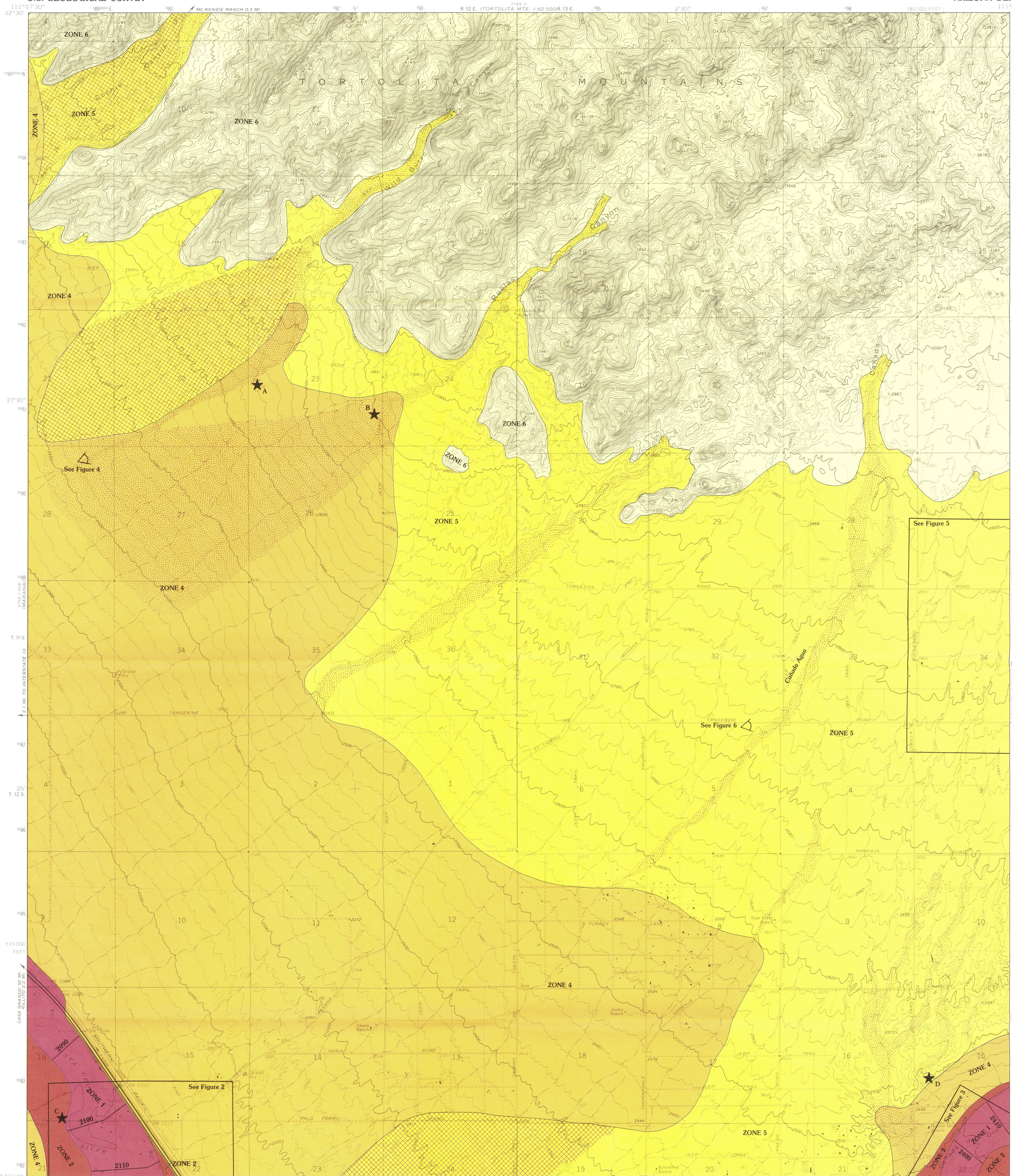
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
ARIZONA DEPARTMENT OF REVENUE

MISCELLANEOUS INVESTIGATIONS SERIES
FOLIO OF THE RUELAS CANYON QUADRANGLE, ARIZONA
MAP I–843–E



Base from U.S. Geological Survey, 1968
10,000-foot grid based on Arizona coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 12

TRUE NORTH
MAGNETIC NORTH
12½°
APPROXIMATE MEAN DECLINATION, 1986

SCALE 1:24 000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
SUPPLEMENTARY CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

ARIZONA
QUADRANGLE LOCATION

DELINEATION OF FLOOD HAZARDS IN THE RUELAS CANYON QUADRANGLE, PIMA COUNTY, ARIZONA

By
Robert M. Myrick and B. N. Aldrige
1986

EXPLANATION

2090

Zone 1

Extent of the 100-year flood on the Santa Cruz River and Cañada del Oro. Number (2090) indicates the altitude, in feet, of the peak water surface during a 100-year flood using 1976 channel condition

Zone 2

Part of flood plain that may be inundated or eroded by rare floods

Zone 3

Flooding from sheetflow and water that collects in depressions. No areas on this map are in zone 3

Zone 4

Sheetflow on slightly dissected alluvial plains. Stippled pattern indicates area of greater than average flood hazard

Zone 5

Flooding confined to defined channels and flood plains of small streams. Stippled pattern indicates area of greater than average flood hazard. Crosshatched pattern indicates area of less than average flood hazard; flow is dependent on the distribution of flow in zone 4 or area is an ancient fan that is no longer inundated by floodwater

Zone 6

Steep mountainous terrain having minimal flood hazard except in defined channels

Location and view angle of photograph

B
Location of special hazards

A. Flow from Wild Burro Canyon is confined to wide braided sandy channel by a dirt bank that is only a few feet high. The bank is on the outside of a bend, and floodwater may overflow the bank and spread through secs. 26 and 27

B. High-velocity flow that leaves Ruelas Canyon branches into several small distributary channels, and floodwater may spread over large areas within the stippled pattern

C. The banks of the Santa Cruz River are continually changing (fig. 2), and the channel may migrate throughout zones 1 and 2

D. Houses are being built on the low terrace along the sandy banks of the unnamed tributary. The terrace could be overtopped and eroded by a large flood. Similar low terraces may be present elsewhere in the map area

CONVERSION FACTORS

For readers who prefer to use metric units, the conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.2832	cubic meter per second (m^3/s)

INTRODUCTION

The flood hazard along the Santa Cruz River and Cañada del Oro—the major streams in the Ruelas Canyon quadrangle—often is under-estimated by those unfamiliar with desert streams. Overflow from streams can inundate large areas, and channels can migrate because of bank erosion. On other streams, the main potential flood hazard is from flash floods that result from intense precipitation on areas of generally less than 5 mi^2. The flash floods can cause severe damage along water courses several miles downstream from where the precipitation occurs. Many flows that originate in the Tortolita Mountains and in the surrounding foothills dissipate on the alluvial slopes and often are unnoticed in the populated areas.

The classification of an area into zones of similar flood hazard is based on the source of flooding, depth and velocity of floodflow, frequency of inundation, and degree of flood hazard related to different terrains. Zone 1, which is the area along the major streams that will be inundated by the 100-year flood, was defined by detailed studies and surveys. The 100-year flood is the discharge that will be equaled or exceeded on an average of once every 100 years. A flood with a 100-year recurrence interval would have a 1-percent chance of being exceeded in any given year. The other zones were defined using maps and aerial photographs and by ground and aerial reconnaissance. Areas that have an above-average potential flood hazard also are identified on the map. The methods for determining the peak discharge for floods of different recurrence intervals are discussed by Patterson and Somers (1966), Arizona Highway Department (1968), U.S. Soil Conservation Service (1972), and Arizona Water Commission (1973).

FLOODING ALONG MAJOR STREAMS

High-intensity storms that cover large areas produce floods that overflow the banks of the Santa Cruz River and Cañada del Oro. The streams overflow the banks on an average of once every 20 to 25 years. During periods of high flow, a stream channel might migrate because of bank erosion or because of the development of new channels that result from concentrations of floodwater on flood plains. Channel conditions change frequently owing to natural and manmade causes. Manmade features, such as channel enlargements and sanitary landfills, cause large changes in the hydraulic characteristics of stream channels and flood plains and the stream's capacity to carry water.

ZONES 1 AND 2

Zone 1 is the area that would be inundated by the 100-year flood if the channels remain stable. The estimated peak discharges used in this study for the 100-year floods—40,000 ft^3/s for the Santa Cruz River and 28,000 ft^3/s for Cañada del Oro (fig. 1)—greatly exceed the capacity of existing channels. Discharges of this magnitude have been measured along several streams in the Santa Cruz River basin that have smaller drainage areas than those being studied. The boundaries and the altitude of the water surface for zone 1 along the Santa Cruz River were defined from detailed studies and surveys by the U.S. Geological Survey, and the boundaries and altitude of the water surface along Cañada del Oro are from unpublished work by Blanton and Co. Architects and Engineers (written commun., 1976) and from Cella, Barr, Evans, and Associates (written commun., 1976). The boundaries of the 100-year flood are defined for the channel conditions and manmade developments on the flood plains in 1976. Zone 1 may include small undefined areas of high ground along the major streams that would not be inundated by the 100-year flood. The Federal Emergency Management Agency (1982) defined the flood boundaries along the Santa Cruz River and Cañada del Oro in greater detail.

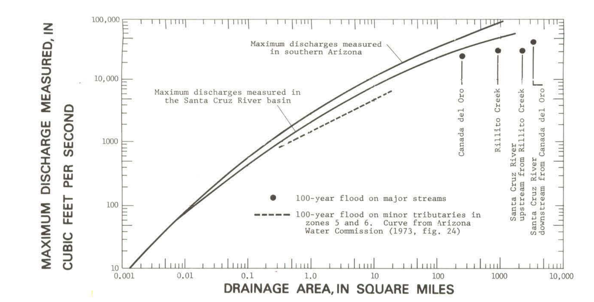


Figure 1.—Relation of maximum discharge measured to size of drainage area.

Zone 2 is part of the flood plain along the major streams that may be inundated by floods larger than the 100-year flood. In much of zone 2, bank erosion and development of new channels are greater hazards than inundation by floodwater. Zone 2 extends from the 100-year flood boundary to the base of the foothills along the sides of the valleys. Along much of the east side of the Santa Cruz River, zone 2 is too small to be delineated at the map scale. The 100-year flood (zone 1) will cover the entire flood plain except for the elevated parts of Interstate Highway 10 and the Southern Pacific railroad tracks.

CHANGES IN THE CHANNELS AND FLOOD PLAINS IN ZONES 1 AND 2

Channel banks along the Santa Cruz River and Cañada del Oro are unstable, and streams carry large sediment loads during floods. The potential for rapid growth of vegetation along the channels is great. The magnitude and frequency of flood peaks are highly variable. Flood plains are susceptible to erosion, and channels migrate. For example, in 1965 a 12-year flood in Rillito Creek, which is in the adjacent Jaynes quadrangle, eroded several hundred feet of bank causing several mobile homes to fall into the channel (Myrick and Aldridge, 1981). The magnitude and rate of erosion are influenced by the length of time between large flows. During periods of low floodflows, sediment is deposited, vegetation becomes established, and flow velocities are reduced. When a few years pass without a large flow, the low-water channel can become narrow and meandering, and some reaches can become braided. An occasional large flow will remove the vegetation and sediment, widen and straighten the existing channel, and cut new channels. For example, the width of clear channel on the Gila River about 80 mi northeast of Tucson averaged 260 ft in 1905, 2,000 ft in 1917, and less than 200 ft in 1964 (Burkham, 1972).

Figure 2.—Meandering channel of the Santa Cruz River near Interstate Highway 10 and El Camino De Mañana in secs. 15, 16, 21, and 22, T. 12 S., R. 12 E. The white area is the low-water channel on May 5, 1966. The line is the boundary of the flood channel in February 1936. The arrow indicates the direction of flow. Scale: 1 in. = about 2,000 ft.

An example of where the Santa Cruz River migrated during the period from 1936 to 1966 is given in figure 2. In 1936 the channel in the photograph was bounded by high steep banks that would confine a 25-year flood but probably would not confine a 100-year flood. By 1966, the low-water channel had migrated as much as 400 ft beyond the banks that existed in 1936. Extensive changes occurred after discharge of sewage effluent from a sewage treatment plant into the Santa Cruz River began in 1966. The effluent provided water and nutrients for vegetation, and a dense growth of brush developed in the channel that had been clean and open in 1969. The average elevation of the channel bed of the Santa Cruz River at Cortaro Road 2 mi south of the map area rose 4 ft between 1966 and 1973 (Myrick and Aldridge, 1981). Similar rapid changes in alluvial channels occur under natural conditions. Cañada del Oro is a braided stream, and many small channels contain the minor floods. A major flood, however, would inundate an area as much as half a mile wide and may cut a new channel anywhere in the flood plain (fig. 3).

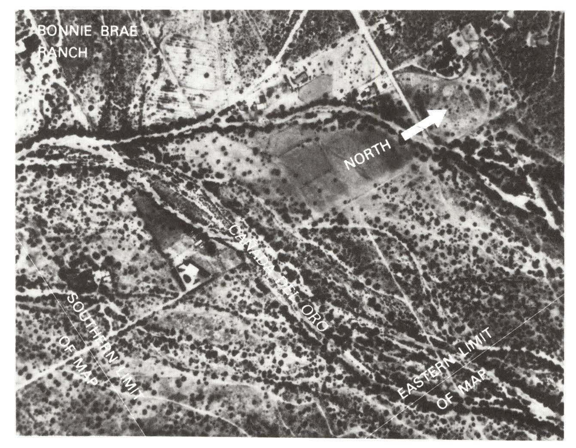


Figure 3.—Braided channel of Cañada del Oro near Bonnie Brae Ranch in sec. 22, T. 12 S., R. 13 E. Scale: 1 in. = about 650 ft. Photograph courtesy of Cooper Aerial Survey Co.

Frequently, manmade changes—landfills, dikes, and channelization—are made along the Santa Cruz River and Cañada del Oro. Changes can alter the natural distribution of flow between the channel and flood plain. Many of the changes result in higher flow velocities, higher stages, and increased scouring of the channel banks and streambeds. A natural or manmade constriction in a channel can create flood hazards that are not readily apparent or predictable.

ZONE 3

Zone 3 designations have been used on the adjacent Marana and Jaynes quadrangle (Aldridge and Burkham, 1974; Myrick and Aldridge, 1981). Flooding in zone 3 is mainly the result of local sheetflow and water that collects in depressions. In the Ruelas Canyon quadrangle no area is large enough to be so defined.

FLOODING IN THE UPLANDS

Much of the area within the Ruelas Canyon quadrangle is comprised of rolling foothills and steep rocky slopes. The largest streams drain less than 10 mi^2 on the upper slopes, and flood hazards generally are confined to narrow flood plains along streams and to alluvial fans at the mouths of the canyons. On the lower slopes, floodwaters may spread out as sheetflow covering large areas with water a few inches deep. The upland slopes have been classified as zones, 4, 5, and 6 on the basis of terrain and potential flood hazard. The boundaries between zones 4 and 5 are indefinite in places because the terrain changes gradually from one type to another.

ZONE 4

Zone 4 is an area of distributary poorly defined channels where floods, which leave well-defined channels of zone 5 or 6, move overland as sheetflow. Channels in zone 4 divide and become braided or discontinuous, and generally are no more than a few feet wide and 2 to 3 ft deep (fig. 4). The distributary channels are cut in fairly coarse sand and gravel and are unstable. The alluvial fans in zone 4 are in varying stages of geologic development. When the larger streams leave the defined canyons, deposition and erosion occur frequently. In these areas the potential flood hazard is great. Floodflows have high velocities and can carry and deposit large amounts of rock debris. As the debris is deposited on the fans, channels migrate and change flow patterns. All parts of the fans are subject to flooding, but rarely will all parts be flooded at the same time. The frequency and amount of deposition and, therefore, the flood hazards decrease as distance downstream from the canyon mouth increases. Near the lower extremes of the fans there is little deposition.

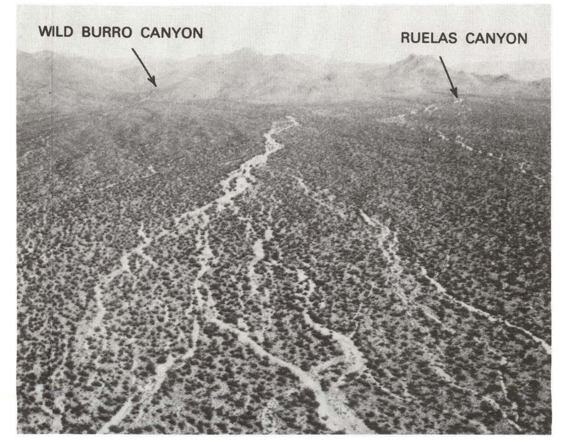


Figure 4.—Distributary channels downstream from Burro and Ruelas Canyons. Upstream view northeast from NE 1/4 sec. 28, T. 11 S., R. 12 E. Typical of zone 4, mountains in background are zone 6. The crosshatched area of zone 5, shown on the map, lies at the base of the mountains in upper left part of photograph.

The sandy soil and many distributary channels allow large volumes of water to infiltrate into the ground. Peak flows generally are reduced as the floodwater moves downstream, and many small floods are dissipated within zone 4. Some large floods reach the flood plains of the major streams as evidenced by the flood of September 13, 1962, in Cottonwood Wash—north of the map area—that inundated Marana (Aldridge, 1968).

The transition from zone 4 to zone 5 occurs gradually over an area that is as much as 2 mi wide. The boundary between the two zones was drawn on the map on the basis of aerial photographs that show where the main channels begin to branch.

ZONES 5 AND 6

Zone 5 is mostly an area of moderately to highly dissected alluvial slopes that contain closely spaced stream channels separated by distinct alluvial ridges (fig. 5). In the higher parts of zone 5, bedrock may be close to the surface. Floodwater is confined to the channels and narrow flood plains, and the ridges generally are free of floods. Zone 6 consists of steeply sloping hills and mountains and narrow V-shaped canyons. In zones 5 and 6 floodflows can become high-velocity walls of water and the normally dry channels may be filled with water in a matter of seconds with little or no warning. Flood discharges of several hundred cubic feet per second per square mile of drainage area are common (fig. 1). In zone 5 floodwater may carry large amounts of debris scoured from the streambeds and flood plains and redistribute the debris in a thick layer downstream in zone 4.

Figure 5.—Stream pattern in zone 5 near Tangerine Road in secs. 27 and 34, T. 11 S., R. 13 E., and sec. 3, T. 12 S., R. 13 E.

The stippled pattern shown along the major tributaries in zone 5 indicate flood plains that have an above-average hazard from erosion and inundation. Although the flood plains generally are flat and appear to be ideal building sites, the hazards are great because the flood plains may be inundated and channels may move laterally across the flood plains. Some of the flood plains are not easily recognized. In the SE cor. sec. 32, T. 11 S., R. 13 E., the channel and flood plain that extend downstream from Cañada Agua appear to be only a low depression (fig. 6). The stream, however, drains several square miles, and a 100-year flood would inundate an area several hundred feet wide.

Figure 6.—Channel and flood plain downstream from Cañada Agua in the SE cor. sec. 32, T. 11 S., R. 13 E. View east on Tangerine Road. The broad low depression is actually the channel and flood plain of a stream that drains an area of several square miles.

Floods generally crest 5 to 8 ft above the streambed in the large tributaries; greater rises may result from ponding of floodwater behind debris jams or manmade obstructions. Where a reach of channel is stable, the depth of flow for a given peak discharge can be determined. Most reaches, however, are unstable, and the depth of flow at a specific site will depend mainly on the amounts of erosion and deposition that occur during the flood. The crosshatched area in and near sec. 24, T. 12 S., R. 12 E., is downstream from a system of distributary channels in zone 4. Frequency relations that are applicable to most of zone 5 are not applicable to this area because the areas drained by the streams are indeterminate. The amount of water entering the crosshatched area, and therefore the potential flood hazard, is a function of the drainage and infiltration characteristics in zone 4.

The crosshatched areas in zone 5 near the northwest corner of the map indicate ancient alluvial fans or plains that are characteristic of fans and plains in zone 4. Wild Burro and Cochie Canyons have incised deep channels along the south side of their respective fans. The channels are 10 to 20 ft below the surface of the fan. An extremely large flood could deposit enough debris to block the main channel and again cause the stream to flow over the fan, but the probability of such a flood is low.

The boundary between zones 5 and 6 is indistinct. The slope between the Tortolita Mountains and the rolling foothills flattens gradually, rolling hills extend into the sharp ridges, and isolated steep-sloped knolls extend into the rolling hills. The boundary between zones 5 and 6 is placed on the map where the dominant shape of the ridges changes from sharp to rounded.

The flood-hazard potential in zone 6 is minimal. Runoff reaches the defined closely spaced channels quickly, and flow is confined until it reaches the foothills in zone 5. Most of the streams in zone 6 drain an area of less than 5 mi^2, and the maximum flow depth seldom exceeds 10 ft except where a channel is blocked by boulders debris, or manmade obstructions. In a few areas debris slides and rolling boulders may follow periods of heavy rain, but they probably would affect only small areas and would create minor flood hazards. Floodwater from zone 6 could cause severe flood hazards in downstream zones.

FLOOD-HAZARD POTENTIAL AND EFFECTS OF URBANIZATION

In 1976 the area in Ruelas Canyon quadrangle contained minor urban development. Urbanization is spreading to the upland slopes and the flood plains of the major streams. In most of zone 1 the meandering or braided characteristics of the streams would dictate that major alterations of the channels be made during urbanization to enable the channels to carry more water and to reduce flood levels and inundation. Channelization and other flood-proofing measures, however, may be ineffective because of the tendency of the streams to move laterally within their flood plains and to scour new channels.

Most of the land in zone 2 is used for agricultural purposes or is in its natural state. In much of zone 2 bank erosion, development of new channels, and channel migration are potentially greater hazards than inundation by floodwater.

Urbanization in zones 4 and 5 could change the hydrologic characteristics in zones 2, 4, and 5. Dense urbanization generally increases runoff from small amounts of rainfall and increases the frequency of moderate floods. Many of the poorly defined channels in zone 4 probably would be obliterated or relocated and enlarged during urbanization. If floodwater from an area that had distributary or braided channels under natural conditions is diverted into a manmade channel, infiltration losses will be reduced and the flood hazard downstream will be increased. Flood-proofing measures may not be effective for large flows in zone 4. For example, in and area east of the map area, the levees upstream from the area of development and the enlarged channel through the development will protect the homes during most flows (fig. 7). A large flood, however, may destroy the levees and flow through the housing area. The present channel could be filled with rocks and debris, which may cause the channel to migrate.

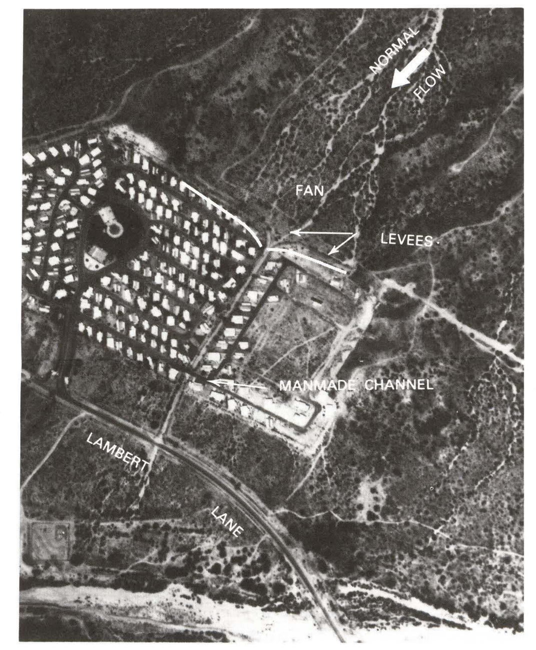


Figure 7.—Flood-proofing measures protecting a mobile home park north of Lambert Lane just east of the map area, sec. 12, T. 12 S., R. 13 E.

Whether urbanization in zone 5 will increase or decrease the flood hazard depends on the methods used to develop the area. A dense network of streets, storm drains, and channels that quickly concentrates runoff could increase the peak discharge. Circuitously routed streets, patio walls, and lawns could reduce peak flow. Small culverts reduce peak flow but also increase the flood-hazard potential owing to ponding and washouts. The existing type of development in zones 4 and 5—scattered multiacre lots generally in a natural state—may cause small peaks to occur more frequently, but the magnitude of floods that have less than a 2-percent chance (50-year flood) of occurring in any given year probably will not change appreciably.

Access to areas in zone 6 is difficult because of the steep rocky slopes, and development probably will be restricted to homes scattered along the fringes of the slopes. Slope restrictions imposed by Pima County (1976) may greatly reduce the probability of future development in this zone.

REFERENCES CITED

Aldridge, B. N., 1968, Flood of September 13 near Marana, Arizona, *in* Rostvedt, J. O. and others, Summary of floods in the United States during 1962: U.S. Geological Survey Water-Supply Paper 1820, p. 105–106.

Aldridge, B. N., and Burkham, D. E., 1974, Delineation of flood hazards in the Marana quandrangle, Pima County, Arizona: U.S. Geological Survey Miscellaneous Investigations Series Map I–846–B, 1 sheet.

Arizona Highway Department, 1968, Hydrologic design for highway drainage in Arizona: Arizona Highway Department Bridge Division Report, 53 p.

Arizona Water Commission, 1973, Floodplain delineation criteria and procedures: Arizona Water Commission Report 4, 12 p.

Burkham, D. E., 1972, Channel changes of the Gila River in Safford Valley, Arizona, 1846–1970: U.S. Geological Survey Professional Paper 655–G, 24 p.

Federal Emergency Management Agency, 1982, Flood insurance study, Pima County, Arizona: Federal Emergency Management Agency report, Community number 040073.

Myrick, R. M., and Aldridge, B. N., 1981, Delineation of flood hazards in the Jaynes quadrangle, Pima County, Arizona: U.S. Geological Survey Miscellaneous Investigations Series Map, I–843–D., 1 sheet.

Patterson, J. L., and Somers, W. P., 1966, Magnitude and frequency of floods in the United States, Part 9, Colorado River basin: U.S. Geological Survey Water-Supply Paper 1683, 475 p.

Pima County, 1976, Hillside development zone (HDZ) ordinance, *in* Pima County Zoning ordinances, 22 p.

U.S. Soil Conservation Service, 1972, Design hydrographs, *in* National Engineering Handbook: U.S. Soil Conservation Service report, section 4, chapter 21, 115 p.

For sale by Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225