UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

POTENTIAL FLOOD AND DEBRIS HAZARDS AT COTTONWOOD COVE, LAKE MEAD NATIONAL RECREATION AREA, CLARK COUNTY, NEVADA

By Otto Moosburner

Open-File Report 80-1216

Prepared in cooperation with the

U.S. NATIONAL PARK SERVICE

Carson City, Nevada

1981

CONTENTS

ILLUSTRATIONS

TABLE

CONVERSION FACTORS AND ABBREVIATIONS

Only the "inch-pound" system is used in this report. Abbreviations and conversion factors from inch-pound to International System (SI) units are listed below.

Multiply	By	To obtain
Inches (in.)	25.4	Millimeter (mm)
Feet (ft)	0.3048	Meters (m)
Miles (mi)	1.609	Kilometers (km)
Square miles (mi^2)	2.590	Square kilometers (km^2)
Cubic feet per second (ft^3/s)	28.32	Liters per second (L/s)

ALTITUDE DATUM

The term "National Geodetic Vertical Datum of 1929" (abbreviation, NGVD of 1929) replaces the formerly used term "mean sea level" to describe the datum for altitude measurements. The NGVD of 1929 is derived from a general adjustment of the first-order leveling networks of both the United States and Canada.

POTENTIAL FLOOD AND DEBRIS HAZARDS AT COTTONWOOD COVE,
LAKE MEAD NATIONAL RECREATION AREA, CLARK COUNTY, NEVADA

By Otto Moosburner

ABSTRACT

At Cottonwood Cove, most of the existing dikes at the recreation site are effective in diverting and routing floodflows, up to and including the 100-year flood, away from people and facilities. The dikes across Ranger Residence Wash and Access Road Wash at the mouth divert floods up to the 50-year recurrence interval away from residential areas. Flow and debris damage in protected areas will be relatively minor for floods including the 100-year flood, whereas damage caused by sediment deposition at the mouths of the washes near Lake Mohave could be significant for floods equal to or less than the 100-year flood.

The extreme flood, a flood meteorologically and hydrologically possible but so rare as to preclude a frequency estimate, could cause great damage and possible loss of life. The present dikes would be topped or breached by such flooding.

INTRODUCTION

In 1978 the Water Resources Division of the Western Regional Office, National Park Service (NPS), requested and funded a flood hazard study, by the Geological Survey, of the Cottonwood Cove site in the Lake Mead Recreation Area. This report is the product of that study.

Cottonwood Cove is a developed recreation site on the Nevada side of Lake Mohave (figures 1 and 2). Included at the site are permanent facilities, such as docks, a restaurant, a motel, and trailer berths and hookups for semipermanent residents, operated by a National Park Service-licensed concessionaire. Camping and picnicking facilities are provided for the motor traveler. Road access is from the west by State Highway 68 from Searchlight.

Delineation of flow hazards should demonstrate the extent and severity of hazards to occupied or potentially occupied areas. Such information may provide a basis for making safety-related modifications at the recreation site or, as a minimum, determine the relative flood hazards associated with present operations.

HYDROLOGIC SETTING

The study area is in the Lake Mead National Recreational Area on the west side of Lake Mohave. Significant lake level fluctuations are caused by releases at Davis Dam and inflows past Hoover Dam at Lake Mead. All development at the site is above the maximum controlled elevation at Davis Dam, and therefore all flood hazards at the site are of local origin and result from streamflow.

The climate at the study site is arid. No systematic records of precipitation and temperature have been published, but Willow Beach, about 25 miles north of the site at the same elevation, has a mean annual precipitation of 4 inches and a maximum air temperature of about 120°F.

All streams (washes) in the vicinity of Cottonwood Cove are dry except during or immediately after heavy precipitation. If the streams flow at all in any one year, the warm season from June to October is the most likely time. Convective thunderstorm cells that are isolated and small in area, or are imbedded in large-scale tropical storm systems, may cause short-term flooding.

The magnitudes of flows have not been monitored in any of the washes in or near Cottonwood Cove. Flood damage has not been significant since the site was established in the 1950's. Damages and inconveniences because of washouts have occurred frequently along the road access west of the recreation area.

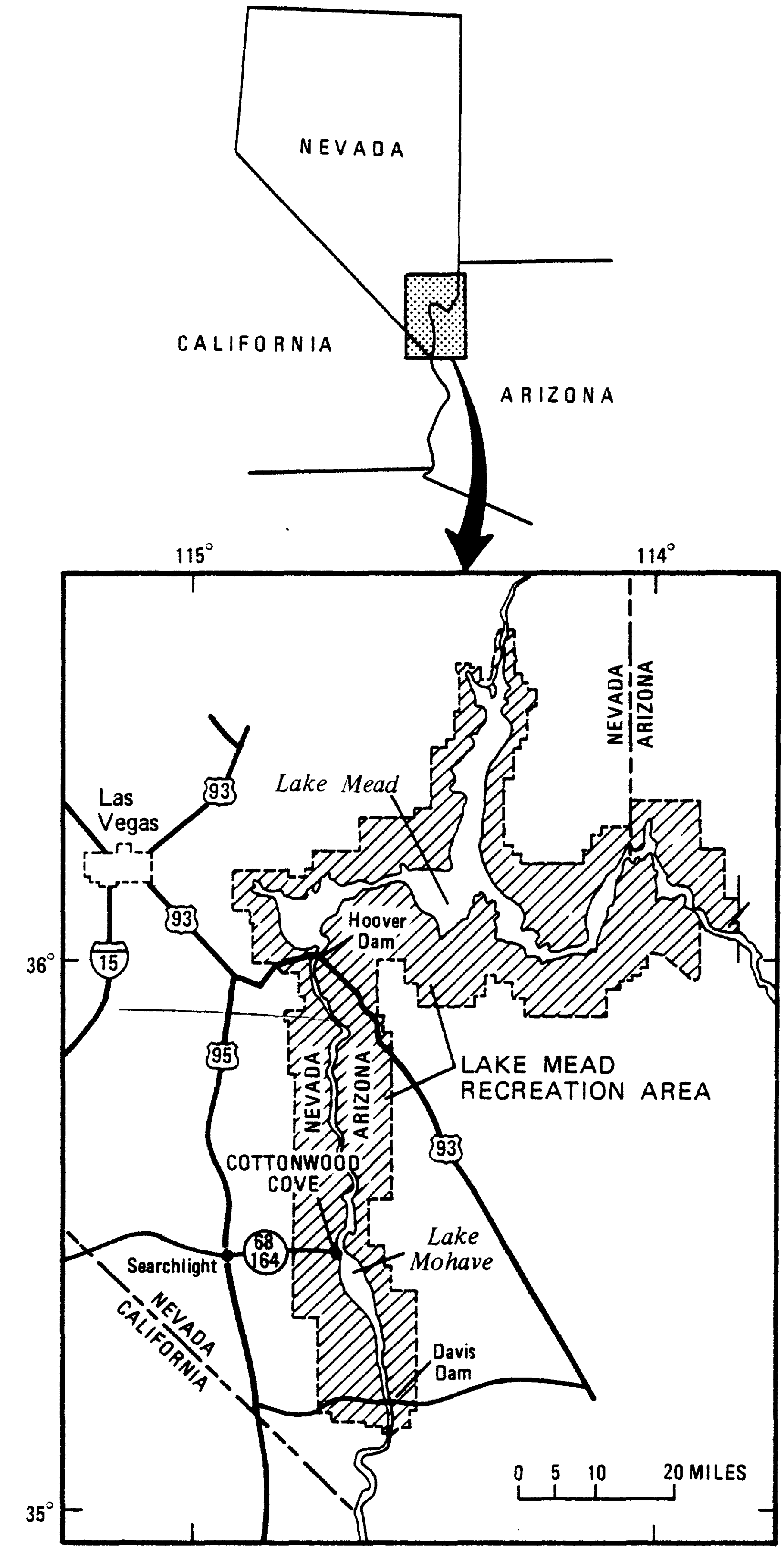

FIGURE 1.—Location of Cottonwood Cove.

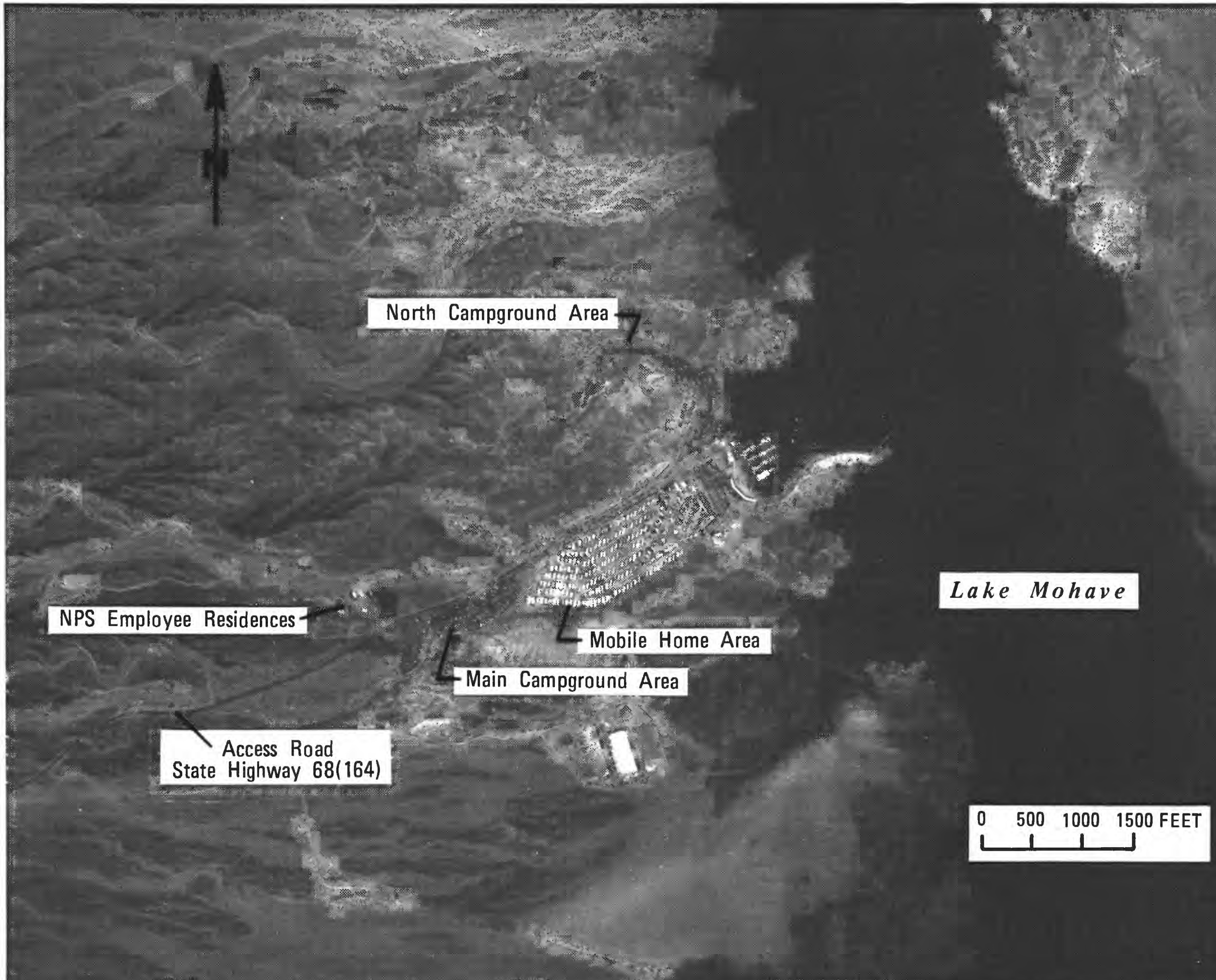

FIGURE 2.—Vertical aerial photograph of Cottonwood Cove, May 28, 1976. Photograph by Cooper Aerial Surveys.

The floodflows that damage the access road bypass the recreation site and enter Lake Mohave south of the site. The fact that the site has not been flooded for a number of years does not mean that hazards are nonexistent.

None of the washes are named on available maps; therefore, for this study, descriptive names have been given to the washes of interest (plate 1 and table 1).

POTENTIAL FLOOD AND DEBRIS HAZARDS

As considered in this study, potential flood and debris hazards are defined by several characteristics of streamflow; flow velocities, flow depths, areal extent of flood inundation, and the amount and character of debris likely to be mobilized by the flows. Generally, the higher the flow velocities and flow depths, the greater are the flow hazards. For example, anyone caught in even 2-foot-deep rapidly flowing water could run the risk of being drowned. If flow velocities and depths become large enough, automobiles and mobile homes will be transported by floodflows and may become upended or destroyed. Similarly, floods that inundate large areas pose greater hazards than floods of more limited areal extent. In addition, debris moving with the water increases the hazard. Among the chief hazards caused by debris loads are the obstruction and modification of floodflows, abrasion and impact by the moving debris, and burial by debris deposition. Drowning is the principal hazard to people. Injury or death by impact or abrasion by high-velocity debris and possible burial by debris are additional hazards. Hazards to property are chiefly those due to impact, abrasion, and burial by rapidly moving water and sediment.

Flood and debris hazards are not separate entities, but they are discussed separately in this report for simplicity and ease of presentation.

Potential Flood Hazards

To appraise the flood potential at a site, the magnitude and frequency of flooding and the stream-channel capacity must be determined. Flow magnitude is expressed as discharge, or flow volume per unit of time. The term "recurrence interval" is used to indicate frequency of flooding and is defined as the average interval of time within which a flood of a given magnitude is exceeded. A flood with a recurrence interval of 50 years is the flood that is exceeded once in 50 years, on the long-term average. The concept implies no regularity in the time of recurrence of a given flood magnitude. Flood frequency may also be expressed in terms of probability. The probability of occurrence of a flood exceeding the 50-year flood in any given year is once in 50, or 0.02. Similarly, the probability of occurrence of a flood exceeding the 100-year flood in any given year is one in 100, or 0.01.

The flood-frequency discharges of the different washes at the study site were estimated (table 1), using the results of regression studies made for streams in desert areas of southeastern California (Waananen and Crippen, 1977). Regression equations relate measurable basin characteristics, such as drainage area, mean annual precipitation, altitude, and slope, to the flood discharges of different recurrence intervals. The results agree reasonably well with regression studies for northwestern Arizona (Roeske, 1978). Discharges have standard errors of estimate ranging from 50 percent less than to 100 percent greater than the values shown. Although this error of estimate is considerable, inundation areas, flow velocities, and flow depths have much smaller errors of estimate because discharge is but one of the factors that enter into their determination.

TABLE 1.--*Peak-discharge estimates*

Stream name	Drainage area (square miles)	Peak discharge, in cubic feet per second, for indicated recurrence interval (years)				
		10	25	50	100	$Q_{extreme}$
North Campground Wash	0.20	64	150	230	340	4,100
Access Road Wash at upper entrance	.34	85	210	340	500	5,700
Ranger Residence Wash	1.61	190	550	970	1,500	15,000
Upper Boat Storage Wash	.06	--	--	--	[c]150	[c]2,000
	[a]1.67	[b]200	[b]570	[b]990	--	--
Access Road Wash at mouth	2.23	230	680	1,200	1,900	18,000
Lower Boat Storage Wash	.04	27	54	78	110	1,500

[a] Effective drainage area including Ranger Residence Wash.
[b] Mostly floodflow from Ranger Residence Wash.
[c] Floodflow from natural drainage of Upper Boat Storage Wash with no contribution from Ranger Residence Wash.

An upper limit of extreme flood severity for the washes was estimated by using a relation based on maximum observed floods throughout the United States (Matthai, 1969, p. B6). The relation is expressed by the following equation:

$$Q_{extreme} = 11{,}000\ A^{0.61}$$

where $Q_{extreme}$ is the flood discharge in cubic feet per second and A is the drainage area in square miles. Larger floods than those estimated by use of this equation are not impossible. On September 14, 1974, washes tributary to Eldorado Canyon, about 15 miles north of Cottonwood Cove, experienced floods that were 44 to 89 percent of the $Q_{extreme}$ (Glancy and Harmsen, 1975).

Channel characteristics that influence the flow-carrying capacities of the different washes were measured as part of the field surveys made in June 1978. The characteristics measured were the cross-sectional area, channel slope, and degree of flow resistance offered by the channel bed and banks. The channel characteristics and the appropriate flood discharges were used to estimate the mean velocity, mean depth, and maximum depth for the various recurrence intervals, as shown in the tables on plate 1.

Bank and channel-bed configurations of the washes have been significantly altered by recreation area development. As of 1978, four dikes have been emplaced to divert floodwater away from developed areas and into Lake Mohave. Their locations and functions are discussed below.

1. The first dike is located on Ranger Residence Wash upstream from the main campground and residence area north of the access road. The dike diverts water from this wash to an adjacent drainage, named Upper Boat Storage Wash. Ranger Residence Wash drains an area of 1.61 square miles. The NPS employee residences are located down-stream from the dike adjacent to the natural channel of the wash.

2. The second dike is a north-south oriented dike located at the extreme west end of the recreational area upstream from any development. The dike diverts the flow from north to south of the access road into Access Road Wash which hugs the south canyon wall past the main campgrounds.

3. The third dike begins upstream from the mobile-home village and veers diagonally in the northeasterly direction across the access road. The dike continues between the road and the north rock wall to the paved area adjacent to the lake. The dike diverts water from the south rock bank to the north rock bank in order to protect the mobile-home area.

4. The fourth dike is emplaced in the area called the North Campground. The dike maintains the flow against the north rock bank in order to maximize the useful campground area.

In the natural state, the channels were not as incised in the alluvium as they are at the present time. For instance, in the main campground and mobile-home area, the hard-rock channel walls served as the lateral limits of flow. At some times in the past, before development, flow at section A (plate 1) may have shifted from the north rock wall to the south rock wall, a distance of about 500 feet. Farther downstream at section B, the channel may have shifted a maximum of about 800 feet. In a similar manner, the flow channel in the north campground area may have shifted laterally about 200 feet. The lateral boundaries of the relatively obscure low-flow channels moved within the confines of the canyon rock walls in response to such factors as discharge magnitude and debris load.

Presently, with diking, flow velocities and depths will be larger than predevelopment velocities and depths for the same discharge magnitude. Inundated areas after diking obviously will be less than before diking for corresponding flows. The severity of potential flood and debris hazards in the washes is mostly dependent on the elevation of facilities and roadways. Another major consideration is the possibility of scour and fill during extreme floods. Such changes may drastically change the flow-carrying capacities of the channels and therefore change flow elevations and velocities from those of stable channel-flow conditions.

Potential Debris Hazards

Intense floods in arid areas commonly mobilize and transport large amounts of debris. The debris, by weight, is mainly composed of rock and inorganic mineral matter. Man-related debris, although generally a minor-weight component of total debris load, also commonly composes an important part of the flood-debris loads of developed basins. The organic and man-related components of the total debris load can have pronounced effects on the nature of flooding, because they are generally more buoyant than the inorganic load. This buoyancy promotes congestive jamming and obstructions and thereby hinders the efficient transport of the floodflows.

Rock debris also tends to obstruct and modify the floodflows during transit, particularly when large quantities of the debris are bulked into the leading edge of the initial flood wave. Debris at the leading edge of the flow acts as a moving dam that influences depths of floodwater behind the front, and the great momentum and abrasive character of the debris movement poses a serious hazard to anything in its path. This moving-dam effect is also capable of diverting the flood path of the trailing water if the flood channel is poorly incised and the surrounding terrain has a low topographic relief, as is common on many alluvial fans.

Potential debris hazards are related to the quantity and character of debris available for mobilization by the floodflows. Damage can be caused by erosion of valuable land areas, debris deposition, abrasion and impact forces of moving debris, and diversion and modification of floodflows as described above.

Inorganic debris is available in large quantities to be mobilized by floodflows in the major drainage of the Cottonwood Cove area. All washes in the study site contain abundant quantities of sand, gravel, and cobbles that will be mobilized during moderate to intense flooding. The potential hazard for severe impact damage by large-size debris is negligible.

The dominantly fine-grained composition of the debris in the channels suggests that most debris-related flood damage will consist of erosion, abrasion, and burial.

DISCUSSION OF STUDY RESULTS

On the basis of present channel configurations, flood elevations, areas inundated, velocities, and depths were computed for the main recreation area adjacent to the access road and the area adjacent to North Campground Wash (plate 1). Critical depth and velocity were used for all estimated peak discharges. Maximum velocities may be up to 50 percent higher than the mean velocities shown on plate 1. Maximum depth is the difference in elevation between the water surface and the lowest ground elevation at the section in question. Pileup due to obstruction and channel curvature (outside curve of bends) may increase inundation areas and the flow depths. The increase of flow depths may be less than 1 foot at velocities of 5 feet per second to almost 2 feet at velocities of 10 feet per second (plate 1). In addition, because the discharges for the different recurrence-interval floods have standard errors of estimate of 50 to 100 percent, the flow elevations have estimation errors of plus or minus about 1 foot for the 100-year floods. Flow depths may consequently be overestimated or underestimated.

Conclusions as to potential hazards may be summarized as follows:

1. In the main campground and resident area adjacent to the access road, the dike across Ranger Residence Wash will be overtopped by a 100-year flood or greater. Smaller floods will be diverted to Upper Boat Storage Wash. If the dike is topped or breached, the employee residence area may be in a hazardous location, depending on where the dike is breached or topped. Farther downstream, larger floods may endanger the campground area and the mobile-home area. If the dike was made to divert 100-year and larger floods, all flow from Ranger Residence Wash would enter the recreation area through the channel of Upper Boat Storage Wash, and the campgrounds and the NPS residences would be completely out of danger. The mobile-home area may still be in danger, depending on the magnitude of the flow.

The north-south dike at the west end of the recreation area can divert floods, including the 100-year flood, to the south of the access road (Access Road Wash). This flow is diked against the south canyon wall opposite the campground area. This dike and the one between the campground area and the mobile-home area is presently effective for floods up to and including the 100-year flood on Access Road Wash and Ranger Residence Wash, regardless of whether Ranger Residence Wash pursues its ancestral channel (plate 1, section A). Farther downstream, the dike forcing water against the north canyon wall will generally be effective in controlling floods up to and including a 100-year flood (plate 1, section B, C). Some locations between sections B and C may only control the 50-year flood; bank sloughing and local fill have reduced channel capacity.

For the floods calculated as the extreme condition, the dikes in the main recreation area will be topped and probably breached (plate 1). The NPS residence area, mobile-home village, store, cafe, and motel will be in the most hazardous areas in the event of flooding resulting from $Q_{extreme}$.

2. All floods up to and including the 100-year flood of the North Campground Wash will be retained between the dike and the north canyon wall. Extreme flooding will inundate the campground adjacent to the wash (plate 1).

3. For floods up to and including that of a 100-year recurrence interval, damage linked to debris in the campground, residence, and mobile home village areas will be minor, because flow will be channeled away from those areas. The minor damage will consist of erosion and deposition by rivulet and sheetflow resulting from intense rains. However, for almost all flows, debris deposition and secondary abrasion will be significant between the mouths of the diked washes and Lake Mohave. Automobiles and boat trailers in these debris-prone areas may be severely damaged (plate 1). Debris and sediment cleanup costs could be significant.

Debris damage and hazard from floods greater than 100-year floods and up to $Q_{extreme}$ would be major because the dikes will be breached or topped, allowing heavily sediment-laden water to enter all developed areas.

In summary, continued dike maintenance, including strengthening and raising the level of the dike diverting Ranger Residence Wash and Access Road Wash adjacent to the mobile-home area, will make negligible the hazard to life and potential for major damage to facilities from the 100-year flood.

For $Q_{extreme}$, strengthening and significantly raising all dike elevations will lessen the likelihood of casualties and property damage.

Repair of erosion damage and removal of sediment will be ongoing concerns as floods of different magnitudes occur.

REFERENCES CITED

Glancy, P. A., and Harmsen, Lynn, 1975, A hydrologic assessment of the September 14, 1974, flood in Eldorado Canyon, Nevada: U.S. Geological Survey Professional Paper 430, 28 p.

Matthai, H. F., 1969, Floods of June 1965 in South Platte River Basin, Colorado: U.S. Geological Survey Water-Supply Paper 1850-B, 64 p.

Roeske, R. H., 1978, Methods for estimating the magnitude and frequency of floods in Arizona: Arizona Department of Transportation Final Report ADOT-RS-15 (121), 82 p.

Waananen, A. O., and Crippen, J. R., 1977, Magnitude and frequency of floods in California: U.S. Geological Survey Water-Resources Investigations 77-21, 96 p.