DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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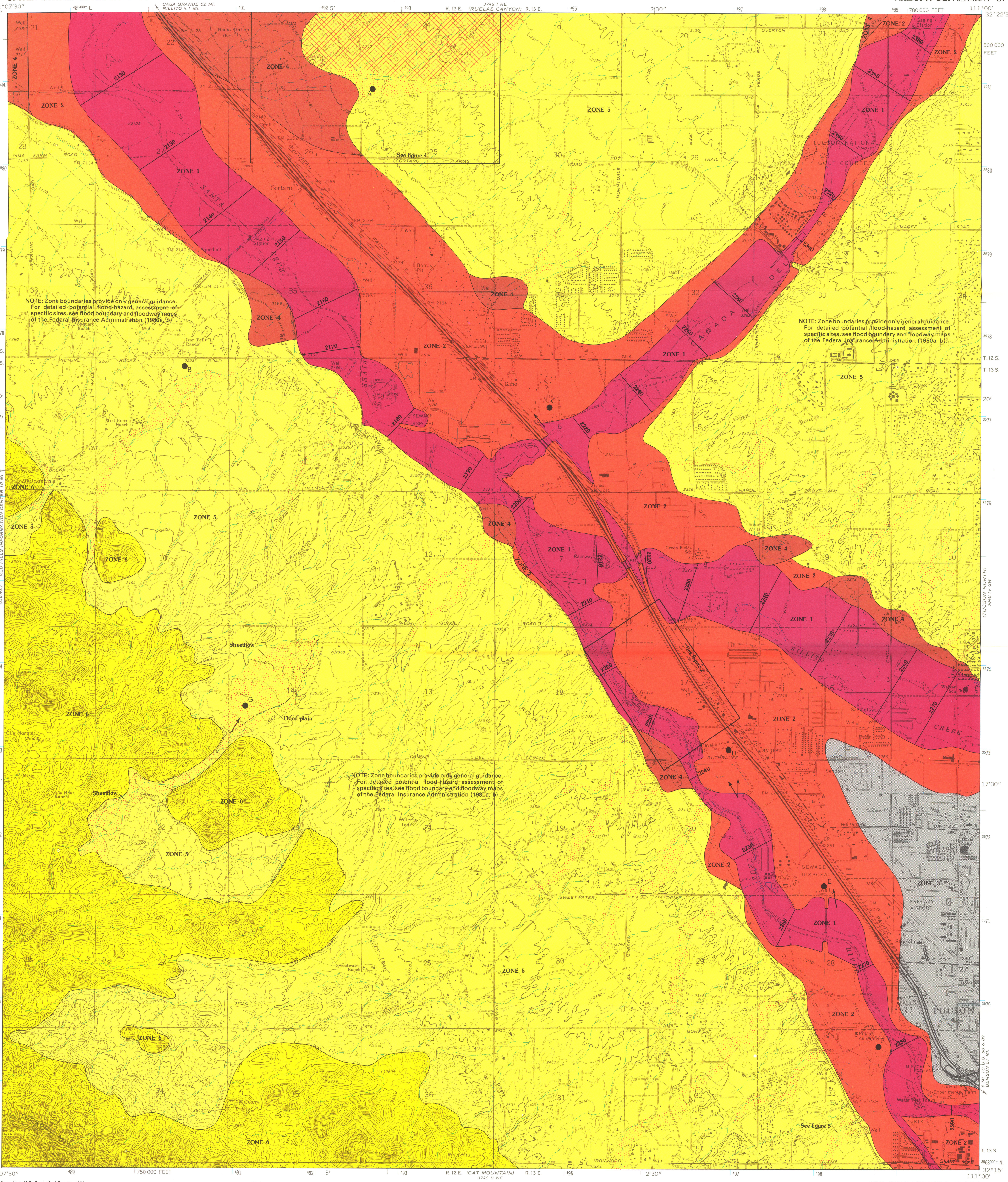
MISCELLANEOUS INVESTIGATIONS SERIES
FOLIO OF THE JAYNES QUADRANGLE, ARIZONA
MAP I–843–D



DELINEATION OF FLOOD HAZARDS IN THE JAYNES QUADRANGLE, PIMA COUNTY, ARIZONA

By

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EXPLANATION

Zone 1
Extent of the 100-year flood on the Santa Cruz River, Cañada del Oro, and Rillito Creek. Number (2190) indicates the elevation, in feet, of the peak water surface during a 100-year flood using 1975 channel conditions

Zone 2
Part of flood plain that may be inundated or eroded by rare floods

Zone 3
Flat area that has some drainage problems; the flood hazard is minimal

Zone 4
Sheetflow on slightly dissected alluvial plains. Strippled pattern indicates area of greater than average flood hazard

Zone 5
Flooding confined to defined channels of small tributary streams. Stippled pattern indicates area of greater than average flood hazard. Crosshatched pattern indicates area where flow is dependent on the distribution of flow in zone 4 north of the map area

Zone 6
Steep mountainous terrain having minimal flood hazard

Location of special hazards
[Arrow indicates direction of flow]

A. Attractive but hazardous building site. The wide flood plain along the south side of the main channel appears to be higher than the channel. The flood plain appears to have carried no large flows in many years. Several distributary channels branch from the main channel upstream; flow from the distributary channels will inundate part of the flood plain
B. The wide part of the flood plain is gravelly and is crossed by several channels along the north side. Flow is confined by a low sloping bank, which could be overtopped by a major flood; the flow would move northeast through the SE cor. sec. 34, T. 12 S., R. 12 E.
C. Computations based on 1975 channel conditions indicate that backwater from the railroad embankment would cause flow along the embankment toward Ina Road during the 100-year flood. Scouring of the streambed under the bridge, however, may enlarge the cross-sectional area of the opening sufficiently to allow all the water to flow under the bridge
D. The 100-year flood may top the dikes around the sewage lagoon upstream from Camino del Cerro. The lagoon might act as a spreading system, which would cause shallow floods in areas that otherwise might not be inundated
E. Flow is obstructed by the north-south road crossing, which causes ponding upstream. At stages above the 100-year flood, water would flow in a northerly direction and thence along Interstate Highway 10. A new channel probably would form at this site during a major flood
F. The channel is constricted by natural high ground on the east bank and by landfill on the west bank. Severe scouring is probable
G. The stippled area is a fan deposit at the mouth of the canyon, and the flood hazard is similar to that in zone 4. Distributary channels could spread floodwater over much of the area

CONVERSION FACTORS

Multiply inch-pound unit	By	To obtain metric unit
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)	0.02832	cubic meter per second (m^3/s)

INTRODUCTION

All land in the Jaynes quadrangle is classified on the basis of potential flood hazard because of rapid urbanization and the several types of potential flood hazard in the area. The potential flood hazard is great in the flood plains of the Santa Cruz River, Rillito Creek, and Cañada del Oro—the major streams in the Jaynes quadrangle. The flood hazard commonly is underestimated by those unfamiliar with desert streams because the streams generally are dry and major floods are infrequent. Floods can cause severe damage to existing and future urban development if the development is not compatible with the potential flood hazard. Floods can inundate large areas, and the stream channels can migrate by erosion of the banks. The uplands slope toward the flood plains of the major streams and consist of rolling foothills and steep rocky hillsides where the potential flood hazard is minimal; large flood hazards exist, however, in the narrow flood plains of several small tributaries and on the small alluvial fans at the mouths of the tributaries.

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 possible degree of flood hazard related to the physical characteristics of the terrain. Zone 1 is the area along the Santa Cruz River, Rillito Creek, and Cañada del Oro that would be inundated by the 100-year flood. The peak discharge of the 100-year flood is the discharge that will be exceeded on an average of once every 100 years. Water-surface elevations for the 100-year flood and the boundaries of zone 1 were defined by detailed studies using channel geometry and step-backwater computations. The other zones were defined by using maps and aerial photographs and by ground and aerial reconnaissance. The upland slopes have been classified as zones 4, 5, and 6 on the basis of terrain and flood-hazard potential.

The peak-discharge amounts for floods of different recurrence intervals along the major streams were the same as those used by the Federal Insurance Administration (1980a, b). The Federal Insurance Administration (1980a, b) defined the flood boundaries for the Santa Cruz River, Rillito Creek, Cañada del Oro, and most of the large tributaries in greater detail than that of the flood boundaries shown on this map. This study was made by the U.S. Geological Survey in cooperation with the Arizona Department of Revenue.

FLOODING ALONG MAJOR STREAMS

The channels of the Santa Cruz River, Rillito Creek, and Cañada del Oro generally are dry more than 300 days a year; however, high-intensity storms that cover large areas produce floods that overflow the banks. During periods of high flow, a stream channel may migrate owing to bank erosion or to the development of new channels when floodwater overtops the banks of the existing channel. Channel conditions change frequently owing to natural and manmade causes. Manmade features, such as the enlargement of channels along a stream reach and sanitary landfills, have caused large changes in the hydraulic characteristics and capacity of the channels and flood plains.

ZONES 1 AND 2

Zone 1 is the area that would be inundated by the 100-year flood discharge. The estimated peak discharges used in this study for the 100-year floods are 30,000 ft^3/s for the Santa Cruz River upstream from Rillito Creek, 31,000 ft^3/s for Rillito Creek, 28,000 ft^3/s for Cañada del Oro, and 40,000 ft^3/s for the Santa Cruz River downstream from Cañada del Oro. The discharges are considerably greater than those that could be carried within the banks of the existing channels, but the estimates are reasonable (fig. 1). Discharges of this magnitude have been measured along several streams in the Santa Cruz River basin that have smaller drainage areas than those of the major streams. It is unlikely that a 100-year flood will occur on all three streams at the same time; therefore, the discharge for the 100-year flood on the Santa Cruz River downstream from Cañada del Oro is much less than the sum of the three upstream discharge values.

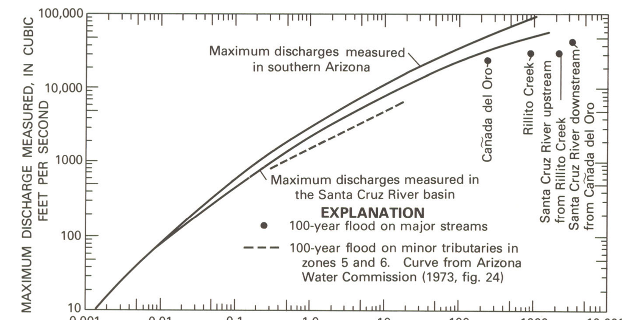

Figure 1.—Relation of maximum discharge measured to size of drainage area.

The boundaries and the elevation 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. The boundaries and elevation of the water surface along Rillito Creek are from the U.S. Army Corps of Engineers (1973), and those along Cañada del Oro are from unpublished work by Blanton and Co. Architects and Engineers; Cella, Barr, Evans, and Associates; and Marum and Marum. The boundaries of the 100-year flood are defined for the channel conditions and manmade developments on the flood plains in 1975. The natural and manmade changes that occurred along Rillito Creek between 1973 and 1975 were minor and do not alter the boundaries as defined by the U.S. Army Corps of Engineers (1973). Zone 1 includes small areas along the major streams that may not be inundated by the 100-year flood. The areas are too small and numerous to be delineated on the map. For detailed potential flood-hazard boundaries based on more recent channel conditions, see flood boundary and floodway maps of the Federal Insurance Administration (1980a, b).

Zone 2 is the part of the flood plain along the major streams that may be inundated by floods larger than the 100-year flood but smaller than the 500-year flood. In much of zone 2, bank erosion and development of new channels are greater hazards than inundation by floodwater, although sediment-laden floodflow could enter zone 2 from small tributary streams. Zone 2 extends from the 100-year flood boundary to the base of the steep slopes along the sides of the valleys. Along much of the west bank of the Santa Cruz River, the boundaries of zones 1 and 2 are close together, and only the boundary of zone 1 is shown. Flow from zone 2 may extend onto the alluvial fans in zone 4. A few knolls in zone 2 are higher than the maximum flood level expected in the adjacent stream. Although the knolls have not been flooded in many years, they could be flooded or eroded by flows from upstream areas.

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

The channels and flood plains in zones 1 and 2 are highly susceptible to erosion. In most reaches of the channels the banks are unstable, the streams carry large sediment loads during floods, the potential for rapid growth of vegetation is large, and the magnitude and occurrence of flood peaks are highly variable. These characteristics make the erosion hazard much greater along these streams than along streams in more humid climates. The degree and speed of the channel changes depend largely on the length of time between large flows. During periods of dominantly low flows, sediment is deposited, vegetation becomes established, and flow velocity is reduced. When a few years pass without a large flow, the channel becomes narrow and meandering; an occasional large flow removes the vegetation and sediment and widens and straightens the existing channel or cuts new channels. For example, in the Gila River about 80 mi northeast of the Jaynes quadrangle the channel width averaged 260 ft in 1905, 2,000 ft in 1917, and less than 200 ft in 1964 (Burkham, 1972).

In 1965 floodwater in Rillito Creek laterally eroded several hundred feet of bank, and several mobile homes fell into the channel. The average elevation of the channel bed of the Santa Cruz River at Cortaro Road rose 4 ft between 1966 and 1973. Near Tumacacori, which is on the Santa Cruz River 50 mi south of Tucson, a dense stand of trees as much as 10 in. in diameter and 30 ft tall grow in a channel that was clean and open in 1969. Although the changes along the Santa Cruz River near Tumacacori and Tucson are the result of the perennial flow of sewage effluent that provides water and nutrients, similar rapid changes in alluvial channels occur under natural conditions.

Manmade changes, such as landfills, dikes, and channelization, are being made on a continuing basis. Between Grant Road and Sweetwater Drive, a landfill blocks a large part of the natural flood plain on the west side of the Santa Cruz River, and a large sewage lagoon blocks the flood plain upstream from Camino del Cerro. Several gravel pits along the Santa Cruz River are enclosed by dikes (fig. 2). The changes alter the natural flow of water in the channel and flood plain and result in higher flow velocities, higher stages, inundation of different areas, and increased scouring of the banks and streambed. A natural or manmade constriction in the main channel may create flood hazards that are not readily apparent. For example, figure 3 shows the reach of the Santa Cruz River upstream from Grant Road where the channel narrows from more than 300 ft to about 120 ft. The constricted reach will convey the 100-year flood discharge, but upstream the overflow through the industrial park may result from the backwater caused by the constriction. If the constricted reach is not widened or deepened, the velocity of the 100-year flood discharge would be more than 16 ft/s; the velocity upstream would be about 8 ft/s. Under these conditions, it is unlikely that the channel will remain stable, and the bed and banks probably would be scoured. Other channel constrictions are present in the area, and additional constrictions can be expected unless they are prohibited by flood-plain management controls. Debris from landfills upstream could lodge on bridges and other obstructions when carried by floodwater and could cause additional backwater.

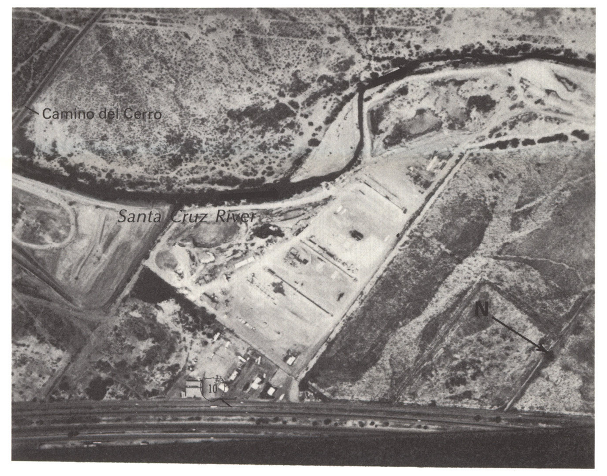

Figure 2.—Gravel pits along the Santa Cruz River in sec. 17, T. 13 S., R. 13 E., about 2,000 ft north of Camino del Cerro. Note how the channel is diverted to the west by the dike around the northernmost pit. This type of channel constriction is common along the river. The arrow indicates the direction of flow. Scale: 1 in.=about 650 ft. Photograph furnished by Cooper Aerial Survey Co.

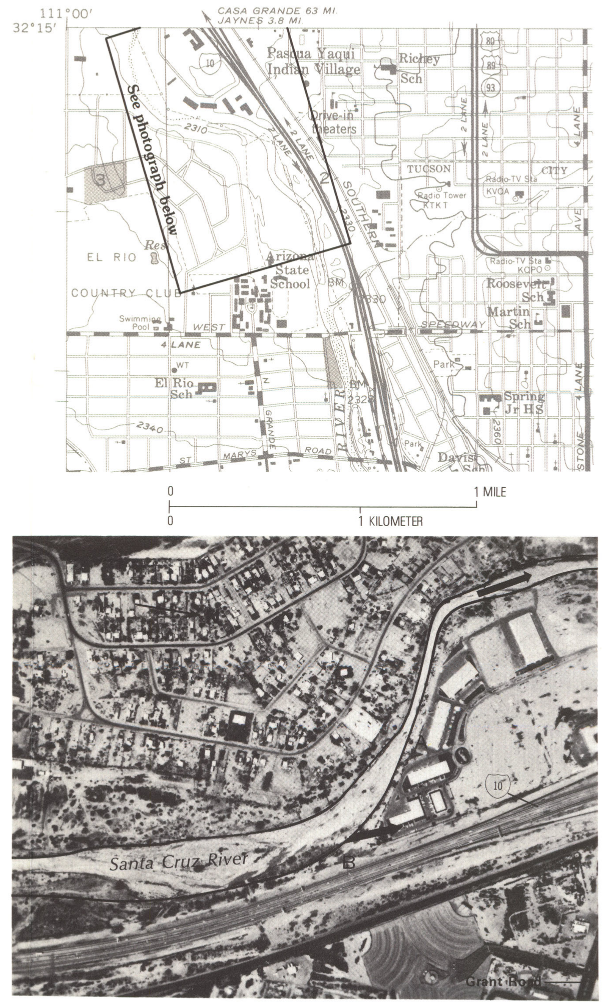

Figure 3.—Santa Cruz River upstream from Grant Road. The constriction at point A on the photograph may cause water to flow over the bank at point B; the water would flow through the industrial park, and buildings would be subject to erosion during major floods. The arrow indicates the direction of flow. Scale: 1 in.=about 800 ft. Photograph furnished by Cooper Aerial Survey Co.

Levees have been built in places along Cañada del Oro, but they are susceptible to erosion and would provide little protection during a major flood. Prior to 1975, a channel was constructed through the Tucson National Golf Course and the housing development northeast of Magee Road. The 100-year flood discharge would be retained within the banks of the channel in the housing development but would inundate part of the golf course. Upstream from Ina Road, the channel of Cañada del Oro was enlarged in 1975 after the surveys for this report were completed. Flood boundary maps of the Federal Insurance Administration (1980a, b) show the effects of the enlarged channel. The flood plain west of the channel was filled to provide a raised area for home construction. Although the channel is large enough to carry the 100-year flood discharge, the banks are unstable and may be eroded easily by a major flood. Since 1975, channel changes have included widening the channel in the 0.6-mile reach upstream from the present channel enlargement and in the reach from the Southern Pacific railroad tracks to Thornydale Road. Development of the flood plain along Cañada del Oro probably will include channelization from the railroad tracks through the Tucson National Golf Course. All improvements have been or will be designed so that the channel will carry the 100-year flood discharge, but the hazard of bank erosion during high flows will remain.

ZONE 3

Zone 3, which is between Rillito Creek and the Santa Cruz River, has local drainage problems but is not subject to flooding by the major streams or upland washes. The natural drainage in zone 3 has been significantly modified by the construction of streets, drainageways, structures, and other developments. On the basis of available data, the area in zone 3 appears to have been a flood terrace prior to urbanization. A distinct break in slope and a rise of about 10 ft at the boundary between zones 2 and 3 are present in most places; in some places, however, no rise is present, and the boundary is indistinct. Flood problems are confined to small areas of ponding and shallow overflow from small drainage channels.

FLOODING IN THE UPLANDS

Rolling foothills and steep rocky slopes make up about two-thirds of the Jaynes quadrangle. The flood-hazard potential on the slopes generally is confined to the narrow flood plains of small tributaries and to the small alluvial fans at the mouths of the tributaries. The upland slopes have been classified as zones 4, 5, and 6 on the basis of terrain and flood-hazard potential.

ZONE 4

Zone 4 is an area of distributary or undefined channels where flows from major floods move overland as sheetflow. The zone includes several active alluvial fans, where small tributaries debouch onto the flood plains of one of the major streams, and the south end of a wide alluvial plain that extends along the base of the Tortolita Mountains, which are north of the map area. The distributary channels are cut in fairly coarse sand and gravel and are unstable. The channels erode easily, frequently change direction and location, and can become main channels. An entire fan may be subject to flooding and to deposition of sand and gravel.

The flood-hazard potential ranges from minimal on the alluvial plain to severe on some of the small fans. The most severe potential hazard is in the area shown by the stippled pattern at the mouth of the unnamed tributary that leaves zone 5 near the SW cor. sec. 24, T. 12 S., R. 12 E. (fig. 4). The tributary drains several square miles and could cause severe flooding on the alluvial fan. On the alluvial plain north of the area shown by the stippled pattern, the potential flood hazard is minimal. The plain is a considerable distance from the sources of flooding, and flows more than a few inches deep seldom occur, which is in contrast to the fairly severe potential hazard that exists in the part of the plain in the Marana quadrangle (Aldridge and Burkham, 1974).

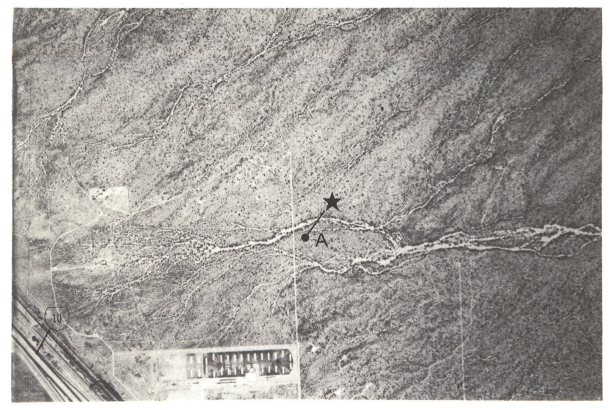

Figure 4.—Flood plain and fan near the mouth of an unnamed tributary in the SW cor. sec. 24, T. 12 S., R. 12 E. The dot indicates the location of a special hazard. Scale: 1 in.=about 2,000 ft.

Most of the defined channels that enter zone 4 drain only a few square miles. Floodflows that enter zone 4 from zone 5 have high velocities and carry large sediment loads, and much of the sediment is deposited in zone 4. A channel that would confine the amount of water carried by one of these streams would be easier to design than a channel that would carry the sediment. Near Tucson, channels built in terrain similar to that in zone 4 generally are filled with sediment during major floods.

Parts of some alluvial fans in zone 4 can be flooded either by the tributary that formed them or by the adjacent major stream. Flooding by the tributary would result from floods having recurrence intervals of less than 100 years, and flooding from the major stream would result from floods having a recurrence interval of more than 100 years. A small area in the northwest corner of the map also may be flooded by small tributaries and by the Santa Cruz River. Sheetflow from the mountains to the west of the quadrangle is considered to be a greater potential hazard than flow from the Santa Cruz River; therefore, this area is designated as zone 4 instead of zone 2.

ZONES 5 AND 6

Zone 5 is an area of moderately to highly dissected alluvial slopes that contain closely spaced stream channels separated by distinct alluvial ridges. Floodwater is confined to the channels and narrow flood plains, and the ridges are large flood-free areas. Zone 6 is 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 for each square mile of drainage area are common (see fig. 1).

In zone 5, floodwater may carry large amounts of debris scoured from the streambeds and flood plains and redeposit the material in a thick layer downstream in zones 2 or 4. The stippled patterns shown along the major tributaries in zone 5 indicate flood plains that have an above-average potential hazard from erosion and inundation. Although the flood plains generally are flat and appear to be ideal building sites (fig. 5), the potential hazards are great because the flood plains may be inundated and the channels may move laterally in either direction across the flood plains. Flood peaks generally are 5 to 8 ft above the streambed in the large tributaries, and greater rises 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; however, most reaches 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 area shown by the crosshatched pattern in sec. 24, T. 12 S., R. 12 E., has slightly different drainage characteristics from the rest of zone 5 because the area is downstream from a system of distributary channels in which the distribution of flow is unknown.

Figure 5.—Downstream view of the channel and flood plain of a small tributary to the Santa Cruz River in sec. 33, T. 13 S., R. 13 E. The flood plain, which extends across the entire photograph, is subject to inundation and erosion.

The boundary between zones 5 and 6 is indistinct. The slope between the Tucson 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 2 mi^2, and the maximum flow depth seldom exceeds 7 ft except where a channel is blocked by boulders and 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 that flows downstream from zone 6 could cause severe flood hazards in downstream zones.

FLOOD-HAZARD POTENTIAL AND EFFECTS OF URBANIZATION

In 1975 about a quarter of the land in the Jaynes quadrangle was covered by extensive urban development. Urbanization has spread to the upland slopes along the major streams and has encroached on the frequently inundated parts of the flood plains. Housing developments occupy large parts of the Rillito Creek flood plain, and several developments are planned or are under construction along Cañada del Oro. Most of zone 1 along the Santa Cruz River has not been developed, and many areas subject to shallow flooding along the fringes of the zone could be blocked without causing the flood level to rise appreciably in the main channel; however, buildings would be subject to damage by erosion. Alteration of the channels of the major streams to enable them to carry more water may reduce flood levels and protect areas from inundation; however, flood-proofing measures may be ineffective because of the tendency of the streams to move laterally within their flood plains and to scour new channels. Urbanization in zone 1 will be subject to the existing flood hazards, and extensive urbanization may create additional flood hazards.

Most of the land in zone 2 is used for agricultural purposes or is in its natural state. In places, however, urbanization is dense, and several large developments are planned. In much of zone 2, bank erosion, development of new channels, and channel migration are greater hazards than inundation by floodwater.

Urbanization in zone 3 is of low to medium density, and the flood problems are confined to small areas of ponding and shallow flooding. Unless future developments are well planned, the flood-hazard potential may increase.

Urbanization in zones 4 and 5 could change the hydrologic characteristics in zones 2, 4, and 5. Many of the poorly defined channels in zone 4 probably would be obliterated or relocated, and new channels would be formed. Dense urbanization generally increases runoff from small amounts of rainfall and causes more frequent moderate floods. Channelization in one area can greatly increase the flood hazards in downstream areas. Whether urbanization in zone 5 will increase or decrease the flood hazard will depend on the methods used to develop the area. A dense network of streets, storm drains, and channels to convey the flow quickly out of an area would increase the magnitudes of peak discharge. Circuitously routed streets and patio walls and lawns reduce peak flows. Small culverts reduce peak flows downstream if the water is ponded upstream from the culverts. The flood-hazard potential is increased upstream from culverts if the ponding is great enough and is increased downstream if culverts are washed out. Urbanization and paving of the type east of the Santa Cruz River and south of Cañada del Oro greatly increase flood peaks. The existing type of development west of the Santa Cruz River—scattered multiacre lots generally in a natural state—causes 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 may greatly reduce the probability of future development in this zone.

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