak flows greater than 100 ft^3/s, only the one during the major general storm of February 1969 occurred outside of the summer period. A field investigation of the area after the storm of September 4, 1967 (peak flow at point Z, 1,060 ft^3/s), revealed that the flood followed a burst of rainfall totaling 1.6 inches which occurred during a 30-minute period over an area of only about 5 mi^2. Figure 3 is a photograph of the wave front of the flow from this flood as it reached Wildrose Station, 2.3 mi downstream from Point Z at station 12180. An observer related that within 3 minutes from the time of the photo, the water covered the road (which here constitutes the entire floor of the canyon) to a depth of more than 1 ft on the near side and more than 2 ft on the far side.

The greatest flood known to have occurred in the Panamint Range was in late July 1876; it destroyed the mining community of Panamint City. The ruins of Panamint City (dominated by the great brick chimney of the reducing mill) are in Surprise Canyon, 10 mi south of Wildrose basin at an altitude of 6,200 ft. The drainage basin of Surprise Canyon at Panamint City is about 4 mi^2; it is similar in shape and topography to the upper Wildrose basin. The Panamint City flood is described by Beebe (1954).

TABLE 2. - Complete record of flow, October 1960-September 1975, Wildrose Creek near Wildrose Station (point Z)

[Drainage area, 23.7 mi^2]

Date	Peak discharge (ft^3/s)	Daily discharge (ft^3/s)
Aug. 5, 1961	330	7.20
Feb. 9, 1963	--	.10
Feb. 10, 1963	1.10	.10
July 26, 1964	--	.20
Aug. 4, 1964	303	7.30
Oct. 29, 1964	--	.02
July 24, 1965	3.00	.03
Nov. 22, 1965	--	.10
Nov. 23, 1965	--	.30
Dec. 29, 1965	50	8.00
Aug. 1, 1966	600	13.00
Aug. 24, 1967	--	.20
Sept. 2, 1967	--	.70
Sept. 4, 1967	1,060	46.00
Aug. 7, 1968	1.00	.03
Feb. 25, 1969	204	16.00
July 20, 1969	10	.64
Nov. 29, 1970	.92	.01
Dec. 25, 1971	.33	.01
Dec. 26, 1971	--	.22
Dec. 27, 1971	--	.06
Jan. 18, 1973	--	.06
Jan. 19, 1973	--	.08
Feb. 11, 1973	.33	.15
Feb. 12, 1973	--	.04
Oct. 26, 1974	--	.01
Dec. 4, 1974	--	.03
Sept. 7, 1975	119	2.70

FIGURE 3.--Flood of September 4, 1967, at Wildrose Canyon.

The data of table 2 have been analyzed according to procedures described by the U.S. Water Resources Council (1977). However, because of the shortness of the period of record and uncertainty as to the statistical parameters that apply to the unique patterns of hydrologic occurrences in the area, the results of regional equations based upon flooding experience throughout the desert region of southern California have been chosen as more appropriate in the Wildrose basin, for both the gaged drainage basin and the larger basins downstream. The equations are presented and their origin and use are discussed by Waananen and Crippen (1977). Because of a dearth of information from larger basins, the equations are derived using data from basins of less than 25 mi^2 area. There is as yet little information on flood peaks from large basins in arid regions. Studies in adjacent regions of California indicate no significant difference in frequency characteristics because of basin size, and the equations are therefore assumed to be valid for use in this region.

Table 3 presents the peak flows computed for the gaged site (point Z) and for selected sites at locations farther downstream. The flood peaks of 0.04 and 0.002 probability as computed from the data of table 2 for point Z by the Water Resources Council technique are very close to the 0.04 and maximum experience (me) values shown here. Floods of 0.02 and 0.01 probability are 36 percent and 76 percent higher, respectively, by the Water Resources Council computations than those shown and used in this report.

The relations among probability and frequency of occurrence of floods are discussed in the previously cited reports by Waananen and Crippen (1977) and by Crippen (1979).

TABLE 3. - Estimated flood discharges at selected sites in Wildrose Canyon

Probability, in percent	Discharge, in cubic feet per second, at indicated locations			Recurrence interval, in years
	Point Z and sections E, F, G, H (23.7 mi^2)	Sections C, D (30.9 mi^2)	Point X and sections A, B (61.0 mi^2)	
0.04	3,010	3,560	5,460	25
.02	6,020	7,220	11,500	50
.01	10,200	12,300	20,000	100
[1]me	79,500	95,400	148,000	--

[1]Peak from envelope curve for maximum floods experienced in the region (Crippen, 1978).

FLOODFLOWS IN WILDROSE CANYON

The flows shown in table 3 have been routed down Wildrose Canyon by use of conventional hydraulic procedures. Figures 4-11 show the computed water levels at sections A-H, and figures 12-18 show the areas of the canyon that are subject to inundation in the vicinity of the sections. Depths of water over the road at each section and average velocities of flow are summarized in table 4.

Once flow enters the canyon, it follows the gorge and the highway downstream to the vicinity of section A; from section A downslope the path of flow is indeterminate. This is especially true for high flows that can move heavy debris and therefore are likely to create new flow paths once they leave the restricting walls of the narrow canyon. The estimates of depth of water over the road within the canyon are based on conditions as noted in April 1979, and as the magnitude of flow increases the estimated depths are increasingly more uncertain. High flows have the capacity to undercut, wash out, and deposit material in unpredictable locations thereby altering the depths of inundation and endangering areas that shortly before seemed safe. Because of the steepness of the canyon floor, even floods of low magnitude move with high velocity, and the less frequent floods of higher magnitude will have velocities capable of completely reshaping many areas of the canyon bottom.

TABLE 4. - Estimated flow velocities and depths over road at selected locations in Wildrose Canyon

[me, maximum experience]

Cross section	Station	Average velocity, in feet per second, for flood of indicated probability				Depth over road, in feet, for flood of indicated probability			
		0.04	0.02	0.01	me	0.04	0.02	0.01	me
A	2700	10	13	14	34	([1])	([1])	([1])	4.0
B	6340	11	13	19	43	1.1	2.1	2.6	8.6
C	7530	10	12	14	34	1.5	2.5	3.5	9.0
D	12180	22	30	36	66	3.6	5.1	7.1	20.1
E	19700	13	15	22	49	([1])	0.7	1.2	8.7
F	20700	12	16	20	48	0.2	1.2	2.2	9.2
G	21600	13	17	20	46	3.0	4.5	6.0	16.0
H	22500	15	22	23	43	([1])	0.2	1.7	11.7

[1]Road is at or above computed altitude of flow.

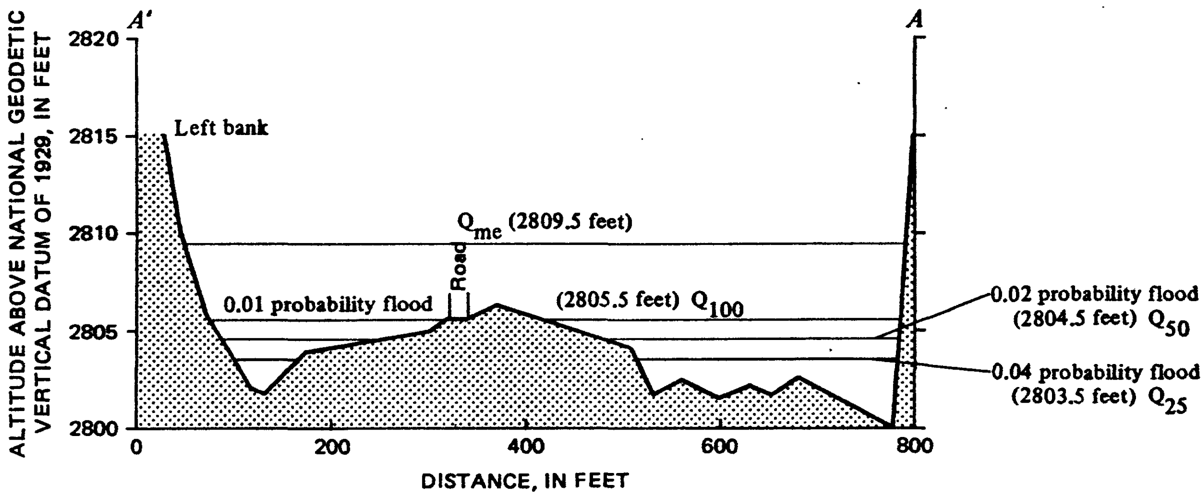

FIGURE 4.--Cross section A (station 2700).

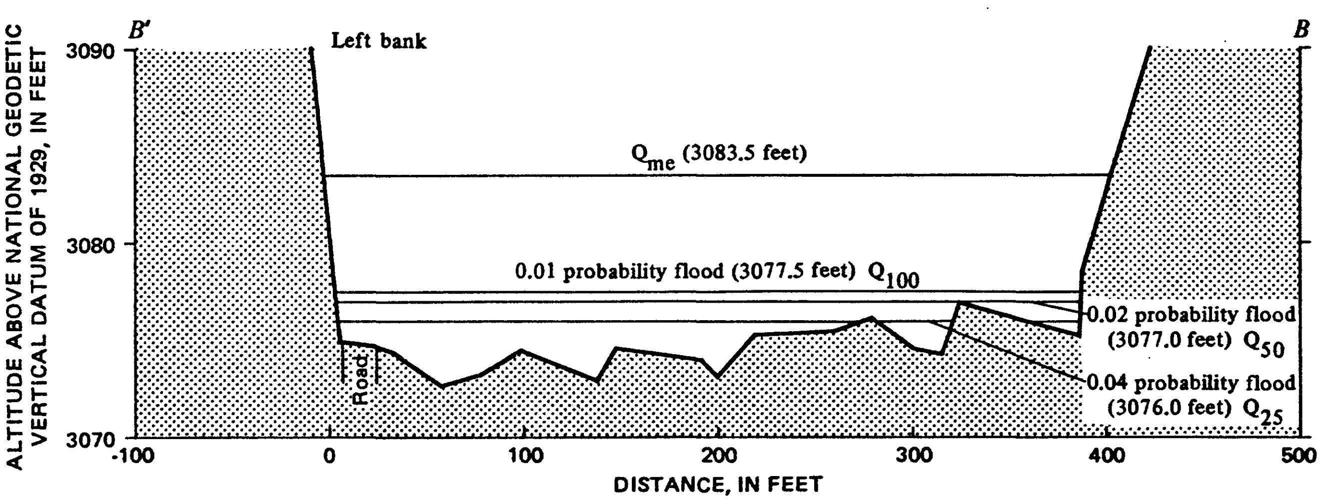

FIGURE 5.--Cross section B (station 6340).

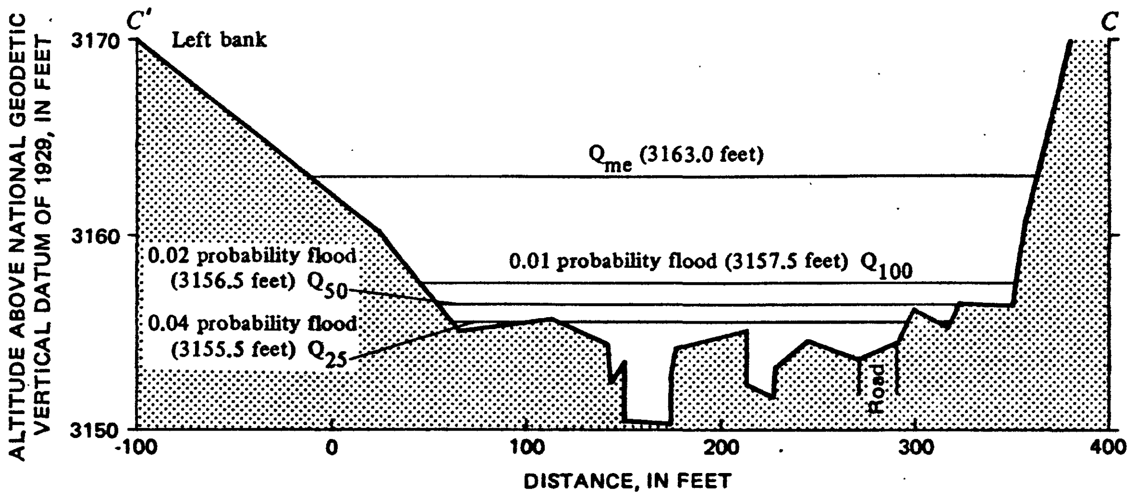

FIGURE 6.--Cross section C (station 7530).

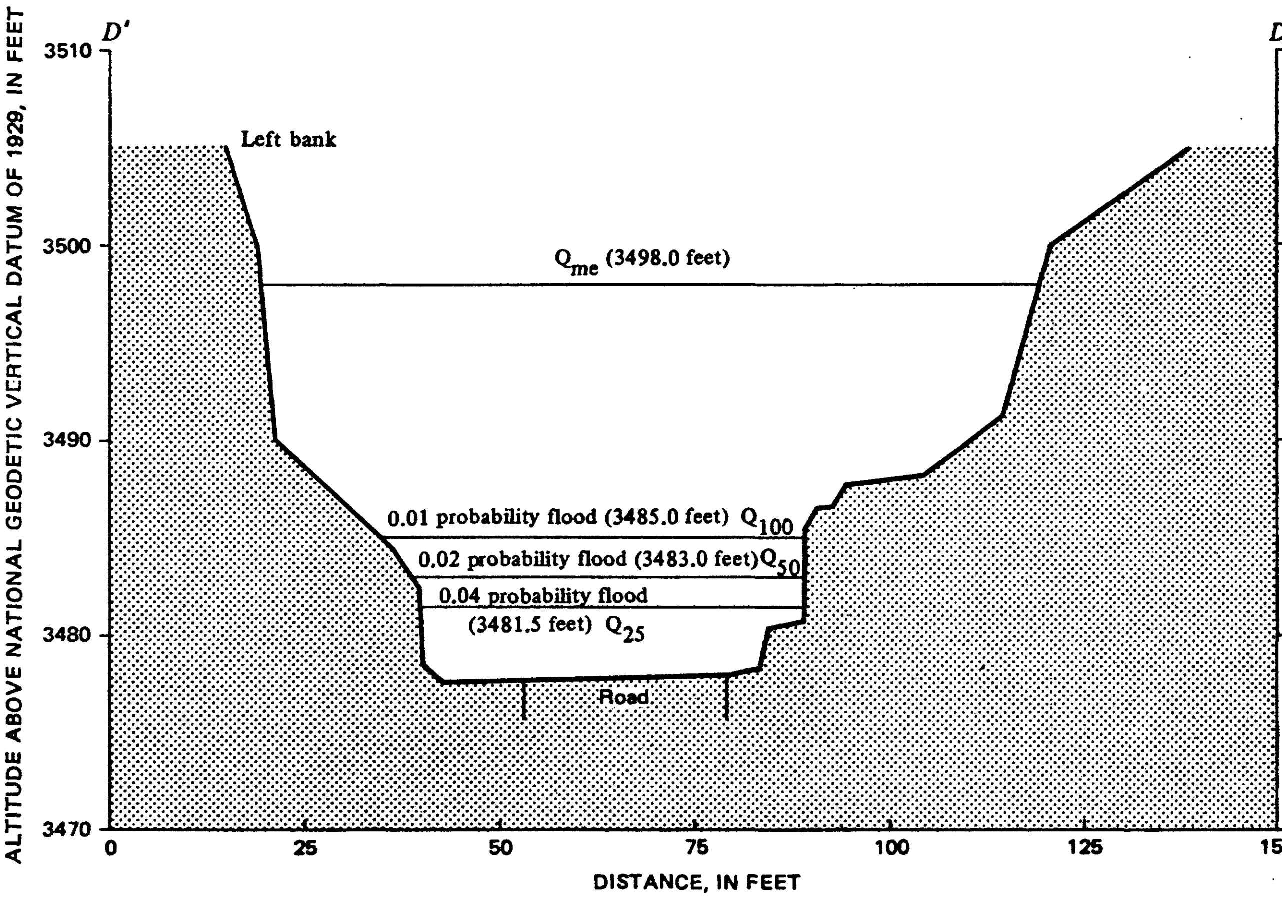

FIGURE 7.--Cross section D (station 12180).

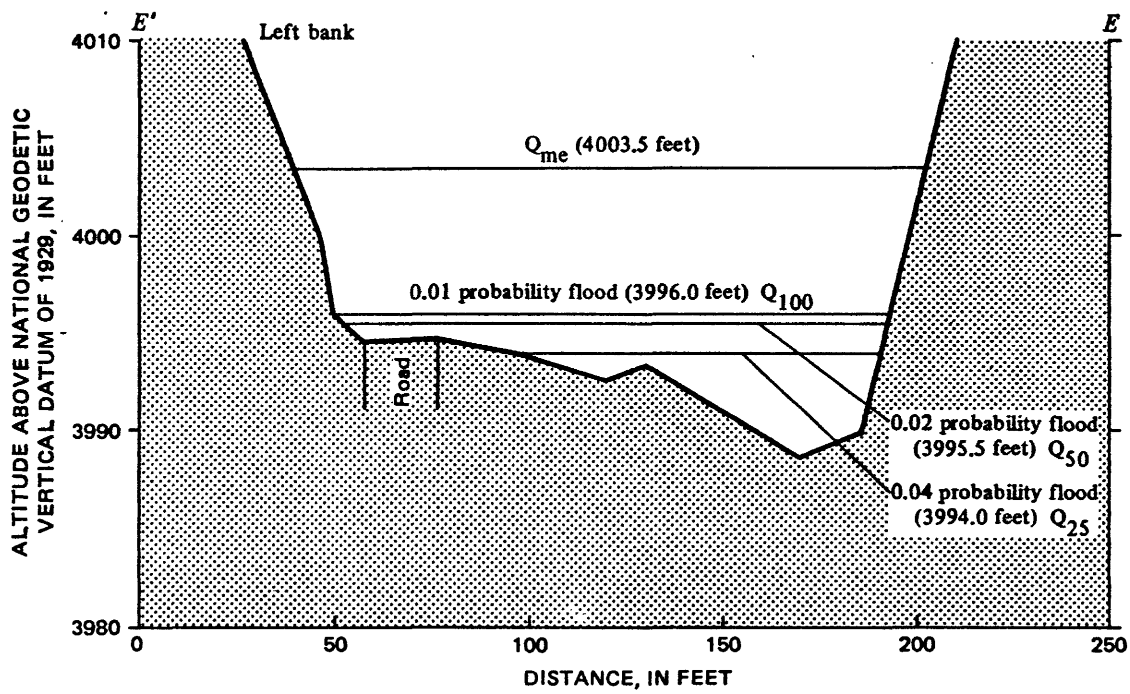

FIGURE 8.--Cross section E (station 19700).

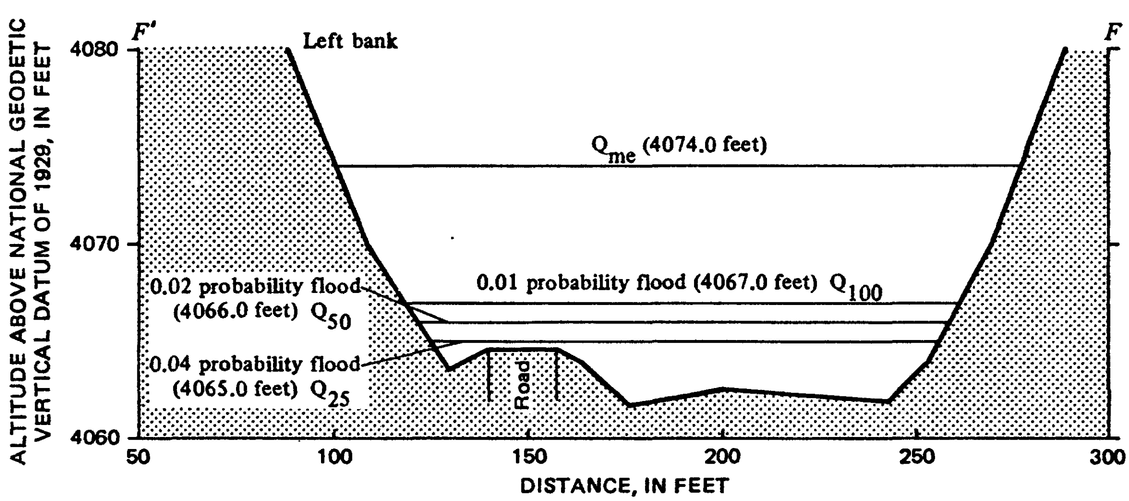

FIGURE 9.--Cross section F (station 20700).

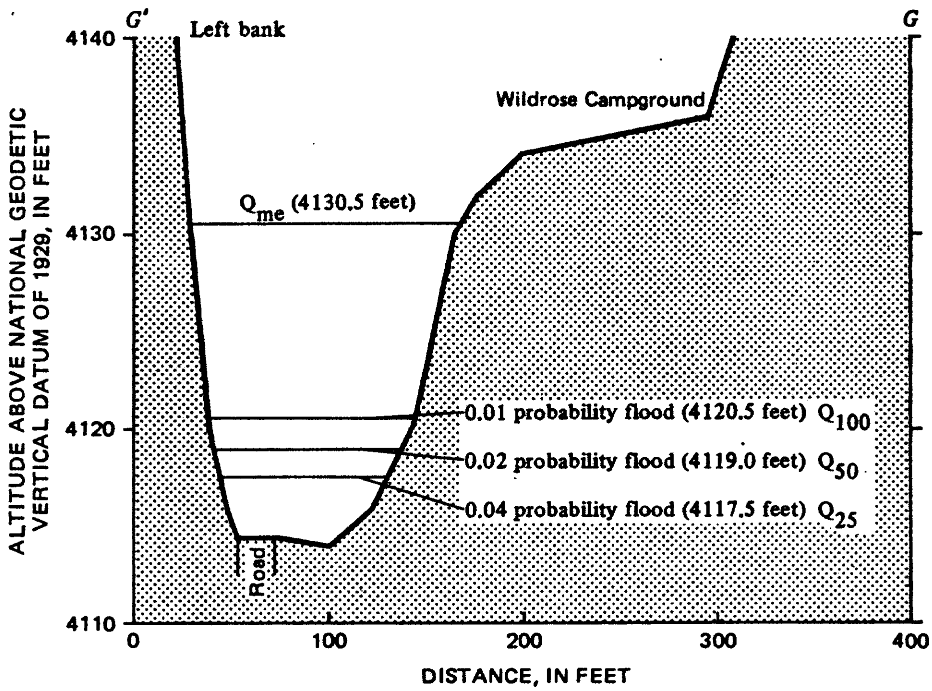

FIGURE 10.--Cross section G (station 21600).

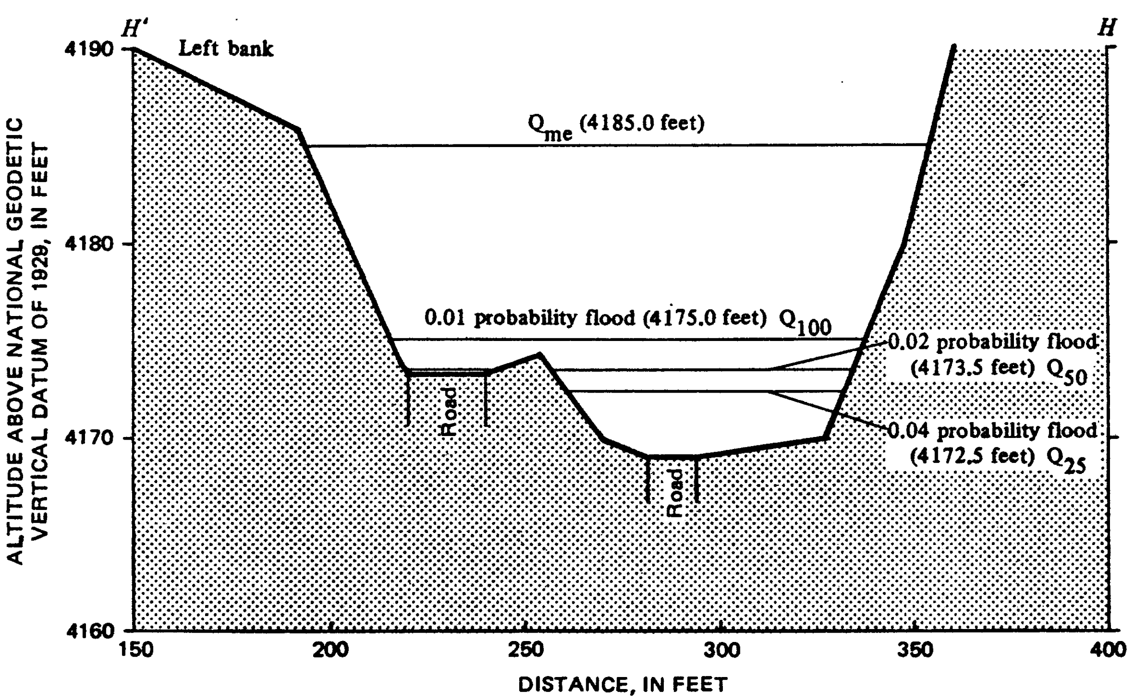

FIGURE 11.--Cross section H (station 22500).

At locations where the canyon is relatively wide and the channel banks slope gently, areas of extreme, moderate, and slight hazard are shown as separate regions (figs. 12-18). Where banks are steep the width increases only slightly as the flooding increases in magnitude, although depths and velocities become greater. In such narrow channels the areas of relative hazard cannot be separately distinguished, and the entire flooded area is shown as subject to extreme hazard.

Two areas of potential hazard that are not mapped and that have characteristics that do not lend themselves to evaluation of relative risk are Rattlesnake Gulch and the stretch of road in the vicinity of Williams Canyon, near the southern boundary of the monument.

Rattlesnake Gulch is a short canyon by which the road ascends from Wildrose Canyon in its route northward to Emigrant Pass. The gulch is very narrow and, with the road occupying the entire bottom width, follows a steep, winding course for about 0.5 mi after it leaves Wildrose Canyon, ascending from 4,050 ft in altitude to about 4,300 ft. The drainage area of the gulch at its mouth, where it joins Wildrose Canyon, is 0.52 mi^2. Despite the small size of the basin, this section of road could be an extremely hazardous area during a flood of 25-year or greater recurrence interval.

Williams Canyon is not within the Wildrose basin; it drains a basin of about 1.3 mi^2 adjacent to Wildrose Canyon to the south. It is mentioned here because its floodflows enter Wildrose graben in the vicinity of the southern boundary of the monument. The path of flow from Williams Canyon, once it leaves the steep west front of the mountains, becomes somewhat indeterminate; however, inspection of aerial photographs and observations on the ground indicate that there may be occasional shallow flows of water and debris across the road near the monument boundary.

All flow from Wildrose Canyon as well as inflow from Williams Canyon and any additional inflows that cross the road from the east or that arise from small, low-altitude drainages near the southwest corner of the monument are directed southward by the scarp of Wildrose graben. Such flows will cross the road outside of the monument in the low dip at the foot of the scarp, about 0.7 mi southwest of the monument boundary.

In addition to the hazards posed by the floodwaters themselves as they pass downcanyon, there is potential hazard from the downwash of water and debris from the steep canyon walls. Storms that would cause heavy runoff from the basin as well as small-area but intense storms that might reach only the canyon itself, without causing large-scale flooding, may cause downslope movement of debris or landslips that could endanger any persons, vehicles, or buildings within the canyon.

EXPLANATION

FOR FIGURES 12 - 18

A ——— A′ LINE OF SECTION

——— BOUNDARY OF EQUAL FLOOD-HAZARD POTENTIAL–Probabilities of 0.04, 0.02, and 0.01 correspond to 25-, 50-, and 100-year frequencies

FLOOD HAZARD AREAS

Extreme hazard–Flooded by all events of less than 0.04 probability

Moderate hazard–Flooded by all events of less than 0.02 probability

Slight hazard–Flooded by all events of less than 0.01 probability

Arrow indicates main channel of Wildrose Creek

× Location of station and (or) reference point

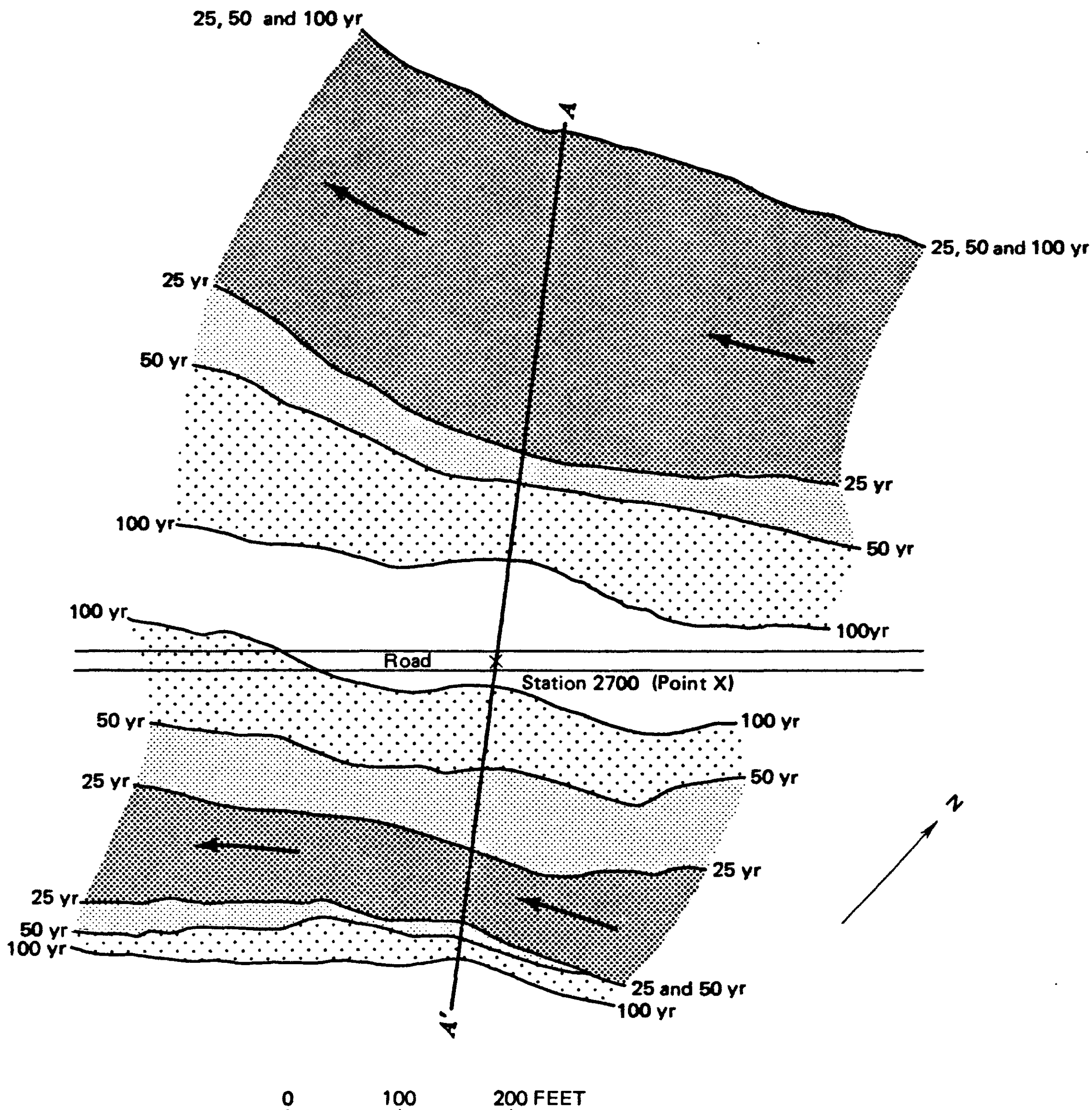

FIGURE 12.--Flood-hazard area in vicinity of cross section A.

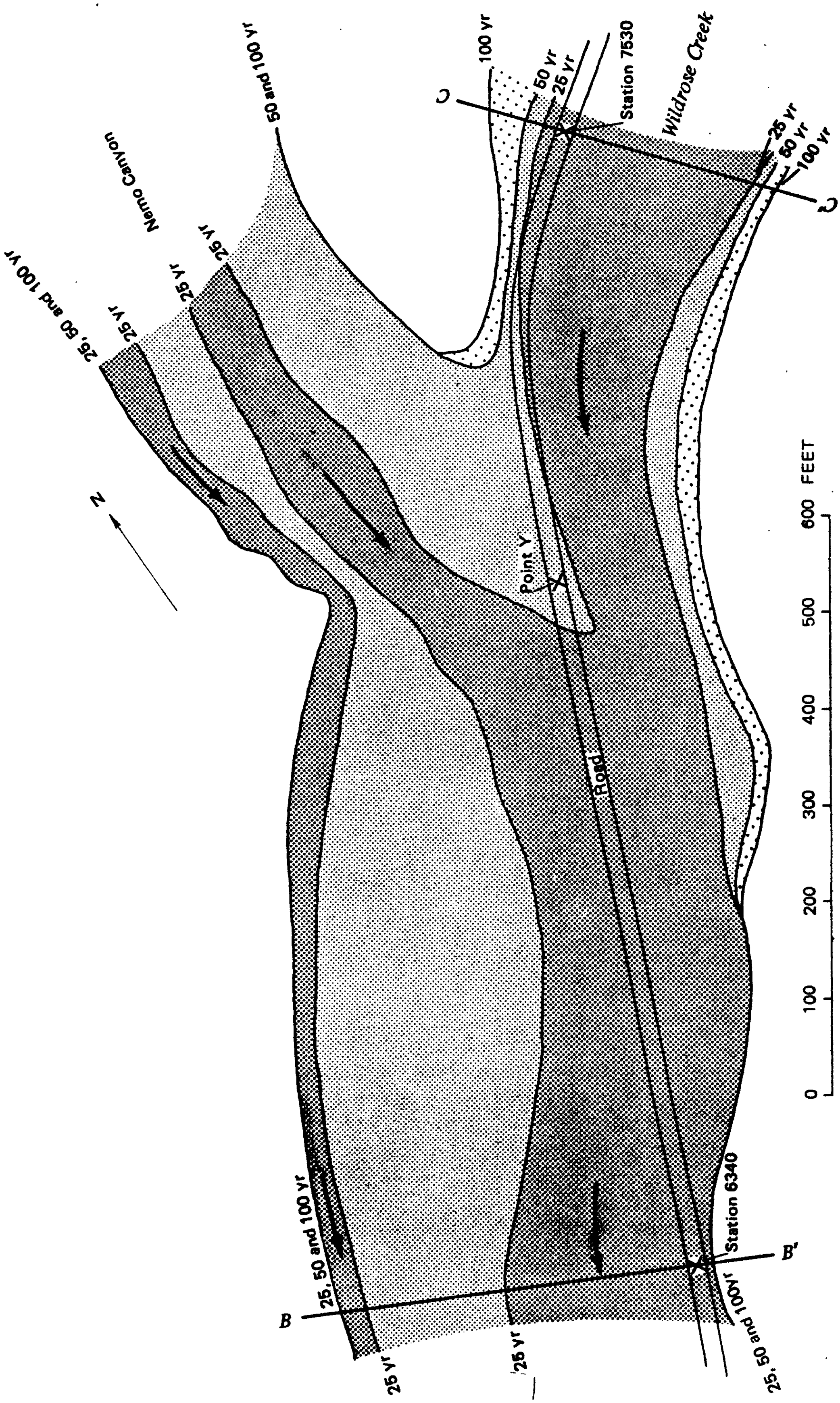

FIGURE 13--Flood-hazard area in vicinity of cross sections B and C.

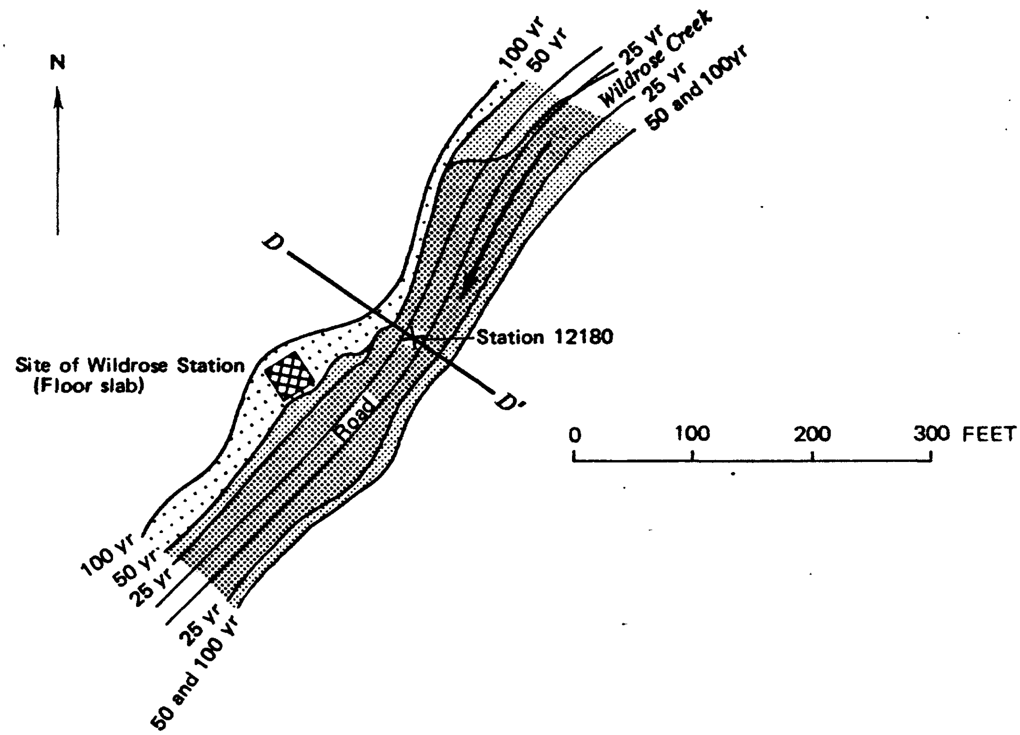

FIGURE 14.--Flood-hazard area in the vicinity of cross section D.

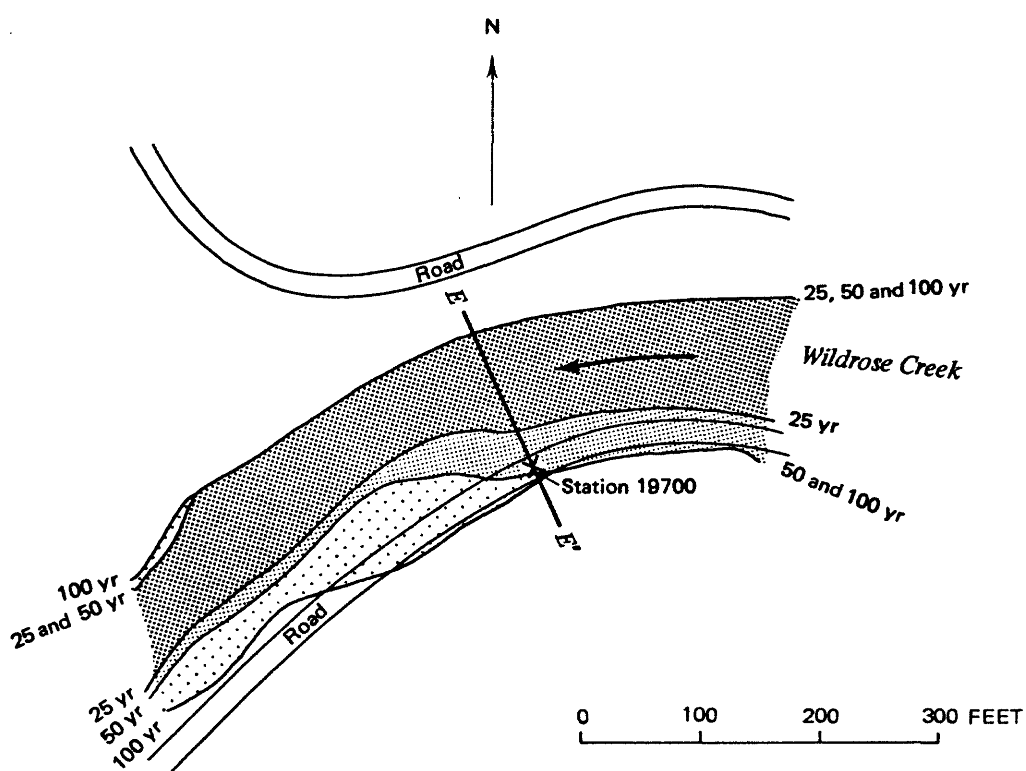

FIGURE 15.--Flood-hazard area in the vicinity of cross section E.

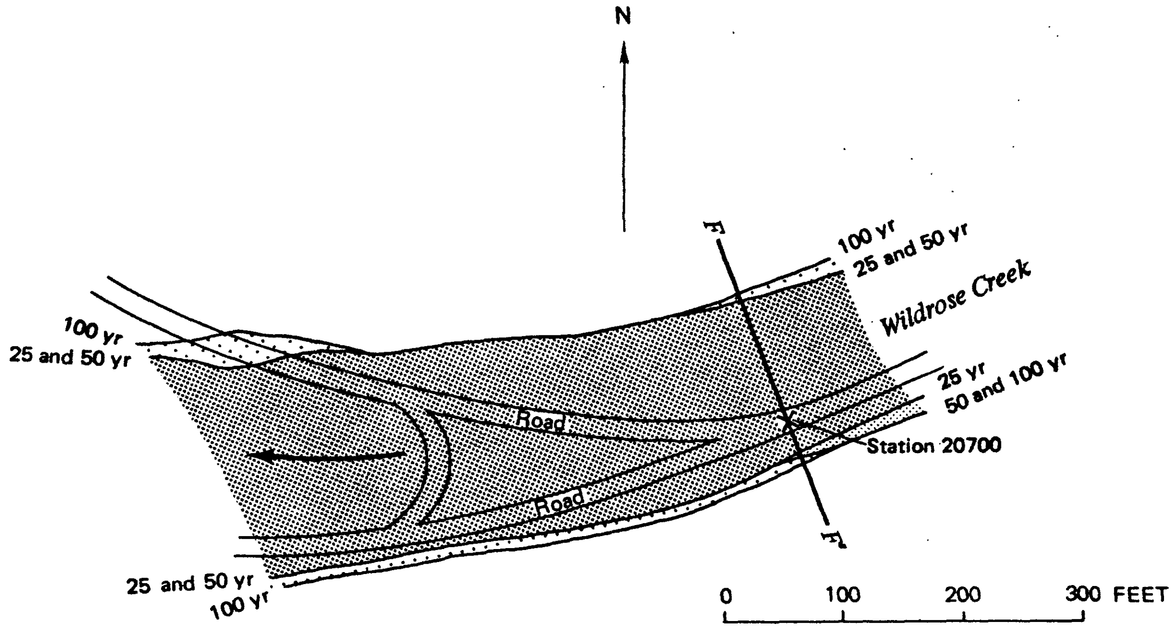

FIGURE 16.--Flood-hazard area in the vicinity of cross section F.

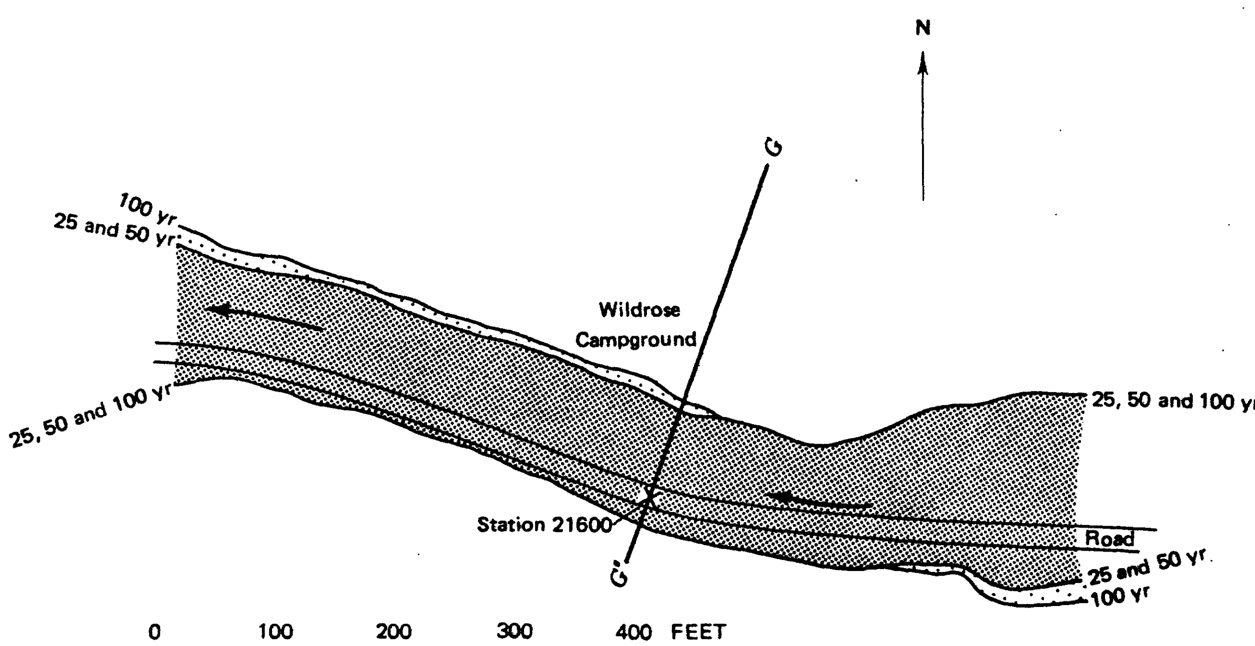

FIGURE 17.--Flood-hazard area in vicinity of cross section G.

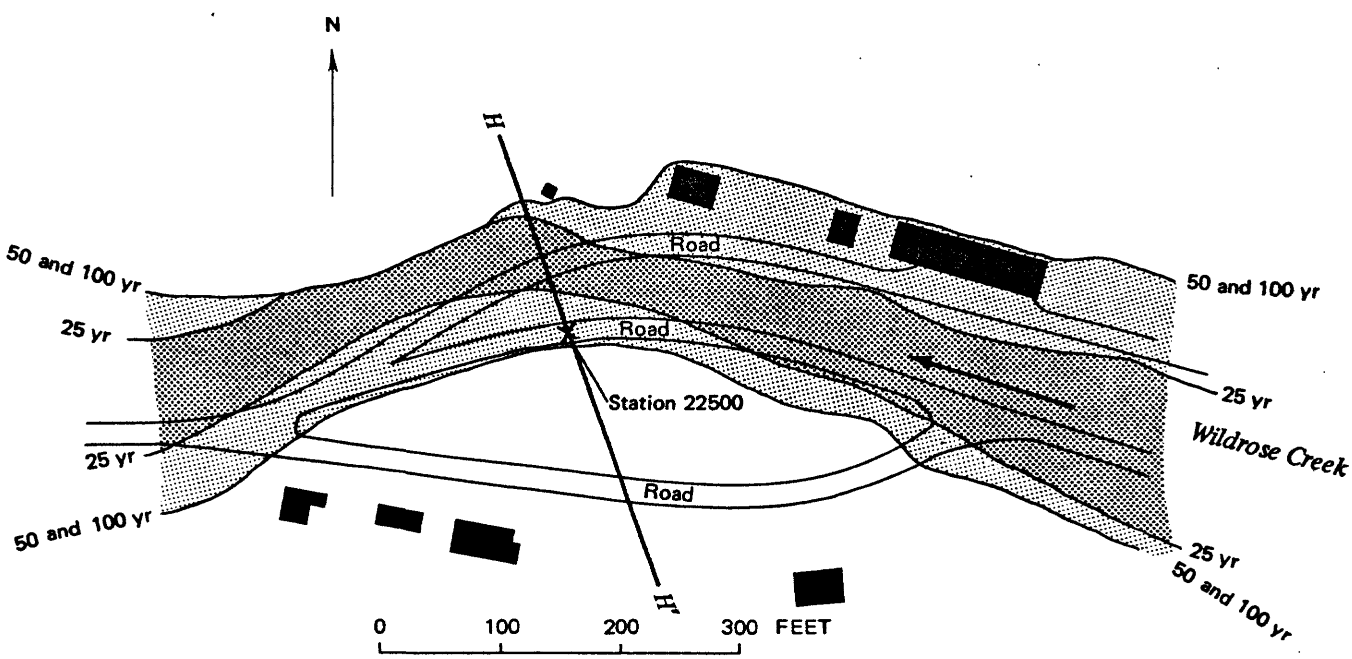

FIGURE 18.--Flood-hazard area in vicinity of cross section H.

HAZARD ASSESSMENT

As must be deduced from the foregoing discussions, at any time of unusual flooding [probabilities of 0.04, 0.02, 0.01, or maximum experience (me)] Wildrose Canyon is likely to be an unsafe area. The computations that have been used to define stages and to outline areas of inundation in figures 12 to 18 are based on hydraulic equations that assume steady-flow conveyance of the discharges at each probability, while channel shape and capacity are assumed to remain constant as they were observed in April 1979. Because of the steepness of Wildrose Canyon, the abundance of poorly consolidated bed material that can be easily eroded, and the likelihood of landslips and downwash of debris from the canyon walls, the computed hazard areas probably do not reflect the full extent of floodtime danger. Floodflow is very likely to occur as a series of waves of water and debris that may swing from one side to the other of the canyon in unpredictable paths. The high velocities of both water and debris may enable even shallow overflows of the highway to exert great force on any obstacle in their path.

Two characteristics of flow that are likely to occur but cannot be assessed in a channel such as Wildrose Canyon are superelevation at the outside of bends, and the occurrence of hydraulic jump, as high-velocity flow meets a temporary or permanent obstacle. Both of these can cause sharp increases in depth of up to several feet at unpredictable times and places.

Because of the possibilities mentioned in the preceding paragraphs, the assignment of relative degrees of hazard to specific sites cannot be done with precision.

The road that follows the steep, narrow reach of Rattlesnake Gulch for about 0.5 mi to its juncture with Wildrose Canyon must be designated as an area of extreme hazard at all levels of flooding that are considered here.

Wildrose Campground and most of the facilities at the Ranger Station are above all the computed flooding levels. However, both are at the foot of high, steep slopes where the downwash of water or debris during intense rainfall could be destructive. Such downwash could occur even though the areal extent of precipitation might be very small and downstream flooding, in the usual sense of the word, might be slight.

The side road that continues eastward from the head of the canyon steepens gradually as it ascends the slopes of the upper basin. It reaches the Charcoal Kilns (about 6.0 mi from point Z), altitude about 6,880 ft, and ends at Mahogany Flat (7.8 mi), altitude 8,133 ft. This road and the short unpaved trails that lead from it do not follow major channels. At many points, however, they are subject to shallow overflow of water and debris in the event of heavy rainfall. The degree of hazard on these roads cannot be evaluated because of the wide range of conditions of exposure and in rainfall intensity.

ADDITIONAL STUDIES

Other areas within Death Valley National Monument that are subject to flash flooding and that are frequented by visitors include:

1. Grapevine Canyon in the vicinity of Scotty's Castle.
2. Emigrant Canyon and Emigrant Wash in the vicinity of the Ranger Station.
3. Boundary Canyon from near Hells Gate to about 2 mi northeast of Daylight Pass (about 8.5 mi).
4. Mosaic Canyon outwash in the vicinity of Stovepipe Wells facilities.
5. Warm Spring Canyon Road between altitudes of 1,200 and 2,600 ft (about 4 mi).
6. Jubilee Pass Road.

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