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Prepared in cooperation with **U.S. DEPARTMENT OF THE AIR FORCE**

OPEN-FILE REPORT 00-183
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Flood-Prone Areas and Waterways, Edwards Air Force Base, California

INTRODUCTION

Edwards Air Force Base (EAFB) is in the Mojave Desert region of southern California (fig. 1). Although the climate in the study area is arid, occasional intense storms result in flooding on the base, damaging roads and buildings. To plan for anticipated development at EAFB, the U.S. Department of the Air Force (USAF) and the U.S. Geological Survey (USGS) began a cooperative study to locate flood-prone areas on the base. This report describes flood hazards and shows flood-prone areas of the base.

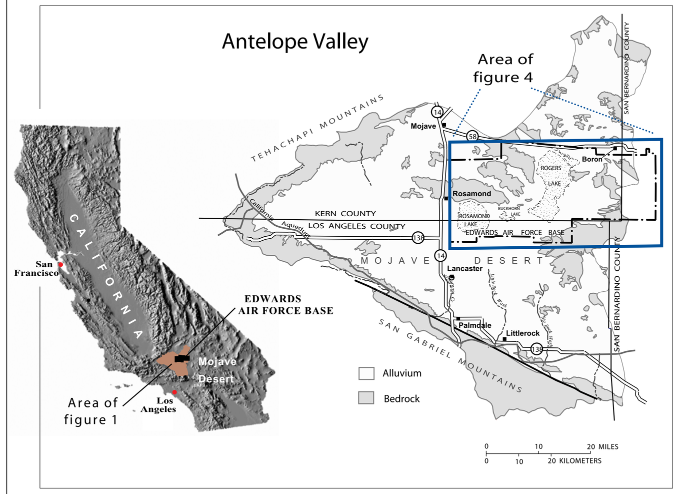

Figure 1—Location of study area.

Analysis of the flood hazards at EAFB is difficult because there is little existing streamflow and precipitation data, the area is extremely arid, and the landforms evolved under different climatic conditions. Previous flood-hazard studies done at EAFB by other investigators used standard methods of analysis, such as physiography and channel geometry. Results of those studies produced very extreme values for 100-year flood discharges; such extremes would not occur under present climatic conditions. Because the results of the previous studies conflict, the USAF requested that the USGS document the type of method used to evaluate flood hazards and describe the methods used.

Five continuous streamflow gages, 5 precipitation gages, and 4 crest-stage gages were installed at EAFB for this study (table 1). Two previously established precipitation gages—the Edwards Air Force Base gage and the Boron gage—were used to provide long-term daily and hourly precipitation data. However, little data have been collected to date because few flow-producing storms have ocurred since the gages were installed.

Table 1. Continuous streamflow, precipitation, and crest-stage gages at Edwards Air Force Base. [Gage type: Cont SW, continuous streamflow gage; CSG, crest-stage gage; PPT, precipitation gage; AFB, Air Force Base]

Station number	Station name	Gage type
10264636	Sled Track Canal at Scout Road, near Rogers Lake	Cont SW, PPT
10264640	Buckhorn Creek at Lancaster Boulevard, near Roger Lake	Cont SW
10264644	North Drainage Bissell/Rosamond Hills, near Edwards AFB	CSG, PPT
10264646	South Drainage Bissell/Rosamond Hills, near Edward AFB	CSG, PPT
10264656	Mojave Creek at Bm G114, near Edwards AFB	CSG
10264658	Mojave Creek at Forbes Avenue, at Edwards AFB	Cont SW, PPT
10264660	Mojave Creek at Rosamond Boulevard, at Edwards AFB	Cont SW
10264673	Unnamed tributary at railroad crossing near North Base, at Edwards AFB	CSG
10264675	Rogers Lake Tributary at Edwards AFB	Cont SW, PPT

DESCRIPTION OF STUDY AREA

Edwards Air Force Base is in Antelope Valley, about 60 mi northeast of the city of Los Angeles. The valley is a closed topographic basin that covers about 2,400 mi^2. The Tehachapi Mountains, with a crest elevation of about 8,000 ft above sea level, form the northern and western boundaries of the valley, and the San Gabriel Mountains, with a crest elevation of about 10,000 ft above sea level, form the southern boundary (fig. 1). The lowest area in the valley is Rogers Lake, a prominent dry lake or playa. Two other significiant playa lakes within the boundaries of EAFB are Buckhorn and Rosamond Lakes.

Average annual precipitation in the Antelope Valley ranges from about 20 inches in the mountains to less than 4 inches on the valley floor (fig. 2) (Blodgett, 1996). Average annual precipitation at EAFB is only 5.04 inches (Philip Harvey, U.S. Department of the Air Force, written commun., 1996). The distribution of precipitation in this desert region is highly variable, particularly the distribution of precipitation from localized summer thunderstorms.

The largest drainage basin at EAFB is the Mojave Creek Basin, which has the greatest potential for storm runoff. This drainage basin includes the area of the Main Base Landfill and an urbanized area approximately 10 mi^2 that produces storm runoff to Mojave Creek downstream of Forbes Avenue. Even during intense rainfall, the hydrologic response of Mojave Creek is slow. The infiltration capacity of the drainage basin delays the onset of stormflow (Dinehart and Harmon, 1998).

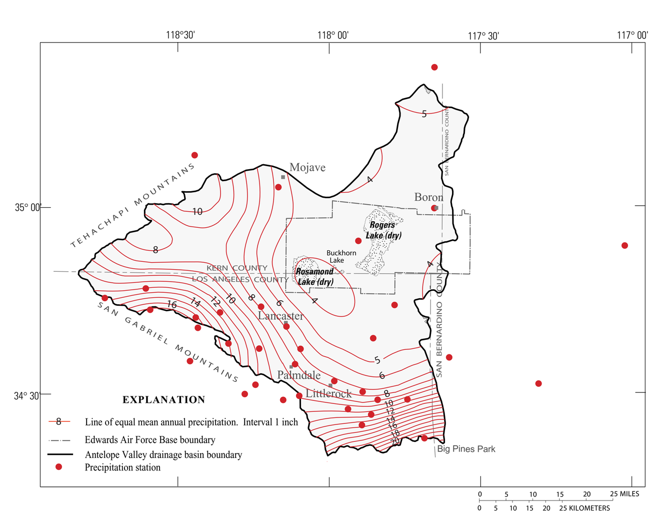

Figure 2—Mean annual precipitation in Antelope Valley, California. (Modified from Blodgett, 1996, fig. 7)

METHODS

Flood-hazard analysis is difficult at EAFB because little historical streamflow and precipitation data exist. Channel characteristics, which are needed for flood-hazard analysis, could not be determined for this study because of the poorly defined channels, the uncertain flow paths, and the extreme aridity that causes most flow paths to be nearly always dry.

Most methods of flood-hazard analysis, including detailed, historical, analytical, physiographic, and channel geometry methods, require a combination of the following information: Historical streamflow records, computed *T*-year discharges, channel survey data, water-surface profiles, identifiable active and bankfull channel widths, and stable channel boundaries.

However, such information is not available or applicable for analysis of the flood hazards at EAFB. Another method of analysis, the geomorphological assessment method, uses field reconnaissance information on topographic and vegetational features and geomorphic and pedological data.

The geomorphological asessment method was selected for this study. Although this method cannot be used to construct 100-year floodplain maps, it can be used to delineate flood-prone areas. During the preliminary geomorphic assessment of EAFB, topographic maps of the base and a 1984 LANDSAT image were used to identify possible flood-prone areas. Stereo pairs of aerial photographs were studied to identify the widths of active channels, gross vegetational types and distribution, gross soil color changes, and flow-path types or impoundments. The photographs and maps also were used to identify natural and man-made channels, changes in flow paths owing to road construction, and probable flow obstruction or detention areas. Distinctive vegetation and pedologic conditions, such as soil development, stratification, drainage, desert pavement, and desert varnish (Williams and Zimbelman, 1994), were used as indicators of flood-prone areas.

The geomorphological assessment method does not yield flow depths and veolcities, but it can depict areas that are prone to flooding. The probable accuracy of this method is not known. This method requires that an investigator have considerable experience in several related fields, including hydraulics of open-channel flow, geomorphology, sedimentology, and botany. The geomorphological assessment method may be the most appropriate method for delineating flood-prone areas of alluvial fans with distributary channels and on valley floors where channels become discontinuous or nonexistent.

All natural flow paths on EAFB are ephemeral (fig. 3). Highly variable precipitation, combined with high evaporation losses and moderate to very high soil permeability, makes the ephemeral channels on EAFB highly unpredictable compared with streams with perennial flows. Given such conditions, there is little likelihood of being able to develop a model that can reasonably simulate flow for large areas of EAFB, and very little possibility of accurately predicting discharge for a given frequency.

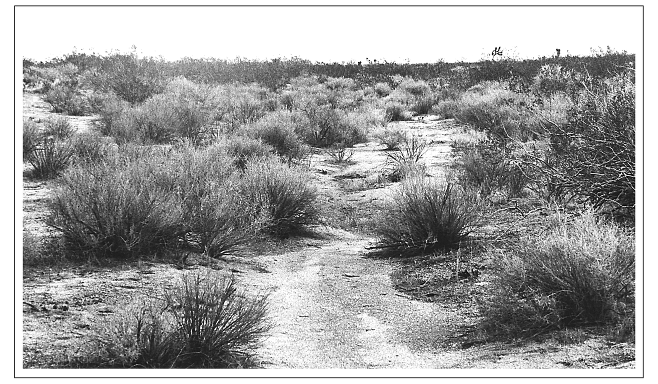

Figure 3—A typical ephemeral channel.

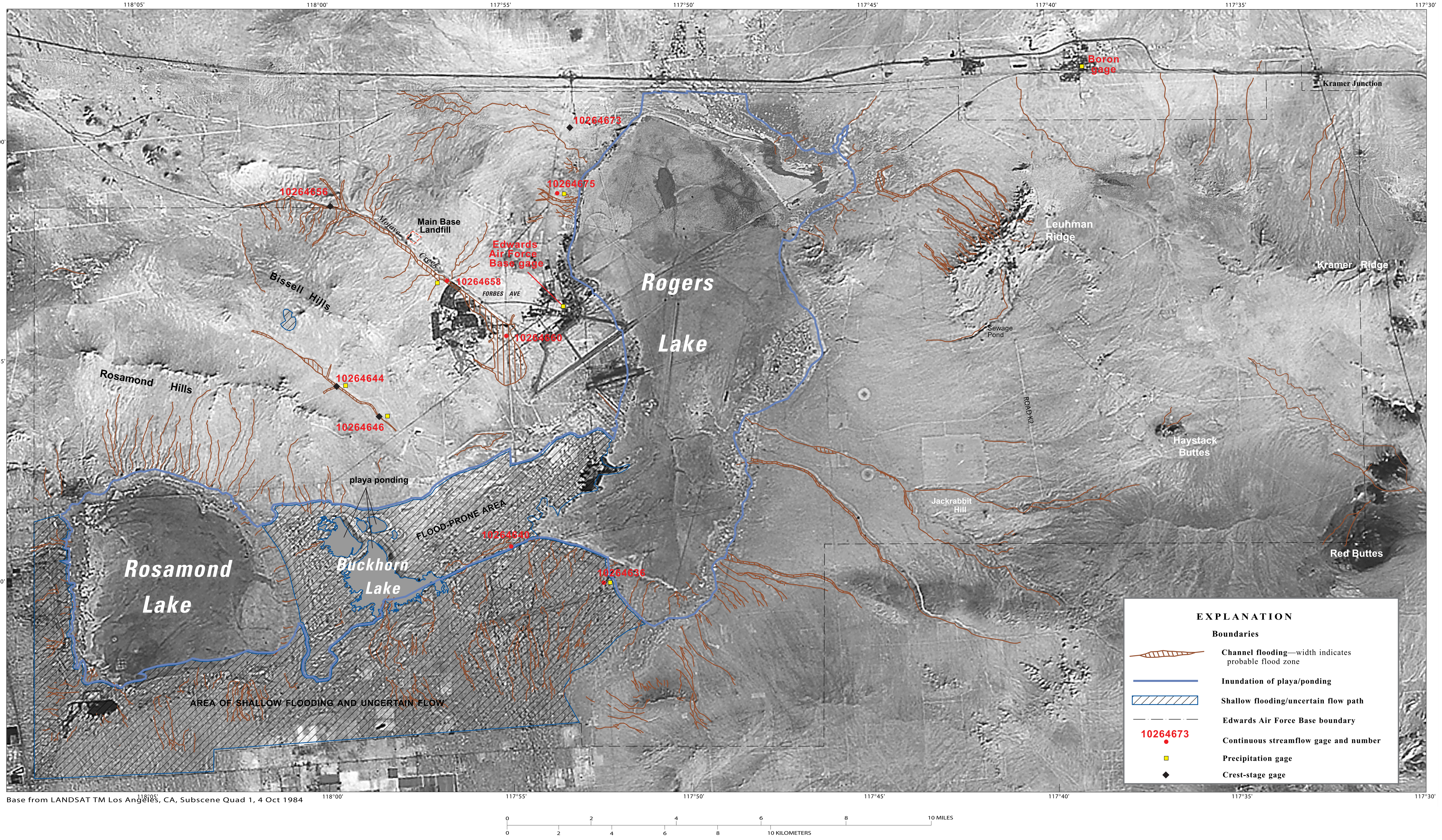

Figure 4—Boundaries of flood-prone areas on Edwards Air Force Base, California.

FLOOD-PRONE AREAS AND WATERWAYS

Three types of flooding occur at EAFB—flooding associated with channels, shallow flooding, and inundation caused by ponding. The boundaries of the areas of potential flooding were determined for this study using the geomorphological assessment method. Flood hazards exist with each type of flooding. For the purposes of the discussion that follows, the flood-prone area, which also is known as a floodplain, is that part of a river or stream valley adjacent to an incised channel that may be inundated during high water.

"A floodplain is built of sediments deposited from streams, as well as fine sediments on the floodplain when a river or stream floods" (Linsley and others, 1958). In geomorphic terms, a floodplain is a strip of fairly smooth land bordering a stream, built of sediment carried by the stream and dropped in the slack water beyond the influence of the swiftest current. A floodplain has been called a living floodplain if it is overflowed in times of high water, but a fossil floodplain if it is beyond the reach of the highest flood (Bryan, 1923). In many regulatory references, a floodplain is defined as the lowlands adjoining inland waters that are inundated by a 1-percent chance flood in any given year. The floodplain at EAFB has been defined in USAF regulations as a 100-year (0.01 probability of exceedence) floodplain. As explained previously, the scarcity of historical streamflow and precipitation data; the permeable, poorly defined channels; and the extreme aridity of the area prevent the computation of specific flood frequencies.

The single, most fundamental finding of this study of flood hazards at EAFB is that all channels at the base that have not been disturbed by human activities are, to a profound degree, losing reaches (reaches where streamflow quantity decreases as floodflows move down these permeable natural channels). This concept is of critical importance when considering flood hazards at EAFB.

Arid environments, if undisturbed by human activity, preserve erosional and depositional features for many years. A storm on March 1–2, 1983, at EAFB produced 3.38 inches of rainfall, an amount equal to a 100-year rainfall, as defined by Hershfield (1961). However, this storm did not produce erosional or depositional evidence of flows greater than 10 ft^3/s in any observed natural channel at EAFB. The lack of significant erosion or deposition and the presence of long-lived vegetation along many of the natural channels indicate that discharges greater than 10 ft^3/s have not occurred for many decades. No floodmarks, debris, nor depositional levees from overbank flows were observed in any of the undisturbed channels during the field reconnaissance for this study.

Precipitation and streamflow monitoring sites installed for this study are listed in table 1. Data recorded at these sites during the El Nino-influenced storms of the winter of 1998 support the results of the analysis of the geomorphic evidence observed at EAFB. The precipitation gages on Mojave Creek at Forbes Avenue and at the south Bissell Hills site (station nos. 10264658 and 10264646, respectively) recorded daily rainfall totals of 2.23 inches and 2.39 inches, respectively, on February 23, 1998. These 24-hour totals represent a storm with a recurrence interval between 50 and 100 years (Blodgett, 1996). During this storm, no runoff occurred in the undisturbed part of either the Mojave Creek or the south Bissell Hills Basins. The only runoff recorded on the north side of the base was from areas that have been disturbed by human activity. The most significant runoff was from the housing area, which drains to the Mojave Creek Basin upstream of the Forbes Avenue streamflow-gaging station 10264658.

Channel Flooding

Natural ephemeral channels at EAFB, with drainage areas of greater than a few square miles, have very low channel gradients. These channels have vague channel definitions, no definable banks, and channel bottoms consisting of unconsolidated sand. The bed materials of these channels have some to no discoloration caused by soil forming processes. Some of the channels have no vegetation, but most have scattered to dense populations of long-lived desert shrubs at the bottom of the channels. There is no evidence of recent sediment transport in the channels; such evidence would include small deposits of sediment covering the root collars of shrubs, actively eroding banks, or gully head cutting. Such channels are considered "active" even though channel-forming flows may not have occurred for decades or even during the past 100 years.

Some of the ephemeral channels that have been disturbed by human activity (this does not include constructed ditches) had evidence of flow occurring within the last decade. Runoff from roads, old mining areas, and other developed areas has increased because of the localized disturbance or compaction of the desert soils. During storms, runoff often is concentrated and follows an artificial route to a low point where it enters a channel. Because the channels at EAFB are losing reaches and because precipitation is minimal, discharges greater than 10 ft^3/s seldom occur. The channels, which are identified with a single line on figure 4, have widths of about 10 ft. The flood-prone area for such channels is 15 ft from the center of the channel.

Flood-prone areas related to channels were identified as flow paths located in a topographic low; with a definable channel geometry; with a channel bed that looked like a stream bed, that is, having unconsolidated sand and little or no evidence of soil building; and with little vegetation. All the channels identified on figure 4 are active channels although many of these channels may not have had flow in decades. Flow in recently active channels (active within the last 25 years) was almost exclusively the result of human disturbance of natural flow patterns. Active channels with no evidence of recent flow had indeterminate or poorly defined drainage areas, indistinct channel geometry, and no discernible evidence of significant flow during the past 100 years.

Shallow Flooding

Shallow flooding occurs in flood-prone areas that have uncertain flow paths (National Research Council, 1996). Such flooding includes unconfined flows across broad, fairly low relief areas, such as

1. Toes of alluvial fans;
2. Bajadas—areas at the distal ends of coalesced alluvial fans;
3. Alluvial plains;
4. Arid regions that have not developed a system of well-defined channels (or that have only the remnants of such a system that has weathered away) and that receive only intermittent flow; and
5. Areas where overbank flow remains unconfined after leaving an incised channel.

In various literature, these flooding conditions have inconsistently been referred to as "sheetflow" or "overland flow." At EAFB, most of the flows that result in shallow flooding originate in disturbed areas of the base and collect along the roadways or come from alluvial fans originating in the San Gabriel Mountains.

Shallow flooding often occurs along highly unpredictable flow paths because the source of the flow may be variable, topographic relief may be low, channels may shift or may be nonexistent, or sediment and debris may be deposited or removed during or after a flood altering the flow path. Shallow flooding also may occur when flows are confined in depressions. Where such conditions exist, the entire area susceptible to flooding is delineated as an area of equal risk of flooding (figs. 4 and 5). As previously stated, because flow paths, discharge, and drainage areas are uncertain in the study area, hydraulic analysis is not possible for EAFB and, thus, the ability to accurately delineate areas subject to shallow flooding is limited. Using topographic maps, aerial photographs, and ground reconnaissance, it was possible, however, to estimate flood boundaries to show areas at risk from shallow flooding. These boundaries were used to define flood-prone areas that have no associated magnitude or frequency.

Figure 5—Flooded areas near Rosamond Lake looking north. Shallow flooding with uncertain flow paths.

Inundation of Playas

The largest areas of flooding on EAFB are caused by the inundation of the playa lakes by ponded water. The large areal extent of this type of flooding occurs because much of the land surface at EAFB is made up of deposits from the relic lakebed of the Pleistocene-age Lake Thompson (Robert Lichvar, U.S. Army Corps of Engineers, oral commun., 1998). Rogers, Rosamond, and Buckhorn Lakes (fig. 4), which are dry lakes, are subject to inundation from runoff and from direct rainfall. The elevation of the boundaries of these dry lakes depicts the approximate level of the lakes during the Holocene, which is relevant to the current climate. The area surrounding these playa lakes have small pan formations that also are subject to ponding (fig. 6). The boundary of the ponded area depicts an area with low relief and gradient and with soil of low permeability subject to ponding. The playa lakes and the surrounding pan and dune areas currently are being studied and mapped by the U.S. Army Corps of Engineers Waterways Experiment Station Wetlands study group. This group will estimate the potential of flooding of the playa and the pan areas independent of this study on the magnitude and frequency of floods.

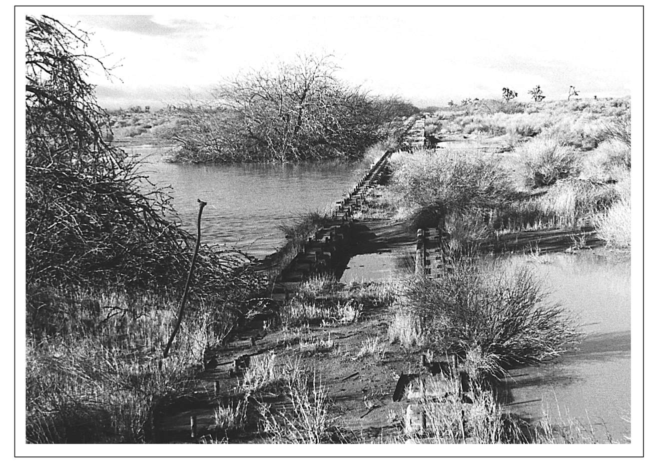

Figure 6—Inundated pans.

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Conversion Factors

Multiply	By	To obtain
inch	25.4	millimeter
foot (ft)	0.3048	meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

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

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