CLARK COUNTY FLOOD CONTROL DIVISION
DEPARTMENT OF PUBLIC WORKS

[Reports-Open file series]

A BRIEF HYDROLOGIC APPRAISAL OF THE JULY 3-4, 1975, FLASH FLOOD IN LAS VEGAS VALLEY, NEVADA

By

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and
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Prepared cooperatively by the
U.S. Geological Survey
Carson City, Nevada

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CONVERSION FACTORS

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

English unit	Metric unit	Multiplication factor to convert from English to metric quantity
Acres	Square metres (m^2)	4,047
Acre-feet (acre-ft)	Cubic metres (m^3)	1,233
Cubic feet per second (ft^3/s)	Litres per second (l/s)	28.32
Do.	Cubic metres per second (m^3/s)	.02832
Cubic feet per second per square mile [$(ft^3/s)/mi^2$]	Cubic metres per second per square kilometres [$(m^3/s)/km^2$]	.01094
Feet (ft)	Metres (m)	.3048
Inches (in)	Millimetres (mm)	25.40
Miles (mi)	Kilometres (km)	1.609
Square miles (mi^2)	Square kilometres (km^2)	2.590
Knots	Kilometres per hour (km/h)	1.8532
Feet per second (ft/s)	Metres per second (m/s)	.3048
Gallons	Litres (l)	3.785
Gallons per minute (gal/min)	Litres per second (l/s)	.06309

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ABSTRACT

Heavy thunderstorm precipitation on the afternoon of July 3, 1975, between metropolitan Las Vegas and the mountains to the south, west, and north, caused flash flooding in the city area. Total storm precipitation equaled or exceeded 3 inches (76 mm) in some areas. The total storm yield on the area of significant runoff was probably between 20,000 and 25,000 acre-feet ($2.5 \times 10^7 m^3$ and $3.1 \times 10^7 m^3$) of water. Of this amount, probably less than 3,000 acre-feet ($3.7 \times 10^6 m^3$) flowed directly to Lake Mead.

Peak flows of Tropicana Wash, Flamingo Wash, Las Vegas Creek, and Las Vegas Wash were the highest ever determined.

Flooding caused the loss of two lives and inflicted extensive property damage. Total damage was reportedly estimated by the Clark County Flood Control District at $4-5 million.

Problems associated with sediment erosion, transportation, and deposition occurred throughout the flooded area. An unknown amount of the material transported during the flood was deposited in Lake Mead near the mouth of Las Vegas Wash. Lateral erosion appeared more prominent than vertical erosion along most major channels, except on Las Vegas Wash at Northshore Road where downcutting threatened the loss of the highway. Sediment deposits were particularly noticeable and troublesome in Flamingo Wash at Caesars Palace parking lot and on the Winterwood Golf Course near the junction of Flamingo Wash and Las Vegas Wash.

INTRODUCTION

Purpose and Scope of the Study

The Las Vegas flood of July 3-4, 1975, was important from both hydrologic and economic standpoints. The U.S. Geological Survey, which traditionally investigates major floods, made a reconnaissance hydrologic appraisal of the flooding.

The objectives of this brief study were to: (1) define the area of significant runoff, (2) characterize the flood and determine peak flows of several key tributaries, (3) qualitatively evaluate fluvial sediment movement, erosion, and deposition, and (4) briefly note flood damage. A flood-frequency analysis is beyond the scope of this reconnaissance investigation.

Physiography

Las Vegas Valley is a north-south trending, roughly rectangular trough bounded primarily by north-south trending mountain ranges. The area covered by this report is shown on the index map (fig. 1).

The Las Vegas Valley basin includes drainage areas in the mountains, on the alluvial fans, and on the valley floor. Precipitation and runoff of the July 3 storm were almost totally confined to the alluvial areas and thus involved only the lower parts of the basin drainage.

Las Vegas Wash is the terminal valley stream. It begins in the Las Vegas Range and Sheep Range (not shown on pl. 1) north of Las Vegas Valley. The wash flows southeastward through North Las Vegas and is joined by its main eastward-draining tributaries, Las Vegas Creek, Flamingo Wash, and Tropicana Wash. Duck Creek drains the southwestern part of the valley. Las Vegas Wash terminates in Lake Mead on the Colorado River.

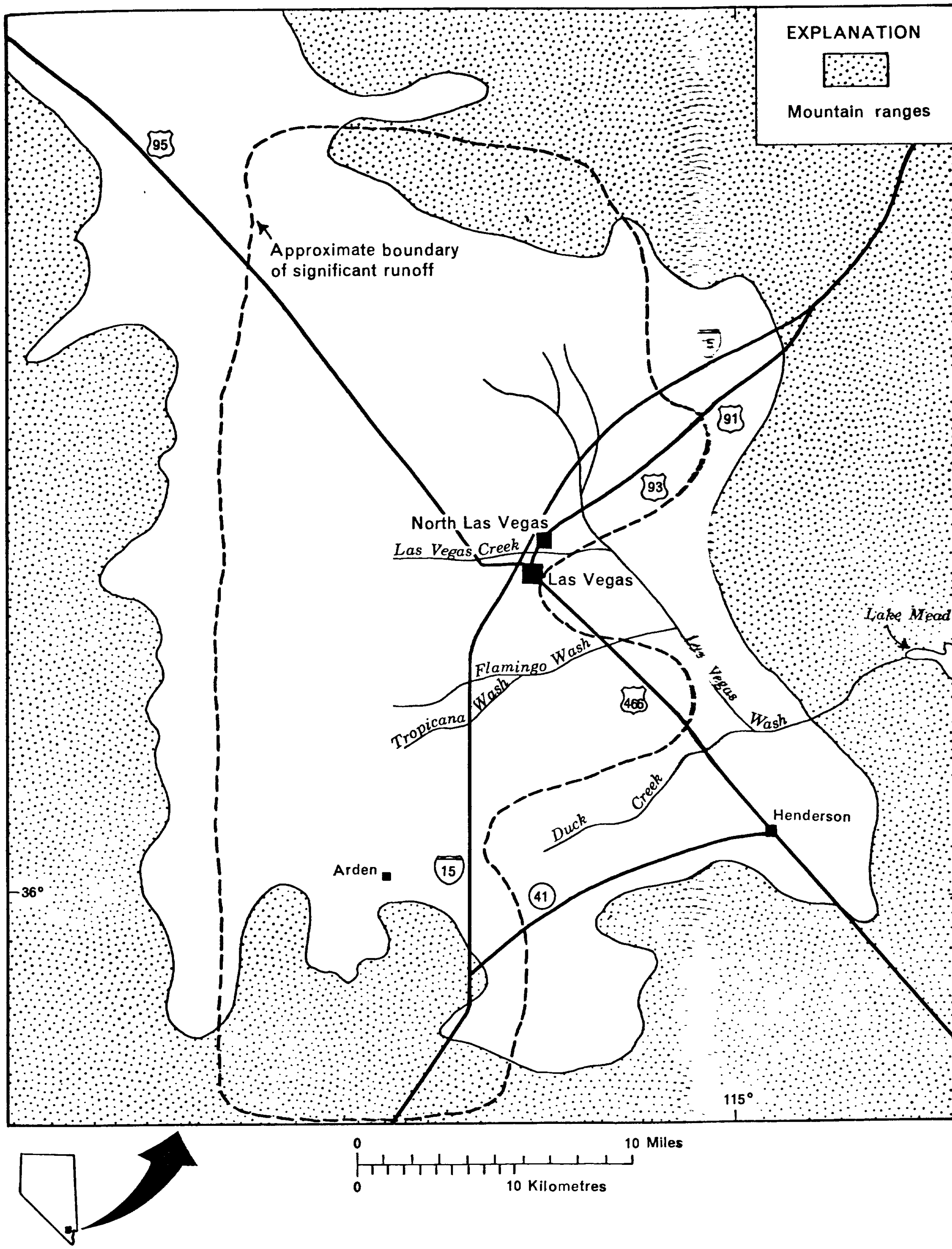

Figure 1.--Location of study area and general features.

Historical Floods in the Valley

Flash flooding is common in Las Vegas Valley. Floods of various magnitudes have occurred many times in the past, as shown in table 1. The tabulation may not be all-inclusive, but it gives a general impression of flooding frequency in the area.

Table 1.--Historical floods in Las Vegas-North Las Vegas area 1/

Date			Relative magnitude	Date			Relative magnitude
July	23,	1923	Large	Mar.		1952	Small
Aug.		1931	Large	June	13,	1955	Large
July	10,	1932	Medium	July	24,	1955	Medium
Sept.		1939	Small	Aug.	20,	1957	Medium
Feb.		1940	Small	Nov.		1958	Small
Aug.		1941	Small	Sept.	16,	1961	Medium
Aug.	9,	1942	Small	Sept.	4,	1963	Medium
Oct.		1947	Medium	Sept.	12,	1969	Small
July		1949	Medium	July	14,	1971	Small
Sept.		1951	Medium	July	3,	1975	Large

1. Data prior to 1960 from U.S. Army Corps of Engineers (1959). Subsequent information from Darryl Randerson (written commun., 1975) and U.S. Geol. Survey files.

The relative-magnitude ranking of these floods is based primarily on damage estimates which do not have a common economic base. Additionally, comparison between floods is difficult considering (1) lack of flow data, (2) the amount and character of man's cultural development between events, and (3) recent changes to the natural drainage system caused by freeway construction and other channel modifications.

Table 1 indicates that flooding occurs frequently in Las Vegas Valley; however, very few items of hydrologic data are available for most of the floods (table 2). During the approximately 70-year period that Las Vegas has been continuously occupied as an organized community or city, streamflow data have been gathered systematically for less than 20 years. In fact, the vast bulk of quantitative streamflow and flood data have been collected only during the last decade. Successful planning to reduce flood losses and assure maximum security against flooding depends on, among other things, knowledge of the flood hydrology and flood potential of an area. Thirteen of the 20 floods listed in table 1 occurred prior to the onset of any continuous collection of streamflow data. As a result of this short period of data accumulation, long-term predictions of flooding potential are difficult to make and are at best uncertain. The main objective of this study is to increase the quantitative hydrologic data base on Las Vegas flooding.

Types and Sources of Data Collected in July 1975

Hydrologic data in this report include those collected by the U.S. Geological Survey and also data from other sources. Geological Survey data include all streamflow measurements and flow estimates, many of the "bucket survey" (see below) precipitation data (data obtained by measuring any available open, unsheltered containers that contained evidence of total rainfall amounts), field inspection data delineating the southern, western, and northern boundaries of the area of effective storm runoff (the eastern boundary was estimated mainly on the basis of precipitation-gage data), field observations of sediment transport, qualitative data on flood damage, and land-surface and oblique aerial photographs. Vertical aerial photographs were taken by the Nevada Highway Department in cooperation with the U.S. Geological Survey.

Data from other sources include measured precipitation data from the Las Vegas rain-gage network established in the valley by Dr. Darryl Randerson of the National Oceanic and Atmoshperic Admistration. Other relevant information includes the storm analysis of Dr. Randerson, eye-witness accounts and descriptions of the storm character and duration, monetary estimates of damage, and flood photographs from Las Vegas newspaper files.

Streamflow data include both direct and indirect measurements of stream stage and discharge. The direct measurements include the continuous records of streamflow obtained at U.S. Geological Survey gaging stations, and a direct streamflow measurement of Las Vegas Wash during the flood at the gaging station near Henderson. Indirect streamflow data were obtained after the flood had subsided. They include peak-flow measurements using slope-area and culvert computations and peak-flow estimates using the slope-conveyance method.

The most reliable "bucket survey" data were those collected soon after the storm, because desert evaporation quickly reduced the amount of trapped water. Some very good data were obtained several days after the storm, however, because the walls of some containers had distinct water lines which indicated the maximum depth of precipitation. Other, later and less reliable "bucket survey" data, at least, indicated the minimum precipitation quantities. The rain-gage precipitation data will be discussed in reports now being prepared by D. Randerson and the National Weather Service.

THE STORM

The thunderstorm that caused flooding in Las Vegas Valley on July 3-4, 1975, produced large quantities of rainfall during a relatively short time and caused runoff from about 350 square miles (910 km^2). A detailed meteorological report of the storm is being prepared by Dr. Darryl Randerson of the Air resources Laboratory, National Oceanic and Atmospheric Administration, Las Vegas (oral and written communs., 1975). The National Weather Service also plans to prepare a meteorological summary of the storm and flood (Dr. Gerald Williams, National Weather Service, Salt Lake City, Utah, oral commun., 1975). The following data and conclusions summarized in this brief description of the storm were largely excerpted and condensed with the author's permission from a preliminary report draft prepared by Dr. Randerson.

The period of intensive rainfall occurred generally between 1200 and 1800 hours, Pacific Daylight Time, July 3. The heaviest cumulative rainfall was about 1 inch per hour. The rainfall was accompanied by strong surface wind gusts (about 50 knots, or 93 km per hour) and some hail about half an inch (13 mm) in diameter. D. Randerson (written commun., 1975) estimates a total storm-water yield of about 19,000 acre-feet (2.4 x $10^7 m^3$) on the area that received more than half an inch of precipitation (about 210 mi^2, or about 550 km^2). As stated above, the storm area which yielded effective runoff contributing to flooding was estimated by the authors as about 350 square miles (910 km^2) on the basis of field evidence. Runoff is assumed to have generally occurred from the areas that received more than 0.1 inch of precipitation. Therefore, the storm-water yield was slightly modified in this report to an estimated 20,000-25,000 acre-feet (2.5 x $10^7 m^3$-3.1 x $10^7 m^3$), and includes runoff from a 350-mi^2 (910 km^2) area. The contributing area is only about 20 percent of the total drainage area tributary to Las Vegas Wash (about 1,600 mi^2, or 4,100 km^2). Heaviest known rainfall seemed to occur in two separate areas, one southwest of the central city business district and the other to the north. Figure 2 is a isohyetal map showing the general distribution of cumulative rainfall.

The storm area that produced flood runoff involved mainly alluvial-fan areas south, west, and north of the city, as indicated by (1) precipitation data of the National Weather Service, (2) Randerson's local rain-gage network, (3) bucket-survey data of Randerson and the U.S. Geological Survey, (4) radar imagery, and (5) field observations that delineated those areas which yielded detectable storm runoff. Some rainfall occurred in adjacent mountainous areas, but field evidence indicates that it did not contribute to flooding in the valley.

Randerson (written commun., 1975) analyzed available surface and upper-air meteorological data. Results of his analyses suggest that

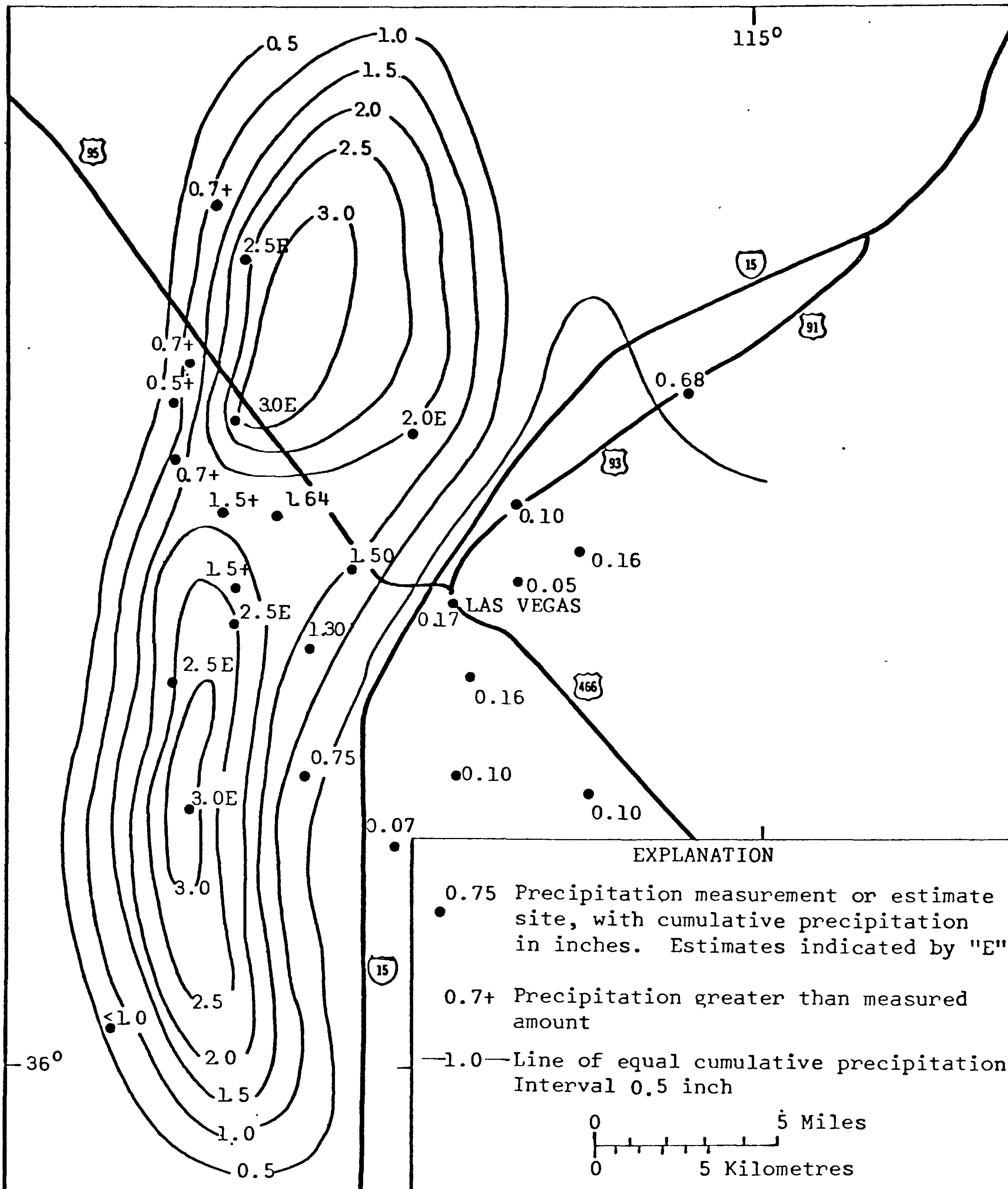

Figure 2.--Cumulative rainfall during storm of July 3, 1975. Map frcm Darryl Randerson (National Oceanic Atmospheric Administration, written commun., 1975).

moisture available for thunderstorm activity in southern Nevada on July 3 had two basic sources. The primary source was a surface surge of moist tropical air from the Gulf of California, while the secondary source was additional moisture aloft from the Gulf of Mexico.

The storm area covered parts of all the major tributaries to Las Vegas Wash. It did not involve the complete drainage area of any major tributary. Several eyewitnesses described precipitation as beginning first in the southwest and then progressing northward. The storm did not appear to move either upstream or downstream along any of the individual tributaries; therefore, the direction of storm movement does not appear to have noticeably increased or decreased peak flows in the individual tributaries to Las Vegas Wash. This is in sharp contrast to the situation at Eldorado Canyon, south of Las Vegas, on September 14, 1974, where the storm moved in a generally downstream direction and apparently had a major effect on the nature of stream flooding (Glancy and Harmsen, 1975, p. 8).

The Las Vegas storm was probably typical of many summer thunderstorms that commonly cause severe flooding each year throughout the desert areas of the southwestern United States. As in the case of the Eldorado Canyon flood, however, the July 3 storm was noteworthy because it occurred in a populated area. Many severe desert floods occur in areas that are unpopulated.

Summer thunderstorm flooding in Las Vegas is not unusual (table 1). On the cover of this report is an aerial photograph of another localized thunderstorm at Las Vegas during the late afternoon of July 4, 1975, the day after the flood storm. Many thunderstorms, however, cause little or no serious flooding. This smaller and milder storm was occurring at the time the Nevada Highway Department and the U.S. Geological Survey personnel were photographing damage caused by the much larger storm of the previous day.

FLOOD CHARACTERISTICS

Source Area

The alluvial fan system southwest, west, and north of metropolitan Las Vegas received the greatest amount of precipitation and therefore contributed most of the runoff. The complex drainage patterns superimposed on the alluvial surfaces, shown in figure 3, indicate that this type of storm runoff has occurred many times in the past. Much of the alluvial surface area was inundated by shallow sheet flow. The vegetation on the alluvium is sparse to moderate, consisting of desert shrubs and grasses, and is not very effective in retarding flows and promoting infiltration. Thus, as sheet flow moves downslope it tends to become channelized. As flow capacities of major channels are sometimes exceeded, areally widespread flooding occurs during particularly large runoff events, as shown in figure 4.

Peak Flows

Hydrologically, the July 3, 1975, flood may have been the greatest flood in Las Vegas history. Peak flows in most major drainages exceeded any previously measured or estimated. However, quantitative records are completely lacking on some earlier floods; thus, the 1975 flood flows may have been exceeded in the past, at least at some sites along some tributaries.

Peak flows for the various measurement sites are shown on plate 1 and listed in table 2. Flood hydrographs of the four recording streamflow stations are shown in figure 5. Parts of these hydrographs have been estimated. Flood peaks generally diminish in a downstream direction in the absence of additional tributary inflow. This reduction in peak flow is at least in part the result of some of the flow being temporarily stored or retarded on the flood plain because of localized flooding. Some of this localized flooding is frequently caused by flood debris clogging bridge and culvert openings, thereby reducing channel capacities and forcing some flow out of the main channels.

The statistics of peak flow rates per unit area of contributing drainage area as listed in table 2 are not particularly great when compared to other flash floods in Nevada; in other floods, peaks as high as 7,000-8,000 $(ft^3/s)/mi^2$ [77-87 $(m^3/s)/km^2$] from small drainages have been determined by U.S. Geological Survey investigations (data in files of Geological Survey, Carson City, Nev.).

Las Vegas Creek probably peaked sometime about 4 p.m., P.D.T., and was the first known tributary to peak on July 3, followed by Flamingo and Tropicana Washes. The first flows reached the Flamingo Wash gaging station at Maryland

Figure 3. Well-developed fan drainage tributary to Tropicana Wash about 2.6 miles (4.2 km) west of Interstate Highway 15 and 1.1 miles (1.8 km) south of Tropicana Avenue. Photograph taken July 4, 1975. All Photograph sites are shown on Plate 1.

Figure 4. Las Vegas Wash flood plain at the junction of Las Vegas Wash and Las Vegas Blvd. Outline indicates approximate limits of major inundation. Photograph taken July 4, 1975.

Table 2.--Summary of flood data 1/

Station number: M, miscellaneous site. Type of measurement: S, slope conveyance; SA, slope area;
Drainage area: ND, not determined. R, rating curve extension; C, culvert.

Station number	Stream, USGS station name, and hydrologic site number listed in downstream order as shown on plate 1	Measurement site: Section, township, range	Drainage area 2/ (mi^2)/(km^2): Total	Drainage area 2/: Contributing	MAXIMUM DISCHARGE, July 3-4, 1975: Date	Approximate time (hour)	Gage height (ft)/(m)	Discharge rounded (ft^3/s)/(m^3/s)	Type of measurement	Discharge per unit contributing area $[(ft^3/s)/mi^2]$/$[(m^3/s)/km^2]$	Previously recorded: Date	Gage height (ft)/(m)	Discharge (ft^3/s)/(m^3/s)	Period of record
09419647	Las Vegas Wash tributary near North Las Vegas, 1	NW¼NE¼ Sec. 15, T. 19 S., R. 61 E.	62/161	32/83	7-3-75	--	--	5,100/144	SA	159/1.74	9-18-72	6.04/1.841	927/26.3	11-21-63 to present
09419650	Las Vegas Wash at North Las Vegas, 2	SW¼NE¼ Sec. 13, T. 20 S., R. 61 E.	ND	ND	7-3-75	9:00 pm	9.64/2.938	12,000/340	SA	--	5-31-73	4.05/1.234	1,640/46.4	6-4-62 to present
M	Las Vegas Creek above F Street at Las Vegas, 3	SE¼SE¼ Sec. 28, T. 20 S., R. 61 E.	ND	ND	7-3-75	--	--	1,000/28.3	S	--	--	--	--	--
M	Las Vegas Wash at Winterwood Golf Course near Las Vegas, 4	SE¼NW¼ Sec. 4, T. 21 S., R. 62 E.	ND	ND	7-3-75	7:00 pm	--	4,400/125	SA	--	--	--	--	--
09419675	Flamingo Wash at Las Vegas, 5	SW¼ Sec. 17, T. 21 S., R. 61 E.	86/223	12/31	7-3-75	--	7.23/2.204	3,900/110	SA	325/3.56	1-25-69	5.29/1.612	1,630/46.2	5-20-67 to present
M	Tropicana Wash above I-15 near Las Vegas, 6	NE¼NW¼ Sec. 29, T. 21 S., R. 61 E.	ND	12/31	7-3-75	--	--	1,700/48.1	C	142/1.55	--	--	--	--
09419677	Flamingo Wash at Maryland Parkway at Las Vegas, 7	SE¼SE¼ Sec. 15, T. 21 S., R. 61 E.	106/275	ND	7-3-75	6:30 pm	11.32/3.450	2,700/76.5	R	--	9-12-69	7.55/2.301	1,500/42.5	9-12-69 to present
09419678	Flamingo Wash near mouth at Las Vegas, 8	NW¼NW¼ Sec. 7, T. 21 S., R. 62 E.	117/303	ND	7-3-75	--	14.6/4.450	2,900/82.1	SA	--	9-12-69	8.75/2.667	1,240/35.1	9-12-69 to present
M	Duck Creek near Whitney, 9	NW¼NW¼ Sec. 12, T. 22 S., R. 61 E.	ND	ND	7--3-75	--	--	300/8.50	S	--	--	--	--	--
09419690	Duck Creek at Whitney, 10	NW¼NE¼ Sec. 34, T. 21 S., R. 62 E.	239/619	ND	7-3-75	--	2.45/0.747	80/2.27	S		8-30-61	6.75/2.057	3,570/101	11-29-61 to present
09419700	Las Vegas Wash near Henderson, 11	SE¼SW¼ Sec. 30, T. 21 S., R. 63 E.	2,125/5,504	350/906	7-4-75	4:00 am	10.67/3.252	6,500/184	R	19/0.21	8-21-57	4.70/1.433	1,400/39.6	2-11-57 to present
09419800	Las Vegas Wash near Boulder City, 12	NE¼SE¼ Sec. 14, T. 21 S., R. 63 E.	2,193/5,680	350/906	7-4-75	1:00 pm	12.32/3.755	2,400/68.0	R	7/0.08	8-14-72	5.65/1.722	435/13.7	8-6-69 to present

1. Includes only data collected by U.S. Geological Survey. Other data are listed by U.S. Army Corps of Engineers (1959). Additional Las Vegas quantitative flood data may exist but are unknown to authors.

2. Total drainage areas were not determined for miscellaneous measurement sites. Contributing drainage areas were determined where the natural drainage was not modified by man and are valid only for this flood.

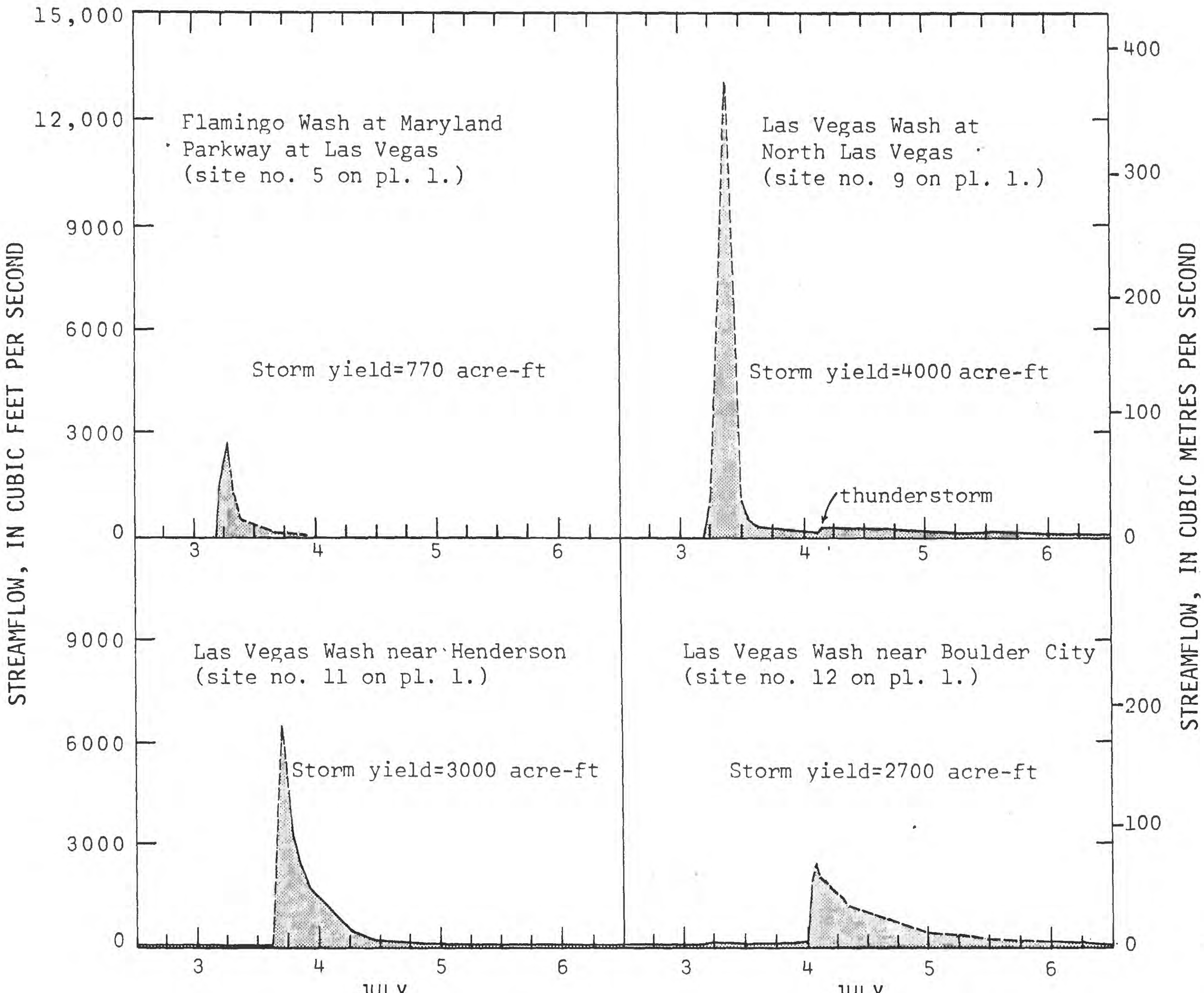

Figure 5.--Hydrographs at continuous-record streamflow gaging stations during July 3-6, 1975. [illegible]

Parkway at 5:00 p.m., about 5 hours after the storm started, with the peak occurring at 6:30 p.m. and lasting just a few minutes. By 7:30 p.m., the flood crest had dropped about 3 feet (.9 m) and was decreasing rapidly. This was the only gaging station that operated throughout the peak-flow period; however, the gage became inoperative later during the flow recession. No known data fix the time of peak flow on Duck Creek.

Flow first reached the Las Vegas Wash gaging station near North Las Vegas at 5:00 p.m. This was about an hour after Las Vegas Creek began flooding downtown Las Vegas. According to Nevada Highway Maintenance personnel, Las Vegas Wash flooding in North Las Vegas started about 5:30 p.m., and lasted for approximately 2½ hours. The gaging station at Las Vegas Wash near Henderson recorded the arrival of flood waters at about 3 a.m., on July 4, and peak flow occurred there about 2 hours later. The next downstream gaging station, Las Vegas Wash below Henderson, was completely washed out and destroyed by channel bank erosion, probably during mid-morning of July 4.

The first flood flows reached the Las Vegas Wash gage at the Northshore Road highway near Boulder City at about 11 a.m. on July 4, approximately 18 hours after most major tributaries began flowing in the Las Vegas-North Las Vegas area. According to employees of the U.S. National Park Service, peak flow at the lower Las Vegas Wash gage occurred between about 1 and 2 p.m.

Flow Velocities

Mean velocities of peak flows at the indirect-measurement sites are calculated to have ranged from about 2 ft/s (0.6 m/s) on Tropicana Wash near Interstate Highway 15 to as high as 15 ft/s (5 m/s) on Las Vegas Wash near North Las Vegas. Maximum point velocities within the cross sections at these sites are unknown, but they are inherently somewhat greater than the average velocity.

One current-meter flow measurement was made during the flood in a channel reach characterized by heavy saltcedar growth at the Las Vegas Wash near Henderson gaging station. The measured stream discharge was 3,500 ft^3/s (99.1 m^3/s). Velocities ranging up to 3.4 ft/s (1.1 m/s) in individual vertical sections were noted, and the mean velocity for the entire cross section was 1.38 ft/s (0.42 m/s). This measurement was made about 3 hours after the peak had passed.

The approximate 4-hour time lag between the start of sheet flow on the alluvial fans (about noon) and the beginning of flooding in the metropolitan area (about 6½ mi maximum distance, or 10½ km) gives a general suggestion of the average integrated flow velocities from points throughout the drainage. The time of travel of the storm runoff, however, is the product of a complex mixture of many factors and is primarily affected by storm and land surface characteristics.

Storm and Runoff Volume

Total storm yield within the effective runoff area is estimated at 20,000 to 25,000 acre-feet ($2.5 \times 10^7 m^3$ to $3.1 \times 10^7 m^3$) (p. 7). The volume of water recorded as passing the Las Vegas Wash gaging station near Henderson was about 3,000 acre-feet ($3.7 \times 10^6 m^3$), or only about 15 percent of the estimated storm yield. The amount passing the gage near Boulder City was also about 3,000 acre-feet ($3.7 \times 10^6 m^3$) (fig. 5). Of the remaining amount (about 85 percent), an unknown quantity probably went to ground-water recharge; however, most of the difference between storm-yield inflow and stream outflow (17,000 to 22,000 acre-feet, or $2.1 \times 10^7 m^3$ to $2.7 \times 10^7 m^3$) probably contributed to increased soil moisture or was stored in local depressions, and ultimately was returned to the atmosphere by evapotranspiration.

SEDIMENT TRANSPORT

The intense rainfall and heavy runoff caused a substantial amount of erosion, sediment transport, and sediment deposition. The field-reconnaissance nature of this investigation did not allow any quantitative measurements of erosion or sediment deposition. Also, an unknown fraction of the total sediment transported by the storm runoff was deposited in Lake Mead near the mouth of Las Vegas Wash and thus is not readily accessible to quantitative assessment. This report, therefore, only addresses some of the more obvious qualitative aspects of sediment erosion, movement, and deposition by the flood.

Erosion

In spite of the reported intense nature of precipitation at many localities from time to time during the storm, subsequent observations did not generally disclose extensive rill erosion of the general landscape. However, many striking examples of ditch, gutter, and gully erosion were seen throughout areas subjected to intensive runoff. Major stream channels also exhibited numerous striking examples of lateral channel cutting and bank caving (fig. 11). However, obvious vertical downcutting along reaches of major channels was not common in and near the metropolitan area, possibly because the major channels are extensively underlain by deposits of caliche (calcite-cemented alluvium) that effectively armor the streambeds against vertical erosion. Vertical scour damage occurred locally at the downstream ends of culverts and similar drainage structures. Some concrete protective aprons or wingwalls were undercut and seriously damaged by the highly turbulent flow. A particularly dramatic example of this type of damage occurred near the mouth of Las Vegas Wash. There, concrete box culverts through the high fill of Northshore Road were progressively undermined after turbulence and vertical channel downcutting of flood flow destroyed the effectiveness of the protective riprap armor lining the channel and mantling the downstream fill slope (figs. 6 and 7). Damage at this site continued even long after peak flows had subsided, and the highway fill section required extensive reconstruction to prevent complete failure.

Figures 8 and 9 show severe but typical examples of eroded roads at diverse locations in the Las Vegas metropolitan area. In most situations, roads that were overtopped by heavy flows failed from progressive headward channel cutting through the roadbed (fig. 8). In other places, the road surfacing was laterally displaced en masse by streamflow (fig. 9). A particularly severe example of eroded roadway occurred where Lamb Boulevard was cut by Las Vegas Wash a short distance south of the intersection of Lamb Boulevard and Owens Avenue (fig. 10).

Probably the most pronounced example of vertical and lateral erosion along a major stream channel occurred in the lower reaches of Las Vegas

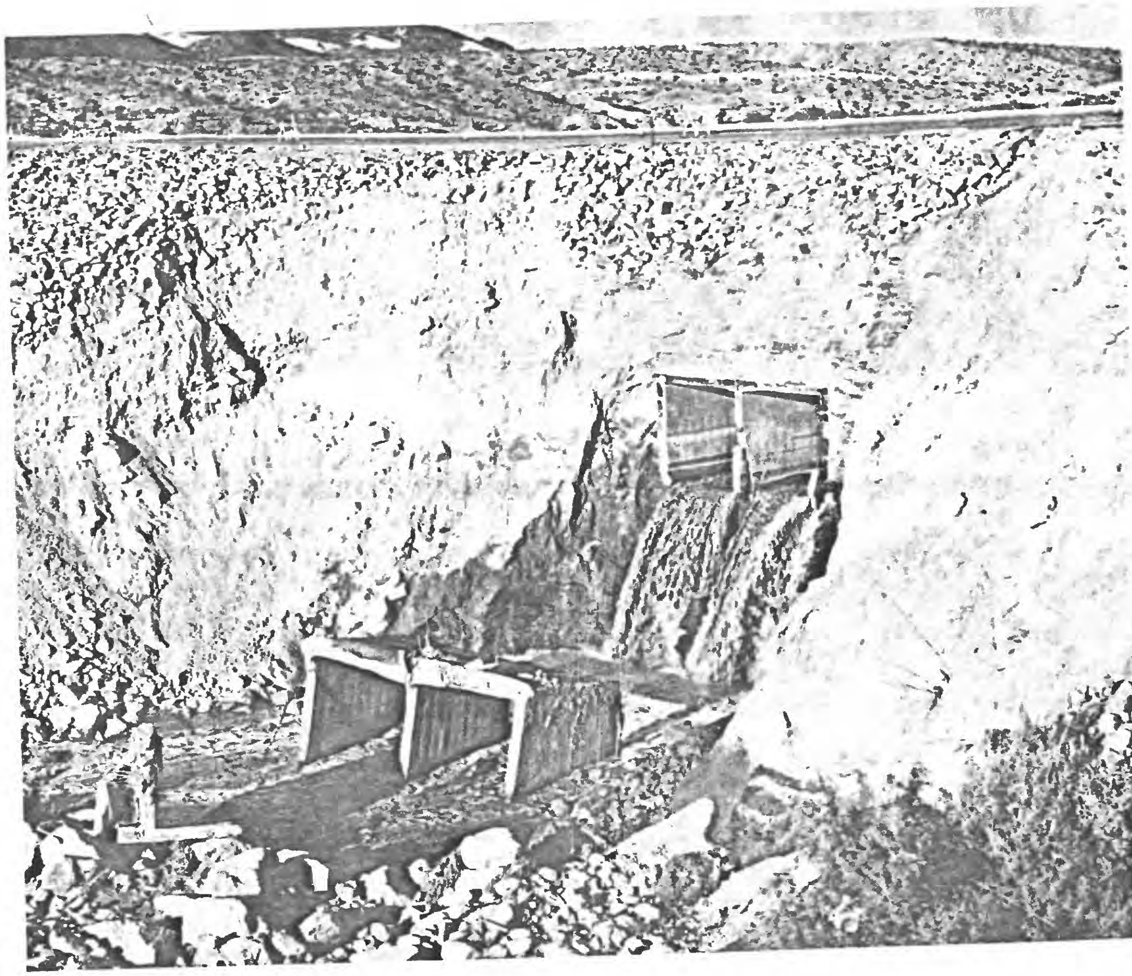

Figure 6. State of severe damage to culverts and highway roadfill on Northshore Road at Las Vegas Wash near Lake Mead at about 7:00 a.m., July 7, 1975.

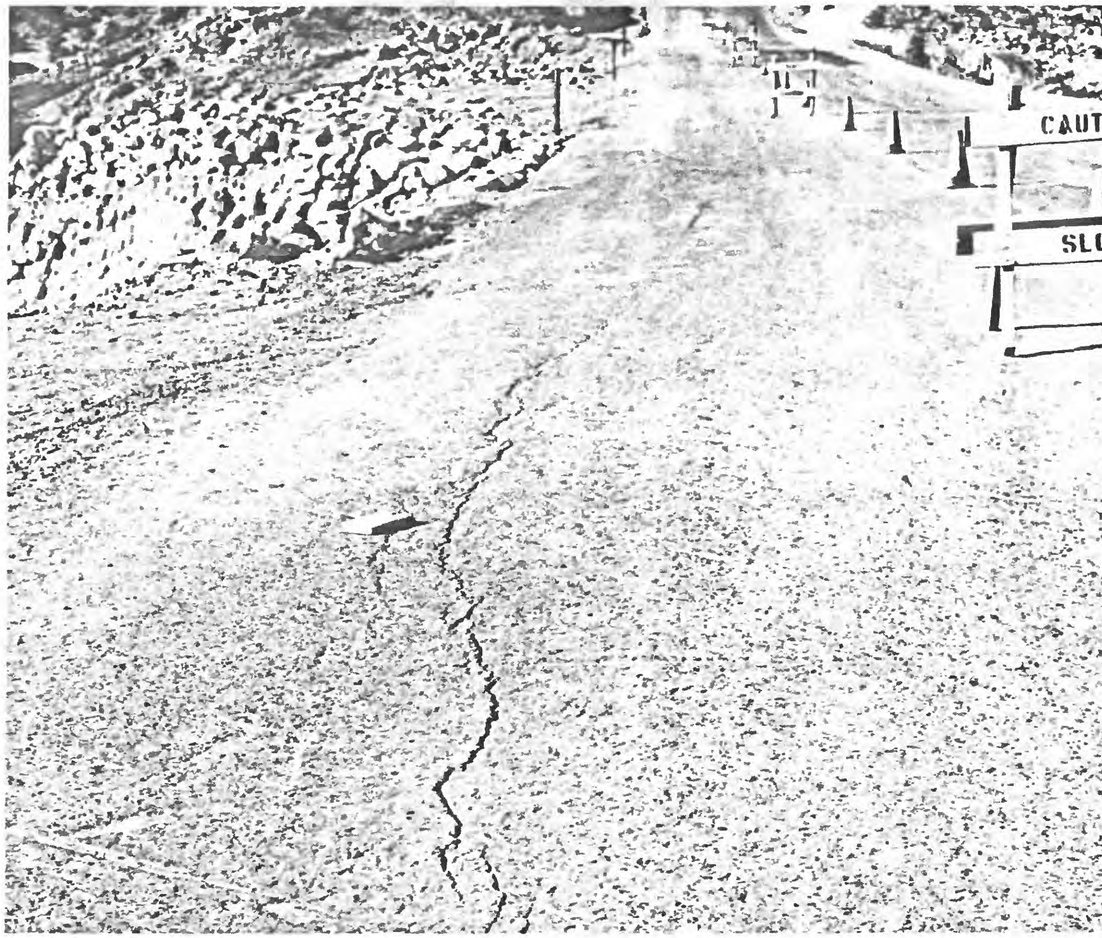

Figure 7. Evidence of impending failure of roadway on Northshore Road at Las Vegas Wash. Progressive failure of downstream fill slope continued on morning of July 7 after cessation of flood flows.

Figure 8. Erosion of Losee Street, just southwest of its intersection with Craig Road near North Las Vegas. Photograph taken July 6, 1975.

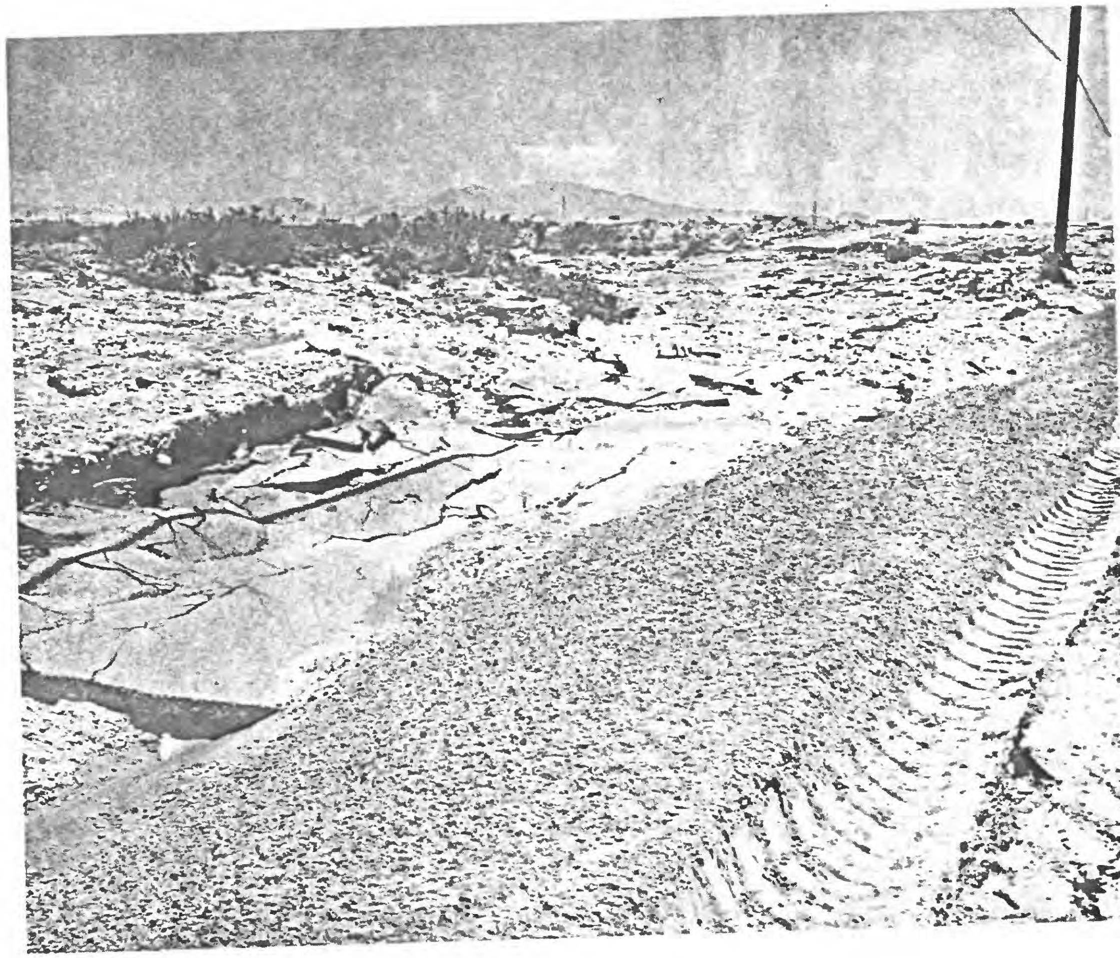

Figure 9. Asphalt road surface laterally displaced by floodflow on Tropicana Road just south of its intersection with Rainbow Blvd. Photograph taken July 5, 1975.

Figure 10. Erosion of Lamb Blvd. and damaged cars displaced by flood in the Las Vegas Wash flood plain. Photograph taken July 7, 1975.

Wash, beginning generally about 2½ miles (4 km) downstream from site 11 (pl. 1). The characteristics of channel erosion along this reach of the wash are typified by figure 11. The site is near the former location of a Geological Survey streamflow gage which was lost when the streambank eroded during the flood. Recent drastic channel erosion in lower Las Vegas Wash had occurred prior to the July 3-4 flood, but the flood flows greatly accelerated the erosion and were largely responsible for the chaotic results typified by figure 11 and similar scenes elsewhere downstream.

The suspended-solids content of Las Vegas Wash at Northshore Road (site 12, pl. 1) still showed pronounced effects of the flood 11 days after the peak flow, and had not as yet recovered to "background" levels more than 4 months after the flood. The data are as follows:

Date	Suspended solids (mg/l)
Range of concentrations for samples collected generally twice per month during Aug. 1974-June 1975	54-200
July 15	704
July 28	520
Aug. 12	316
Aug. 25	274
Sept. 15	324
Sept. 29	230
Oct. 14	420
Nov. 10	430

Lateral channel cutting by overbank flood flows also affected man's works other than road surfaces. Figure 12 shows effects of Las Vegas Wash undercutting masonry block walls, sidewalk, street curbing, sewer lines, and street signs. Similar erosion damage in other places included segments of people's yards and property-line fences.

A minor erosion problem having the potential for serious consequences occurred in at least one area. Figure 13 shows a natural-gas line exhumed

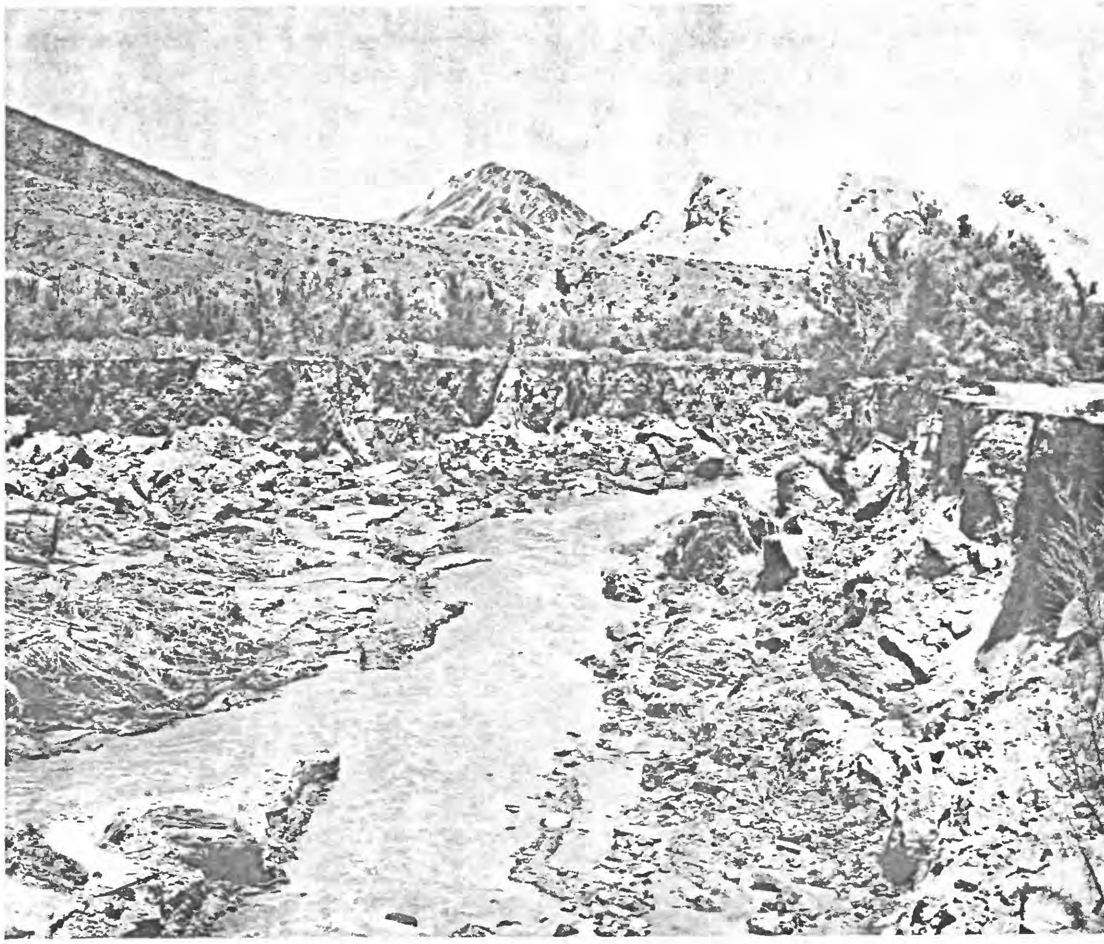

Figure 11. A typical scene of channel erosion along lower Las Vegas Wash. Photo taken on July 9, 1975, in NE¼ sec.28, T.21 S., R.63 E.

Figure 12. Riparian erosion damage by Las Vegas Wash flooding to works of man at intersection of Cheyenne Road and Bassler Street. Photograph taken July 4, 1975.

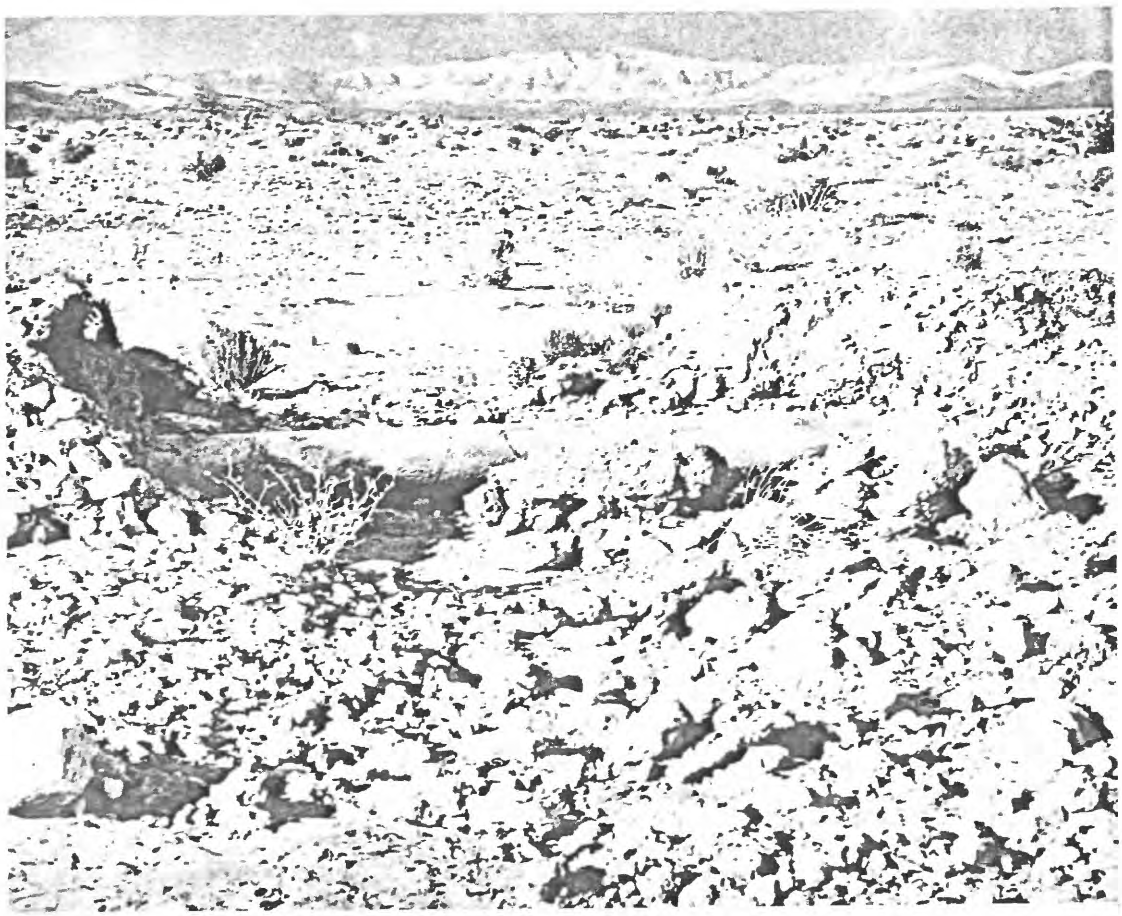

Figure 13. A natural gas line exhumed by erosion of its thin alluvial cover along the south side of West Sunset Road, about 5¼ miles (8.4 km) west of Interstate Highway 15. Photograph taken July 8, 1975.

by erosion. The line was constructed on top of the land surface and covered only with a relatively thin blanket of alluvium. The path of the pipeline lies across numerous shallow gullies that drain surface flow down the alluvium fan, creating the potential for exhumation by any moderate to heavy surface runoff. Exposure of the pipeline renders it vulnerable to further flood damage and vandalism, that could trigger more serious problems.

Sediment Deposits

Sediment deposits created many problems and may actually have caused greater overall economic damage than that caused by erosion. One of the most obvious sediment deposits that received early cleanup attention was in Flamingo Wash at the Caesars Palace parking lot. Figure 14, an oblique aerial photograph of the parking lot, shows the general areal extent of the deposit. Figure 15 reveals the fine-grained character of the sediment as it was being gathered for removal on July 5. Although the deposit covered only a few acres at most, cleanup probably involved removal of several acre-feet of sediment.

Another obvious problem area of sediment deposition was at Winterwood Golf Course near the junction of Flamingo Wash and Las Vegas Wash in southeast Las Vegas. Figure 16 is a typical scene of the nature of sediment deposition on the course. The deposits covered many acres, but the depths of most of the deposits are uncertain. Total volume of the deposits was at least several acre-feet.

Sediment was also profusely deposited on numerous streets, highways, lawns, and in homes, businesses, and other buildings. Cleanup of much of this sediment probably accounted for a large part of the cost of the flood damage. Sediment deposition at the delta of Las Vegas Wash in Lake Mead was probably great. The effects of this sediment transport on lake and stream biota are unknown, but may have been significant.

Particle-Size Distribution of the Transported Sediment

The sediment loads transported by floodwaters consisted of three basic components:

(1) Natural inorganic particles (mineral and rock material).
(2) Natural organic debris (mostly trees and brush).
(3) Manmade or man-related objects.

Manmade objects compose probably the smallest volume of material transported, but involve the greatest economic impact because of the high financial losses associated with displacement and damage of automobiles and other expensive articles. Natural organic debris probably makes up a minor fraction of the total weight and volume of all sediment transported, but was important because the debris and manmade objects together effectively

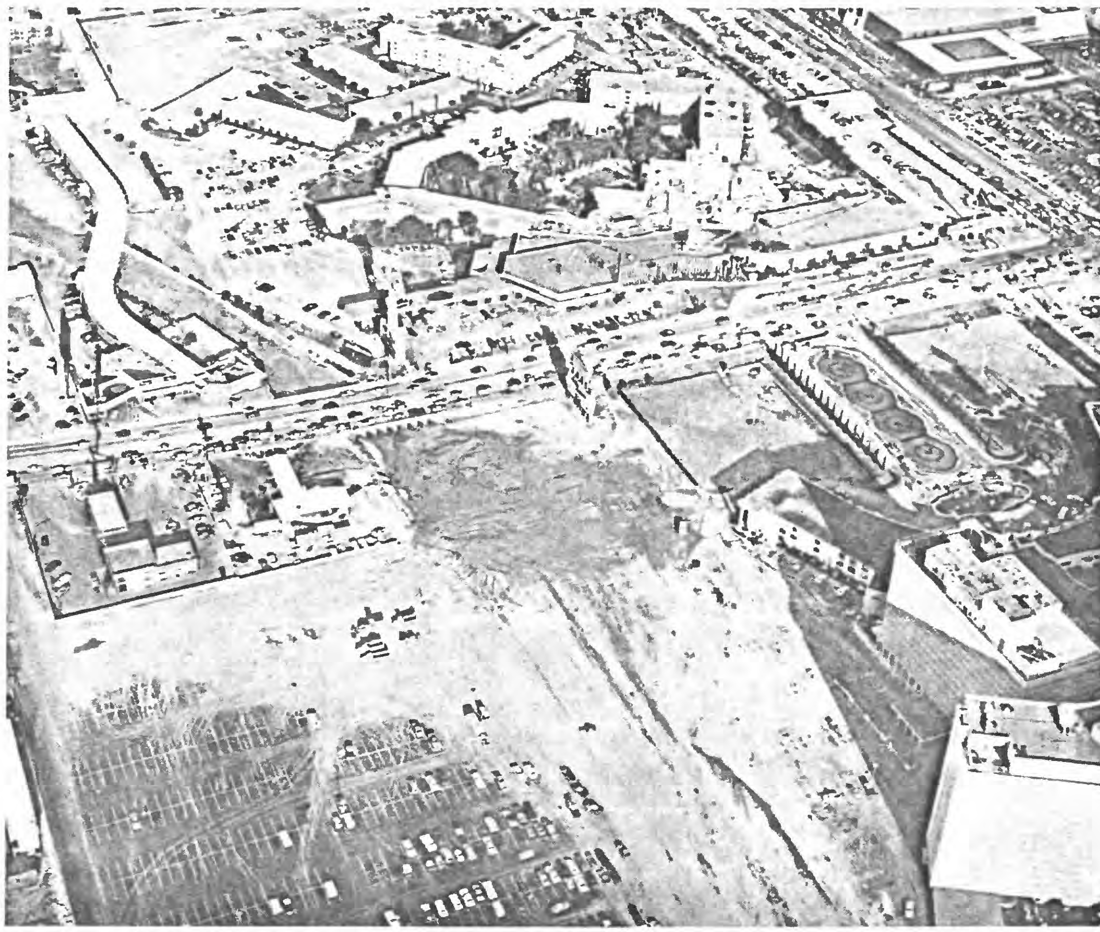

Figure 14. Sediment deposits in Caesars Palace hotel-casino parking lot. Photographed about 7:00 p.m. on July 4, 1975, after cleanup operations had begun.

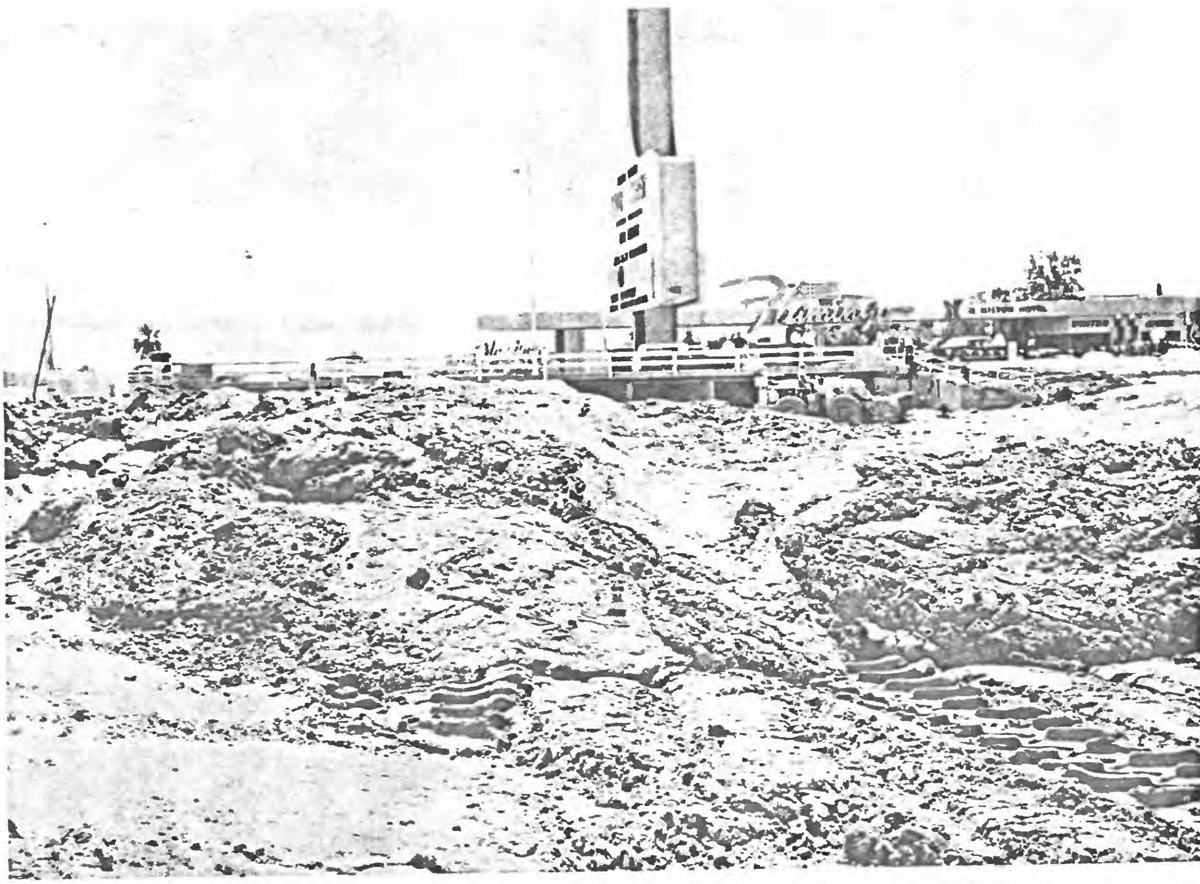

Figure 15. Character of sediment deposited in Caesars Palace parking lot. Photograph taken July 5, 1975.

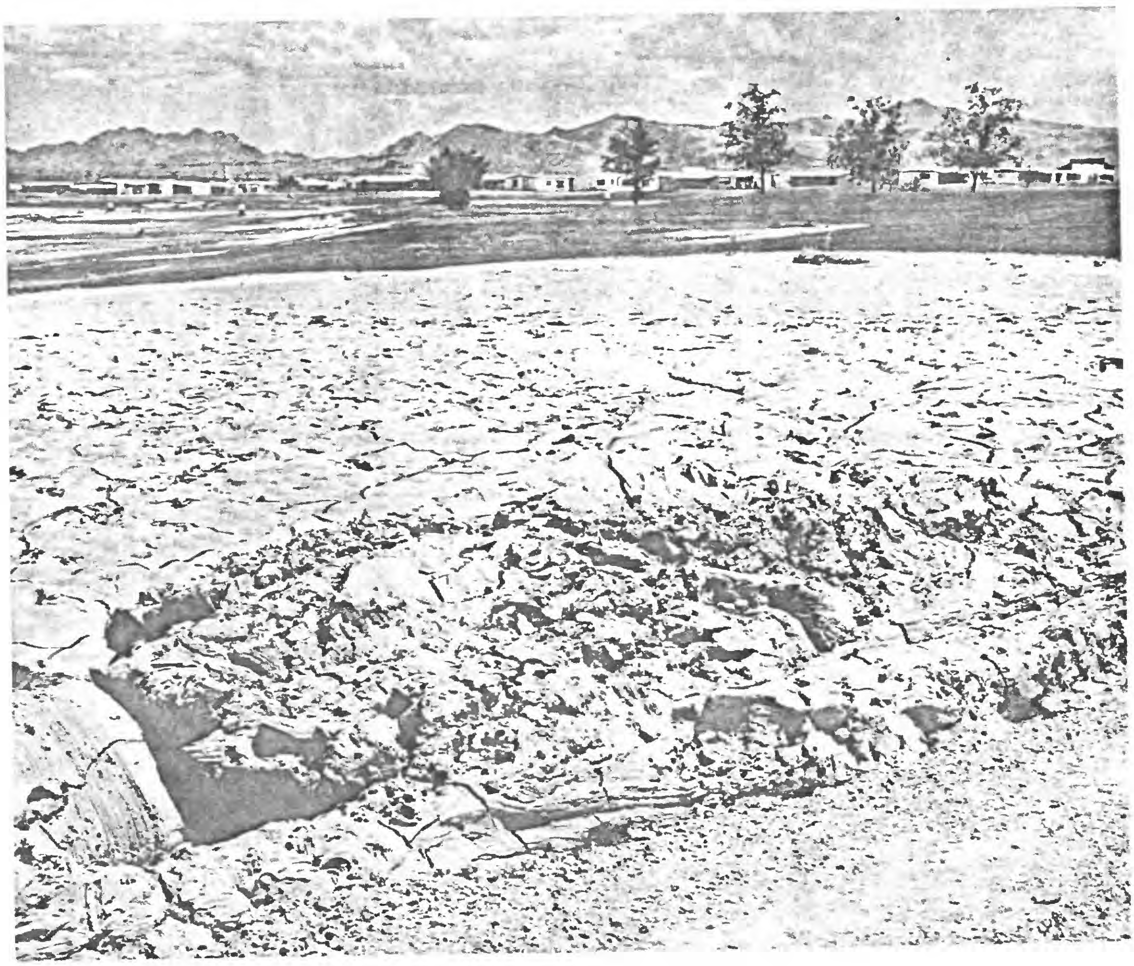

Figure 16. Sediment deposits on the Winterwood Golf Course near the junction of Flamingo and Las Vegas Washes. Photograph taken July 9, 1975.

blocked and clogged culverts. The clogged drainage ways ponded and diverted floodflow, which caused increased flooding and damage. The bulky character of much of the organic debris and the manmade objects, as well as their generally floatable nature, contributes to the clogging problems. Fine-grained organic debris and small manmade objects probably had only minor effects on the floodflow movement.

The nonorganic mineral and rock material made up the majority of the weight and volume of sediment transported and deposited by the flood. Almost all observed sediment deposits, both overbank and in-channel, were dominated by fine-grained sediments (sand, silt, and clay). Undoubtedly, some coarse material moved, but cursory visual inspection suggests that gravel and boulders were only a minor part of the total weight and volume of transported sediment. The main-channel flows commonly displayed the competence to move automobiles, concrete drainage pipe, and other large heavy objects over considerable distances. Therefore, if gravel and boulder transport did not occur, it was probably because that size of material was unavailable for transport in most major channels. The particle-size distribution of the sediment apparently moved by the flood was therefore controlled more by availability than by the competence of flows required to move it.

DAMAGE

Heavy damage occurred along Flamingo Wash in the vicinity of Caesars Palace, where automobiles were parked in the flood plain, despite several signs warning of flash floods (fig. 17). Several hundred cars were damaged by submersion and collisions when they were moved by the flood waters. Many of the vehicles were piled up at the entrance to drainage structures under Las Vegas Boulevard South, commonly referred to as "The Strip" (fig. 18). The obstructions caused increased backwater, and more cars and a larger area were inundated (figs. 19, 20). Damaged automobiles along Flamingo Wash are shown in figure 21.

Many automobiles in various parts of the flooded city suffered similar consequences. Several autos were lost when they were driven onto flooded sections of streets and the flows swept the vehicles off the roadways.

Overbank flooding of major creeks caused great damage to buildings that were invaded by the turbid water. Floodwater in the downtown business district is shown in figure 22. Many utility poles tilted to non-vertical positions during the flood (for example, see fig. 10). Streets were inundated and later left coated with sediment, as were lawns and other improved real estate features (figs. 15 and 16). Curbs and drainage structures were undermined and pipelines were exhumed and commonly damaged (figs. 12, 13). Sewage plants were inundated and deactivated by mud and water.

Apparently no detailed list or description of damage was compiled. However, Mr. James Scholl, Clark County Flood Control District engineer, estimated that the overall damage would total $4-5 million (oral commun., July 30, 1975).

Figure 17. Flash flood warning signs posted in the asphalt covered streambed of Flamingo Wash near Caesars Palace hotel-casino. Post-flood cleanup operations in background. Photograph taken July 5, 1975.

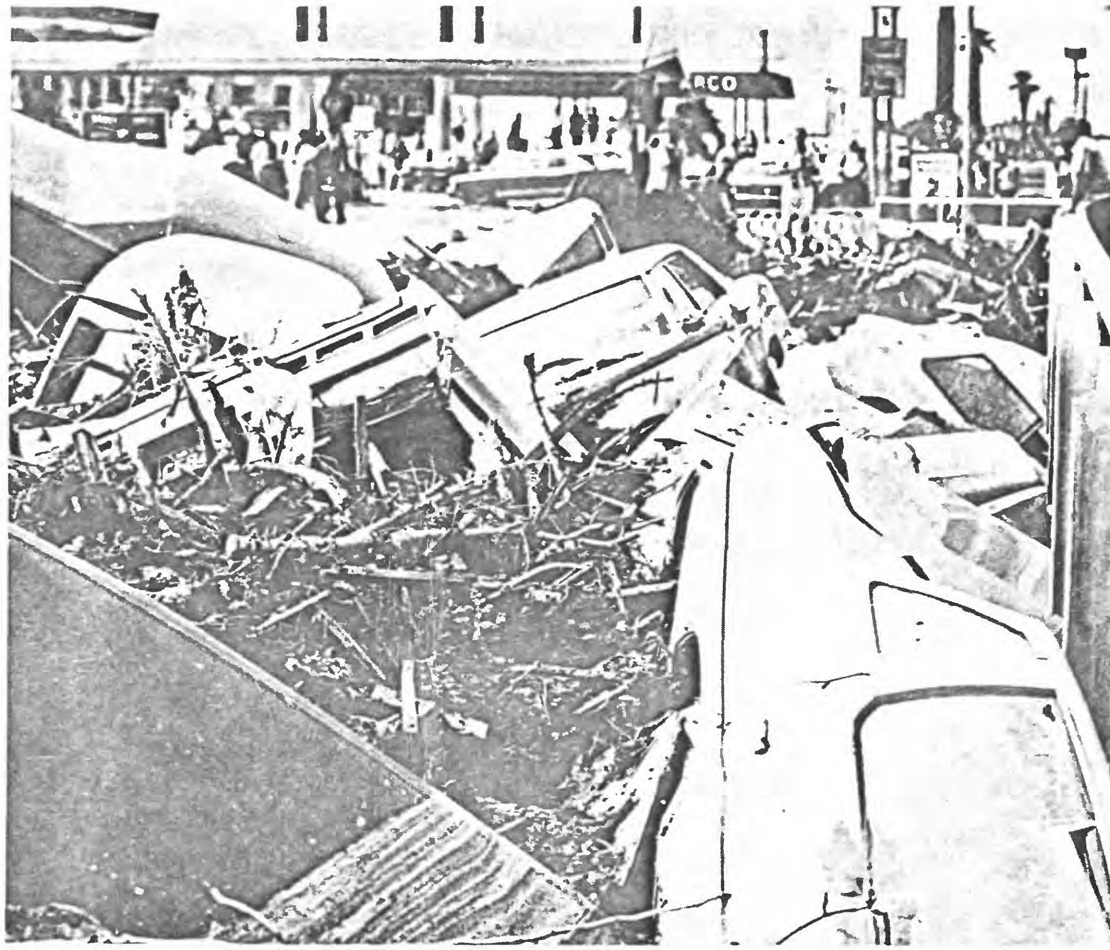

Figure 18. Chaotic conglomeration of automobiles and organic debris deposited against drainage structures of Flamingo Wash under Las Vegas Blvd. South. Photograph courtesy of David Lee Waite.

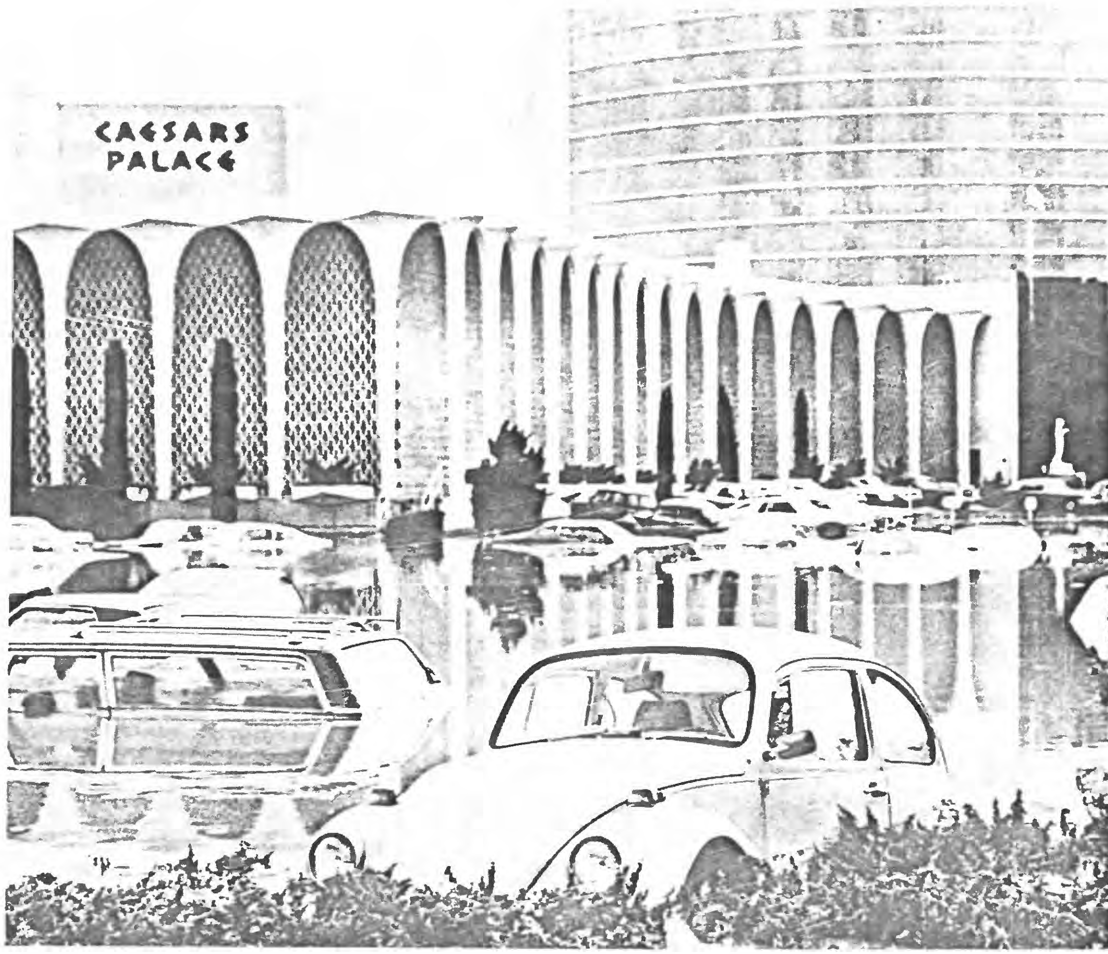

Figure 19. Partially inundated vehicles in Caesars Palace hotel-casino parking lot near Flamingo Wash. Photograph courtesy of David Lee Waite.

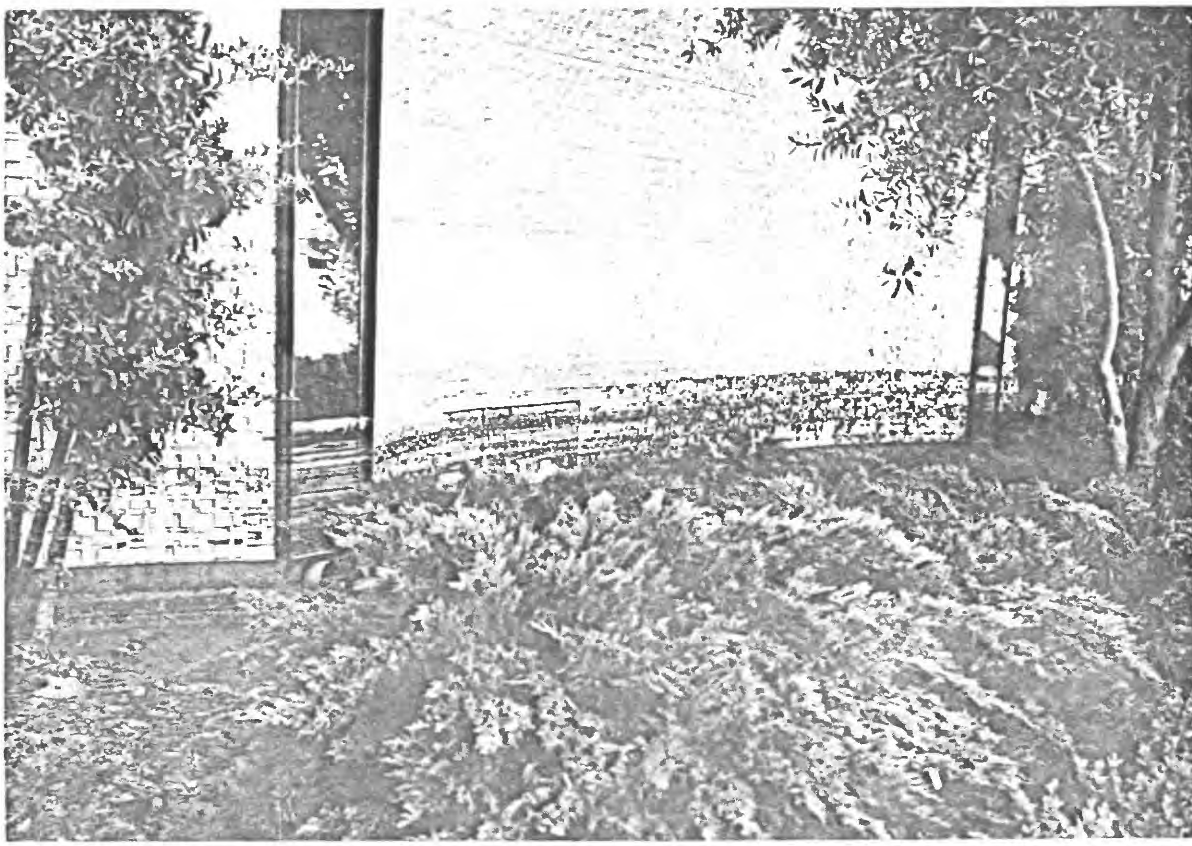

Figure 20. High-water marks of Flamingo Wash floodflow on the southwest wall of the Flamingo Hilton hotel-casino.

Figure 21. Examples of automobiles damaged near Caesars Palace hotel-casino by flooding of Flamingo Wash. Photograph taken July 6, 1975.

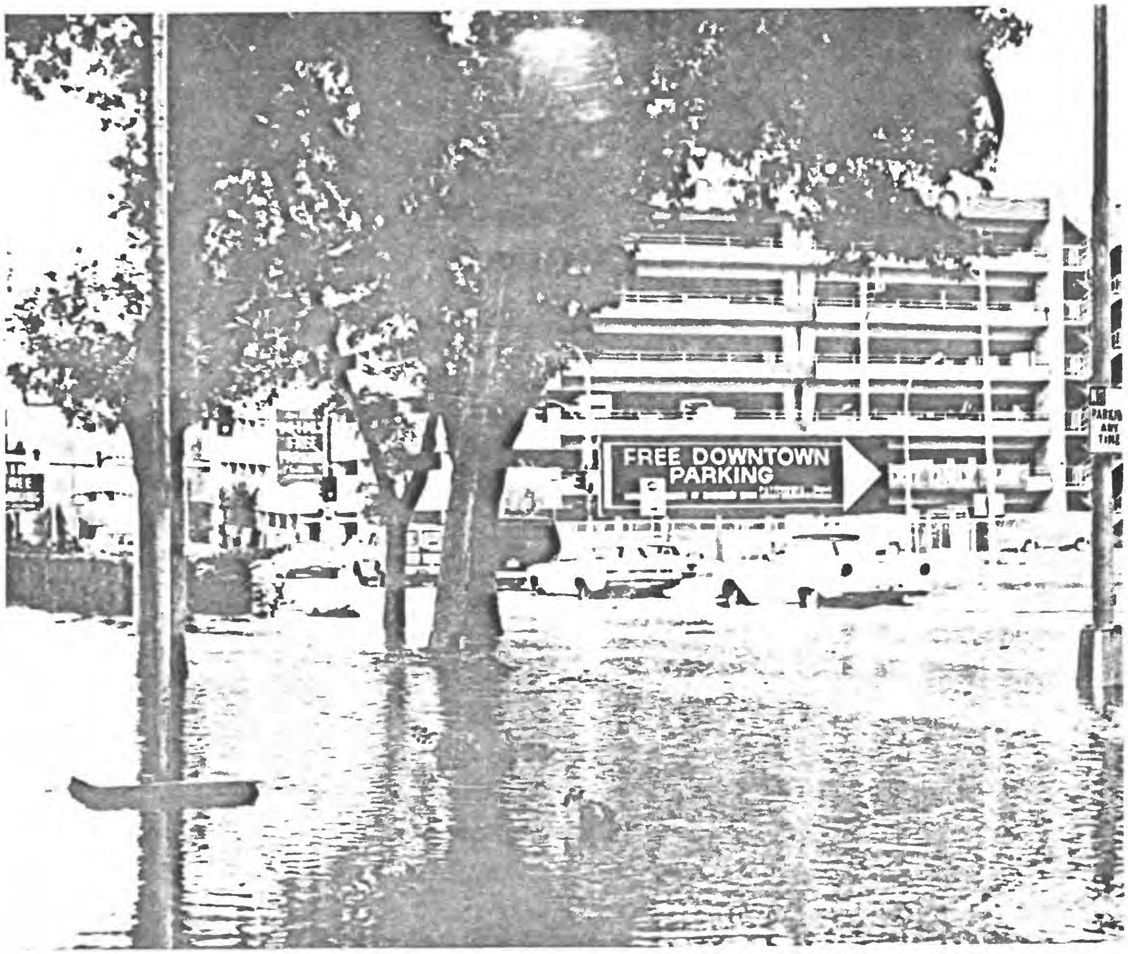

Figure 22. Flood water mainly from Las Vegas Creek invading downtown Las Vegas. Photograph courtesy of David Lee Waite.

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SELECTED REFERENCES

Glancy, P. A., and Harmsen, Lynn, 1975, A hydrologic assessment of the September 14, 1974, flood in Eldorado Canyon, Nevada: U.S. Geol. Survey Prof. Paper 930, 28 p.

U.S. Army Corps of Engineers, 1959, Report on survey for flood control, Las Vegas Wash and tributaries, Las Vegas and vicinity, Nevada; App. 1, Hydrology: Los Angeles Div., Los Angeles, Calif., 19 p.