

JANUARY 1993 FLOODS PIMA COUNTY, ARIZONA



Summary Report July 1993

Pima County Department of Transportation
and Flood Control District

Prepared for the
Pima County Board of Supervisors
sitting as the
Flood Control District Board of Directors

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APPENDIX A Pima County Flood Warning System

APPENDIX B Summary of Flood Repair Costs and Related Financial Data
Transportation and Flood Control Facilities

1.0 INTRODUCTION

During January 5th - 19th, 1993, heavy rain fell over most of central and southeast Arizona, resulting in significant flooding along most major watercourses. In Pima County, raging floodwaters, sediment deposition and extensive bank erosion caused severe damage to public infrastructure and significant damage to private property.

1.1 Overview of January 1993 Flooding

Perhaps the most unusual feature of the January 1993 Floods was the prolonged extent of rainy days and flooded washes. Although a three-or-four day rainy period with associated flooding like that in October 1983 would raise few eyebrows, the 15-day period of heavy rain and high floodwater stages was one of the most extensive wet winter periods witnessed in recent times in the greater Tucson area.

Emergency response personnel, private property owners and contractors worked long hours to protect areas threatened by flooding and erosion, and to repair damaged sites. The prolonged period of heavy rain caused added concern for Pima County Department of Transportation and Flood Control District (PCDOT & FCD) personnel, as temporary repairs completed to protect some areas damaged after the January 7th-8th flood were threatened by the continuing rain. As discussed in Chapter 5.0, additional repairs were constructed as needed to protect vulnerable locations from the protracted flooding.

During the height of the flooding, access to some locations was eliminated for several days. In the aftermath of the flooding, the Pima County Board of Supervisors (Board) caused the construction of the Tanque Verde Road bridge over the Agua Caliente Wash and the Rillito Bank Stabilization project to be expedited, to minimize future flood losses.

1.2 Purpose

The purposes of this report are three-fold: 1) to describe the magnitude and location of flooding and related damage along the major watercourses in eastern Pima County; 2) to compare the January 1993 Floods to the October 1983 Flood; and 3) to propose actions which should be taken by the Pima County Flood Control District (District) in response to the flooding.

Because this is a summary report, only brief discussions of the various topics are provided. Tables and figures are used when possible to convey a maximum amount of information in a brief format. As a large number of sites were damaged, only those with the greatest damage are discussed herein; however, most sites which incurred significant damage are listed in the tables.

2.0 RAINFALL AND RUNOFF

2.1 Weather Pattern and Flooding Affecting the State

During January 1993, the entire state of Arizona was affected by abnormal weather patterns which caused excessive rainfall and flooding across much of the state. The prolonged period of heavy rain lasted about two weeks, and resulted in multiple flood peak discharges on most watercourses.

Winter storms impacting the state typically originate in the Gulf of Alaska and pass over the Pacific northwest, losing most of their moisture before they reach Arizona. However, a series of low pressure systems stationed over the northeast Pacific Ocean caused the polar jet stream to shift southward, where the warmer-than-normal system picked up subtropical moisture from the Pacific Ocean west of Baja California. This warmer and wetter-than-normal system impacted California and then Arizona with a fury (Figure 2.1).

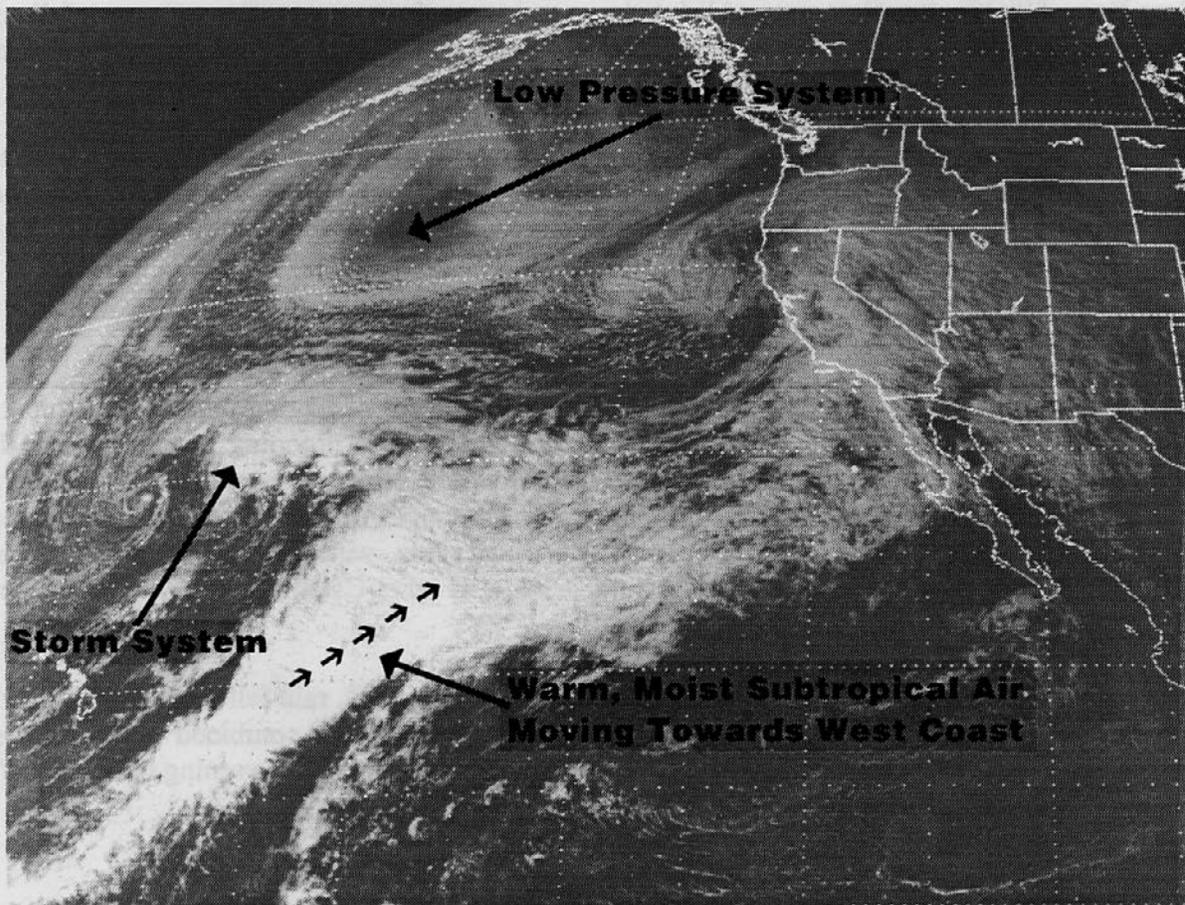


FIGURE 2.1

National Weather Service photograph, January 7, 1993; 2:15 P.M.

The Pacific storms were both a blessing and a disaster for California: the state's six-year drought was ended, but mudslides destroyed or severely damaged several residences perched along steep slopes near the coast. After dumping much rain in California, the fully-formed storms continued eastward.

In Arizona, many locations experienced record precipitation. The unusually warm rains melted snow in upper watersheds, contributing to record floodwater volumes on many major watercourses in central and southern Arizona. Statewide, the Verde, Salt, and Gila River watersheds were hardest hit; a peak discharge estimated at 145,000 cfs on the Salt River raged through Phoenix (Chris Smith, USGS), resulting in the collapse of portions of the partly-constructed Mill Avenue bridge.

Southeast of Phoenix, the San Carlos Reservoir behind Coolidge Dam, a dangerous federal dam according to a 1988 Interior Department report (Safety of Dams Modification Report for Coolidge Dam, Nov. 1988) was filled to capacity. By January 20th, a series of back-to-back storms and associated runoff caused a record 32,849 cfs to pour over the spillway and down the Gila River (Greg Pope, USGS), flooding parts of Winkelman and areas downstream. Excessive rainfall and snowmelt continued across the northern part of the state into February, causing more flooding primarily in the Flagstaff area and along the Gila River.

Throughout January and part of February, many flood warnings were issued across the state; widespread damage to residential and agricultural areas along the Gila River caused Governor Symington to declare a State of Emergency effective January 5, 1993. President Bush later declared the state a Federal Disaster Area on January 19, 1993.

2.2 Overview of Local Storm and Flooding

Although the flooding in eastern Pima County was widespread, damaging public infrastructure and private property in several locations, it was not as severe as flooding in Counties to the north. Weather patterns responsible for the January flooding were in place and bringing warm rains to the Tucson area as early as late December. On December 27th and 28th, 1992, heavy rains and snowmelt near Mount Lemmon caused flooding along watercourses in the northeast metropolitan area; Tanque Verde Creek, Sabino Creek, and other Catalina foothills washes were flowing heavily.

Beginning on January 5th, 1993 and extending through January 19th, rain fell in Pima County on an almost daily basis. The initial heavy rainfall on January 5th and 6th combined with snowmelt in the Santa Catalina Mountains resulted in severe flooding beginning the evening of January 7th, primarily in the northeast metropolitan area.

Areas near Agua Caliente and Finger Rock Washes and Tanque Verde and Sabino Creeks were most heavily affected. These in turn drain to Rillito Creek, where the observed and recorded peak discharge on January 8th was almost as large as in the October 1983 Flood. During the January 1993 Floods, severe bank erosion occurred on Rillito Creek from Craycroft Road to Interstate Highway 10 (I-10). On January 8th, flows in the Santa Cruz River upstream of the Rillito Creek confluence were relatively less than those in the northeast washes, as less rain fell over the upper Santa Cruz River watershed.

On January 17th and 18th, a cooler system which moved into the area from the south resulted in storms more heavily centered over the upper Santa Cruz River watershed. From the Santa Cruz to the Pinal County line, flooding and related damage along the Santa Cruz River were greater in this storm than on January 7th and 8th. Several bridge approaches were damaged, overbank flooding inundated agricultural areas north of Green Valley and in Marana and areas to the north, and significant erosion occurred in several locations where the banks are unprotected.

Convective rainfall which occurred over the foothills areas on January 17th and 18th impacted the Catalina foothills washes to a lesser extent than on January 7th and 8th. Although the observed and measured flood peak discharges on the Santa Cruz River downstream of the Rillito confluence were similar on January 7th and January 18th, the distribution of contributing flows was not: a larger portion of flow in the earlier event originated from the northeast metropolitan area, whereas most of the discharge on January 18th originated on the upper Santa Cruz River watershed.

2.3 Rainfall and Peak Discharge Data

The District obtains real-time rainfall and peak discharge data from the ALERT flood warning system (Automated Local Evaluation in Real Time). Rainfall and streamflow data are transmitted via UHF radio signals to a repeater site on Mount Lemmon, where they are transformed into microwaves and transmitted to the County Communications Center (part of the Pima County Sheriff's Department), located on Ajo Highway near Kino Parkway. At the County Communications Center, the signal is rebroadcast via UHF radio signals to computers at the Tucson National Weather Service Office and the District's office in the County-City Public Works Building. Additional information regarding the ALERT system is provided in Appendix A.

During the January 1993 Floods, the District operated 47 precipitation gages and 21 stream gages. Of these, 97% of the precipitation gages and 87% of the stream gages were operational during the flooding (Figure 2.2). Watersheds monitored during the January 1993 Floods included the Santa Cruz River, Rillito Creek, Cañada del Oro (CDO) Wash, Tanque Verde Creek, Sabino Creek, Ventana Canyon Wash and Rincon Creek.

ALERT system precipitation totals for January 5th - 19th are shown on Figure 2.3. Rainfall depths ranged between 1.11 inches at Green Valley and 8.83 inches at Mt. Lemmon, with the most precipitation recorded in the north- and south-facing foothills of the Santa Catalina Mountains. Table 2.1 summarizes daily rainfall depths for January 5th - 19th, 1993 at selected gages. In the discussion which follows, total depths for all ALERT precipitation gages within each watershed were arithmetically averaged for ease of comparison.

**TABLE 2.1 - DAILY RAINFALL DEPTHS - PIMA COUNTY FLOOD CONTROL DISTRICT
JANUARY 5 - 19, 1993**

	1/5	1/6	1/7	1/8	1/9	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	TOTAL
Santa Cruz River																
6050 @ Continental	0.35	0.75	0.04	0	0.63	0	0	0.12	0	0	0.31	0.04	0.55	0.08	0	2.87
6330 @ Anamax near Green Valley	0.51	0.28	0.12	0.04	0.04	0	0	0.04	0	0	0	0	0.04	0	0.04	1.11
6040 @ Valencia Road	0.63	0.71	0.04	0.08	0.31	0	0	0.47	0	0	0.04	0.04	0.79	0.08	0	3.19
6020 @ Cortaro Road	0.51	1.06	0.55	0	0.2	0.08	0	1.02	0	0	0.08	0	0.59	0.35	0	4.44
3050 Rillito Creek @ Dodge Blvd. Bridge	0.39	0.94	0.51	0	0.28	0.04	0.04	0.14	0	0	0.08	0	0.75	0.12	0	3.29
Tanque Verde Creek																
2080 @ Alamo Tank near Redington Road	1.02	1.93	0.98	0.12	0.67	0.16	0	0.79	0.08	0	0.47	0.2	1.42	0.35	0	8.19
2090 @ Tanque Verde Guest Ranch	0.91	1.54	0.51	0.04	0.55	0.12	0	0.87	0.04	0	0.35	0.08	1.14	0.20	0	6.35
2120 @ Sabino Bridge	0.71	1.34	0.63	0.12	0.51	0.08	0	1.02	0	0	0.16	0	1.54	0.08	0	6.19
Sabino Creek																
1090 @ Mount Lemmon	1.34	2.28	0.83	0.16	0.51	0	0.35	0.12	0.08	0.2	1.34	0.87	0.67	0	0.08	8.83
2160 @ Sabino Canyon Recreation Area Dam	0.79	1.54	1.06	0.08	0.67	0.2	0	0.87	0	0	0	0	1.54	0.28	0	7.03
3310 Alamo Wash @ Glenn	0.28	1.1	0.47	0.04	0.47	0.08	0.04	0.91	0	0	0.16	0	1.14	0	0	4.69
4280 Cienega Creek @ I-10	0.08	1.02	0.12	0	0.51	0.04	0	0.16	0	0	0	--	0.55	0.12	0	2.60
1010 Cañada del Oro @ Golder Ranch	0.54	0.91	0.79	0	0.55	0.31	0	0.67	0	0	0.28	0.08	1.06	0.31	0	5.50

* Incomplete record. Note: These data represent the best information available at this time.

As shown in Figure 2.3, the highest total rainfall depths were recorded in the northeast and north central metropolitan areas, and in the upper CDO watershed. The highest average depth for a watershed, 7.93 inches, occurred on the Sabino Creek watershed; the next highest average of 6.34 inches was recorded on the Tanque Verde Creek watershed. An average depth of 6.04 inches was recorded on the upper CDO watershed.

No precipitation gages are located in the Aqua Caliente Wash watershed, where some of the most severe flooding occurred; however, it is likely that rainfall on this watershed was similar to that on the Sabino Creek and Tanque Verde Creek watersheds. The lone rainfall gage on Rillito Creek received 3.29 inches total rainfall.

An average rainfall depth of 3.18 inches occurred on the upper Santa Cruz River watershed in Pima County. An average depth of 2.37 inches, the smallest of all the watersheds monitored, was recorded at Cienega Creek.

Table 2.2 shows ALERT and United States Geological Survey (USGS) streamflow data for the major watercourses; the regulatory (100-year) peak discharge is provided for comparison. Selected maximum peak discharge data ranged from 1,590 cfs recorded January 8th on the Cañada del Oro Wash north of the Pinal County line to 40,000 cfs recorded January 18th on the Santa Cruz River at the Cortaro Road bridge.

Based on stream stage observations and District and USGS data, maximum peak discharges were recorded on January 8th for the Rillito, Sabino, Tanque Verde and Rincon Creeks. The peak flow of 28,000 cfs on Rillito Creek approached the regulatory peak flow of 32,500 cfs; the USGS peak flow on Sabino Creek, 10,820 cfs, approached the regulatory peak flow of 12,500 cfs. Note that the locations for which the regulatory peak discharge is specified differ from those where the flows were recorded. Also note that the peak discharge measured on Rillito Creek at Dodge Boulevard was much larger on January 8th (28,000 cfs) than on the 18th (13,500 cfs).

On the Santa Cruz River, the maximum peak discharge occurred early in the morning on January 18th, as rainfall during this storm was most heavily concentrated on the upper Santa Cruz River watershed. Peak discharges of 35,800 cfs and 22,000 cfs were recorded at the Continental Road and Valencia Road bridges, respectively. The 40,000 cfs recorded January 18th at the Cortaro Road bridge includes flows contributed from Rillito Creek.

The peak discharge recorded on the CDO Wash was comparatively small; this was consistent with flow observations and the relatively minor amount of damage received. The discrepancy between high rainfall received on the upper watershed and low streamflow values may possibly be attributed to large sand and gravel pits located in Pinal County which may have provided detention during the January 1993 Floods; this remains to be investigated and is speculative only.

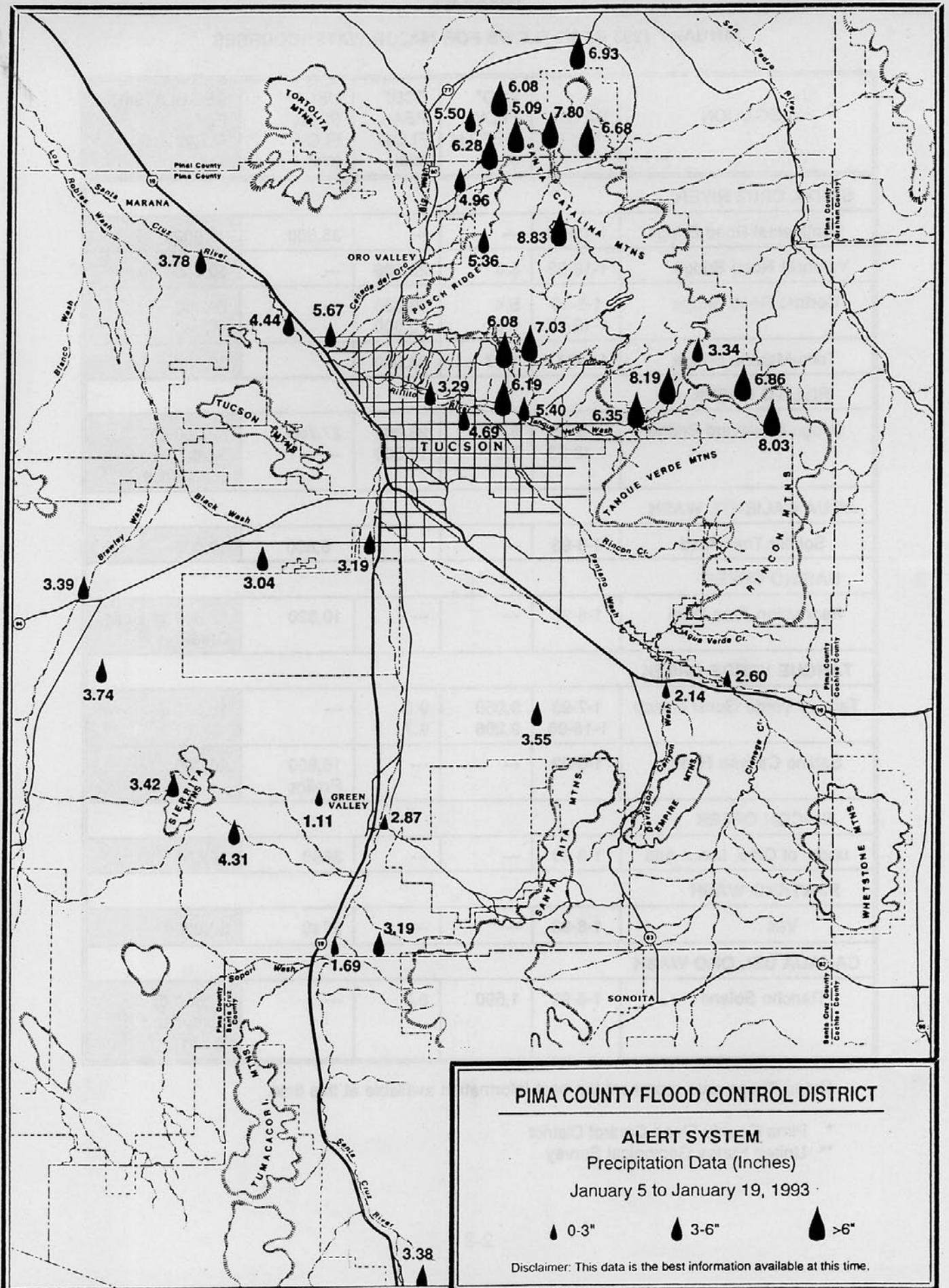


TABLE 2.2

JANUARY 1993 PEAK FLOWS FOR MAJOR WATERCOURSES

LOCATION	DATE	FCD* FLOW DEPTH (feet)	FCD* PEAK FLOW (cfs)	USGS** PEAK FLOW (cfs)	REGULATORY PEAK FLOW (cfs)
SANTA CRUZ RIVER					
Continental Road Bridge	1-19-93	---	---	35,800	45,000
Valencia Road Bridge	1-18-93	8.0	22,000	---	60,000
Cortaro Road Bridge	1-8-93	5.4	39,000	---	70,000
	1-18-93	6.0	40,000		
Trico-Marana Bridge	1-8-93	12.7	38,000	---	70,000
RILLITO CREEK					
Dodge Boulevard Bridge	1-8-93	8.3	28,000	27,700	32,000 @ Santa Cruz confluence
	1-18-93	5.6	13,500	---	
AGUA CALIENTE WASH					
Soldier Trail Road	1-8-93	---	---	5,800	12,000
SABINO CREEK					
Recreation Area Dam	1-8-93	---	---	10,820	12,500 @ Bear Creek
TANQUE VERDE CREEK					
Tanque Verde Guest Ranch	1-7-93	9,950	9.0	---	16,000
	1-18-93	9,206	8.7		
Sabino Canyon Road	1-8-93	---	---	16,800 Prelim.	28,000
RINCON CREEK					
upstr. of Cmo. Loma Alta	1-8-93	---	---	3680	16,000
PANTANO WASH					
Vail	1-8-93	---	---	2230	30,000
CANADA DEL ORO WASH					
Rancho Solano	1-8-93	1,590	6.5	---	17,500 @ Sutherland Wash

Note: These data represent the best information available at this time.

* Pima County Flood Control District

** United States Geological Survey

3.0 AGENCY RESPONSIBILITIES AND INTERAGENCY COORDINATION

Prior to and during a flood emergency, several local agencies share information and coordinate the response to safeguard life and property. Coordination occurs among the National Weather Service (NWS), the Tucson - Pima County Office of Emergency Services (Emergency Services), and the Pima County Department of Transportation and Flood Control District (PCDOT & FCD). Details on each agency's responsibilities and interagency coordination are provided in the sections below.

3.1 National Weather Service (NWS)

Much interaction occurs between NWS and the above-referenced agencies prior to and during flooding as NWS is the sole agency empowered to issue weather forecasts. Of primary importance in forecasting is the local weather radar system, operated and maintained by NWS at their Tucson International Airport Office. Radar data provide information on the direction of storm movement, and the size, precipitation intensities, aerial extent, and growth or decay of storms. The data are transmitted to the District via a dedicated phone line, and can be viewed on a monitor at the District's downtown office.

NWS is also responsible for issuing urban and small stream advisories, and flash flood watches and warnings to local agencies and the community as warranted. An urban and small stream advisory is issued when there is a potential for flooding to occur; a flash flood watch is issued when weather patterns are conducive to flooding; and a flash flood warning is issued when flooding is imminent or is actually occurring. The NWS forecast data and issued statements are automatically transmitted to PCDOT & FCD via the District's ALERT Flood Warning System.

Prior to issuing a flood warning statement, staff of the local NWS office confers with District ALERT system personnel regarding when to issue the statement. When a flood warning statement is issued, NWS notifies the County Communications Center, and the County Communications Center in turn notifies Emergency Services and PCDOT & FCD. Emergency Services also notifies the Chairman of the Pima County Board of Supervisors, other County Departments and community support organizations.

Anticipated rain caused NWS to issue a flash flood watch for southeastern Arizona, including Tucson, on January 5th, 1993 at 2:50 P.M. A statewide flash flood watch was subsequently issued at 3:45 A.M. on January 7th, applicable for next several days. Locally, flash flood warnings for Tucson and eastern Pima County were issued by NWS prior to 9:00 A.M. on January 8th; at 9:26 A.M. on January 13th; at 8:49 A.M. on January 18th; and at 1:00 A.M. on January 19th (personal communication, Tom Zickus, NWS, April 1993).

3.2 Tucson-Pima County Office of Emergency Services

Locally, the Tucson-Pima County Office of Emergency Services (Emergency Services) is the lead agency which coordinates the response to emergencies, including flooding. Emergency Services is part of the Pima County Sheriff's Department, and the Pima County Sheriff is the designated Director of Emergency Services. During an emergency, activities are monitored and the response coordinated from the Emergency Operations Center (EOC), located in the Sheriff's Administration Building on East Benson Highway near Kino Parkway.

When flooding begins in Pima County, staff of the Sheriff's Department and PCDOT & FCD's Operations Division are dispatched to vulnerable locations to assess the situation and report back to the EOC. Real-time information on rainfall and stream stage is provided to the EOC by PCDOT & FCD staff operating the ALERT Flood Warning System.

When the magnitude of flooding warrants close coordination with other agencies, representatives from various County and City departments, local utility companies, and other municipalities as needed are called in to the EOC to coordinate the emergency response. The EOC becomes, in effect, the main "nerve center" for emergency response activities; decisions are made there regarding the prioritization and proper use of resources.

During major flooding, the EOC also coordinates requests for emergency response assistance from state and federal sources, and other southern Arizona counties as warranted. General information regarding assistance available, and specific information regarding emergency assistance received during the January 1993 Floods, are discussed respectively in Chapters 4.0 and 5.0.

During the January 1993 Floods, the EOC was initially activated at about 4:00 P.M. on January 7th, and remained operational until about 11:30 P.M. that night; it was reactivated several times during the next two weeks as conditions warranted (Mike Walsh, Pima County Sheriff's Department). Due to the extensive damage to public infrastructure and private property, a State of Disaster was declared by the Chairman of the Board of Supervisors, the Governor of the State of Arizona, and, finally, the President of the United States. Details regarding the official declarations are provided in Chapter 4.0.

3.3 Pima County Department of Transportation and Flood Control District (PCDOT & FCD)

Several PCDOT & FCD staff respond to flood emergencies. The Director assists the EOC in making key decisions regarding emergency response; the Operations and Flood Control Planning and Development Divisions provide flood warning and emergency response functions; and the Engineering Division assists in emergency response. Additionally, the Director may request help from other PCDOT & FCD Divisions as warranted.

PCDOT & FCD staff responds to emergency flood situations as prescribed in a Pima County document titled Disaster Control Plan -Departmental Standard Operating Procedures. As the Plan applies only to unincorporated Pima County, other jurisdictions such as the City of Tucson are responsible for their respective disaster and emergency response plans.

3.3.1 Director's Office

During major flood emergencies, the Director is ultimately responsible for decisions regarding PCDOT & FCD's emergency response actions. To ensure that the Department's response is quick and efficient, and to provide guidance as needed, the Director is in close contact with and oversees all PCDOT & FCD Divisions' flood emergency activities.

Typically, the Director delegates many decisions regarding emergency repair to the Manager of the Operations Division, who is most familiar with specific field conditions, and the Manager of the Engineering Division. Additionally, except for road and bridge closure information provided by the Operations Division, the Director's Office provides information to the general public about flooding and related items. The Director also keeps the Board of Supervisors and County Administrator informed of flood-related activities, and responds to their requests for information.

3.3.2 Operations Division

The Operations Division maintains and repairs Pima County's transportation and drainage infrastructure. Pima County is divided into six maintenance districts, each with a supervisor responsible for activities within his respective district. During flooding, district supervisors are heavily relied upon due to their familiarity with and expertise in responding to problem areas within their respective districts.

As water levels rise, Operations Division staff is dispatched to the field to monitor conditions. Flood Control District staff monitoring the ALERT flood warning system provides weather forecast data to Operations Division personnel, so they can best allocate resources to respond to the flooding. Operations Division staff in turn updates District staff on field conditions, and District staff closely monitors problematic areas.

During flooding, the Operations Division Manager is responsible for identifying and providing resources (manpower, equipment, and supplies) as needed to respond to flood emergency conditions. Operations Division staff places barriers at dangerous roadway crossings and other locations to prohibit entry; performs emergency maintenance on damaged infrastructure; and updates the EOC on field conditions. Private contractors are used as necessary to support County staff making emergency repairs. Operations Division personnel also provide lists of road and bridge closures to the Director's Office, Emergency Services, school districts and the media.

Typically, six to ten storms per year require emergency response activities, often after "normal" working hours. PCDOT and FCD personnel take action as necessary and with minimal delay; Operations Division staff works long hours to repair damaged infrastructure in order to minimize disruption within the community.

During the January 1993 Floods, Operations Division staff worked round-the-clock. Even before the January 8th flood emergency was declared, staff was performing emergency repairs at four high-priority locations. Details on the number and location of sites damaged, the type of damage incurred, and repair cost estimates are provided in Chapters 5.0 and 7.0.

3.3.3 Flood Control Planning and Development Division

The Flood Control Planning and Development Division includes the Flood Control Planning and Floodplain Management Sections. Flood Control Planning Section staff monitors the ALERT Flood Warning system and NWS radar data and issued statements, and provides weather forecast and real-time rainfall and stream stage data to Emergency Services and other local jurisdictions.

Floodplain Management Section staff establishes a base station in the downtown District office to monitor critical areas, and directs field investigation/damage assessment by staff from both sections during and after flooding. Floodplain Management Section staff also investigates drainage complaints on private property when so-requested by the owner or occupant.

During the January 1993 Floods, the base station was operational for almost two weeks. Investigation/damage assessment teams were sent to headwater and upstream areas to evaluate the potential for downstream flooding; observations were called in regarding whether the water surface elevation was rising or falling; ALERT Flood Warning System flow gages were checked to ensure they were functioning properly; high water marks were made to enable evaluating peak discharges; and, last but not least, damage to public infrastructure and private property was documented. As appropriate, information was relayed to Emergency Services EOC and other County personnel.

During and after flooding, District staff compares the extent of flooding to the federally-mapped floodplain, in order to field-check the established flood limits. Observed flood limits from the January 1993 Floods compared favorably with mapped flood limits.

The ALERT/Flood Warning System is relied upon heavily by District staff and Emergency Services to determine where, when, and how to respond to flood emergencies. Based on the availability of NWS information, reports on field conditions from Operations Division and District staff, and ALERT system rainfall and stream stage data, District personnel have the expertise and the most complete information to assess flooding potential and severity; consequently, District staff updates Emergency Services as conditions warrant. Additional details on the ALERT/Flood Warning System are provided in Appendix A.

3.3.4 Engineering and Field Engineering Divisions

The Engineering and Field Engineering Divisions are most knowledgeable about the design and construction, respectively, of roads, bridges, soil-cement bank stabilization, and other public infrastructure. During flooding, Engineering Division staff "makes calls in the field", i.e., they make on-the-spot decisions regarding how to best repair and protect damaged infrastructure, and guide Operations Division personnel responding to the most critically-damaged locations.

Engineering Division personnel also inspect bridges for damage and recommend closure as warranted. Additionally, staff assesses the magnitude of damage to infrastructure, and the extent of temporary and permanent repairs needed. Engineering Division staff designs or assists in the design of emergency and long-term repairs as warranted.

During the January 1993 Floods, staff assisted in emergency response at several locations. Federal assistance was provided by the Soil Conservation Service (SCS) and Army Corps of Engineers (COE), with staff from the Operations and Engineering Divisions serving as PCDOT & FCD's liaison. Field Engineering Division staff provided material testing and survey services needed for emergency repairs.

4.0 FLOOD DECLARATIONS AND EMERGENCY ASSISTANCE AVAILABLE

This chapter includes general information on agencies which provide emergency assistance during flooding. Chapter 5.0 identifies six sites at which major emergency assistance was received, and specifies the type of assistance provided and by whom.

To receive assistance during and after a flood emergency, a formal declaration of a disaster by the appropriate authorities is required. Assistance may include technical help to assess damages and the type and cost of needed repairs. More often, however, financial aid is provided by the federal and state governments to enable the local agency to recover emergency repair costs and construct long-term repairs. During the January 1993 Floods, PCDOT & FCD Operations Division personnel maintained records to substantiate emergency expenditures and enable reimbursement from available sources.

Soon after the onset of heavy rains, an emergency disaster was declared by the local and state governments, as the resources needed to respond to the emergency exceeded those available locally. A federal flood disaster was subsequently declared, making federal funds available to public agencies and private citizenry. The Tucson-Pima County Office of Emergency Services coordinated the solicitation of federal and state aid for emergency repairs.

4.1 Local

The Tucson-Pima County Office of Emergency Services (Emergency Services) is responsible for informing the Pima County Board of Supervisors (Board) about flood status, weather forecasts, and the ability of county staff to manage flood emergencies. The Board in turn is responsible for declaring disasters in Pima County, thereby recognizing as well as alerting others to the severity of the emergency; and providing justification for dedicating and soliciting additional funding and resources to respond to the emergency.

On January 8, 1993 the Board unanimously declared Pima County a disaster area due to severe damage to roads, bridges and drainageways. Emergency Services was directed to request disaster assistance from the State of Arizona Division of Emergency Services as the needs were "beyond the ability of Pima County to meet individually."

To construct emergency and long-term repairs for flood and related damage incurred during January 5th -19th, Pima County estimated over \$13.0 million would be needed. Before the flooding occurred, approximately \$408,000 in PCDOT & FCD funding was available for use in emergency situations, including \$250,000 from the District's annual budget for Emergency Repairs/Improvement Districts, and \$158,00 in unused carryover from prior years. PCDOT & FCD's annual operation and maintenance budget under "normal" conditions is about \$1,700,000. It was readily apparent that PCDOT & FCD's emergency funding would be depleted and regular funding for the remaining fiscal year dramatically affected by repairs necessitated by the flooding.

On January 19, 1993 the Board authorized the use of \$1.0 million of General Fund Contingency monies for flood repairs; they also voted to accelerate the construction of a bridge across Agua Caliente Wash at Tanque Verde Road. The bridge would be funded by Municipal Property corporation bonds, and construction could begin as early as October 1993.

4.2 State

The Arizona Division of Emergency Services is responsible for informing the Governor about disaster-related occurrences throughout the State. Governor Symington on January 8, 1993 toured Arizona by helicopter and later that day declared a State of Emergency throughout Arizona, effective January 5th when the heavy rains began.

The disaster proclamation enabled \$100,000 from the General Fund to be made available to the Arizona Division of Emergency Management (Emergency Management), the agency responsible for coordinating federal aid to affected counties (from the Federal Emergency Management Agency, FEMA). Emergency Management coordinates the procurement of federal assistance to repair damaged public infrastructure through two programs: the 1) Public Assistance Program and 2) Hazard Mitigation Program. Public Assistance funding is provided on a cost-sharing basis; FEMA contributes 75% of the funding, the State contributes 15%, and local governments pay the remaining 10%. Hazard Mitigation Program funding is used for long-term post-flood repairs; the cost-sharing ratio is not straightforward and is not described herein.

As part of the Public Assistance Program, FEMA begins to disburse funds immediately after Damage Survey Reports (DSR's) have been submitted and approved. According to guidelines of the Hazard Mitigation Program, however, before federal funds are disbursed, Emergency Management must, in cooperation with the affected Counties, devise a statewide plan (Plan) to prevent future flood and erosion damages, and the Plan must be approved by FEMA (Barbara Corsette, Arizona Division of Emergency Management).

While Emergency Management coordinates the procurement and disbursement of federal assistance, the State Legislature may appropriate State emergency funds to be administered through ADOT and the Arizona Department of Water Resources (ADWR). State matching funds may be provided for federal emergency assistance programs which require financial participation from local jurisdictions.

4.3 Federal

When emergency and post-flood damage needs cannot be met by local and state governments, and only after a State disaster has been declared, that State may request that a federal disaster be declared. After two weeks of persistent rain and widespread flooding across the State, President Bush on January 19, 1993 in one of his last official acts as President, declared the State of Arizona a federal disaster area, allowing federal aid to be provided to Arizona counties.

Federal aid for damage to public infrastructure is provided by the following four agencies:

1) U.S. Department of Agriculture via the Soil Conservation Service (SCS), 2) U.S. Department of Transportation via the Federal Highway Administration (FHWA), 3) U.S. Department of Army via the Army Corps of Engineers (COE), and 4) FEMA. Funding assistance for damage to private property is provided by FEMA and the SCS.

4.3.1 USDA - SCS Emergency Watershed Program (EWP)

SCS administers the EWP to relieve imminent threats to life and property caused by flooding and erosion. SCS pays 100% of the costs in exigency situations requiring immediate action; for non-exigency situations where damage to life or property constitutes an emergency but the threat is not as immediate, SCS pays up to 80% of the construction cost, with a local sponsor paying the remaining 20% in cash or in-kind services. SCS reviews requests for EWP assistance on a case-by-case basis; non-exigency situations are coordinated through Pima County Emergency Services and the Flood Control District.

To qualify for EWP Assistance, the proposed project must 1) reduce threats to life and property, 2) be economically and environmentally defensible and sound from an engineering perspective, 3) benefit more than one person, and 4) be the least expensive alternative except in exigency situations. Public and private landowners are eligible for EWP assistance provided they are represented by a sponsoring local unit of government. Sponsors provide land rights and local cost sharing, and install the work with their own equipment or through a local contractor.

Limitations on the use of EWP funding are as follows: protection is restored only to the level existing prior to the emergency; funding cannot be used for operation and maintenance work, or to repair private or public utilities or transportation facilities; and funding cannot be used on improvements installed by another federal agency.

4.3.2 USDOT - FHWA

FHWA administers emergency assistance to repair highways through ADOT via the Emergency Relief (ER) Program. Reimbursement is provided at the 100% level for emergency repairs. For long-term repairs, a local match is required, with the match ratio based on the Intermodal Surface Transportation Efficiency Act (ISTEA). Currently, the federal share will be 94.3%, with a local contribution of 5.7%. Criteria for participating are as follows: 1) facilities to be repaired must be part of the Federal Highway System, as approved by ADOT and FHWA; and 2) facilities are repaired only to the pre-flood condition.

A separate FHWA program, the Bridge Repair and Replacement Program (BRP), provides assistance when permanent repair or replacement of a highway bridge structure is needed. This is a continuing program authorized under the Federal Highway Program Act. As considerable time is required to program funds under BRP, it is not intended for flood disaster emergency relief.

4.3.3 U.S. Department of Army - COE

The U.S. Army Corps of Engineers provides flood disaster assistance for damaged public infrastructure via the following: 1) acting under its Emergency Operations authority, the COE pays 100% of project costs, with the intent of preventing further damage; and 2) the Emergency Stream Bank Protection (ESBP) program, where up to \$500,000 is available per bank protection project, with the local public agency contributing 25% towards construction in cash or in-kind services.

4.3.4 FEMA

FEMA is the principal federal agency providing disaster relief funding to public agencies and private individuals, through the State's Public Assistance, Hazard Mitigation, and Individual Assistance programs. FEMA damage assessment teams review site-specific damage to determine the amount of assistance which will be provided, and assign Damage Survey Report (DSR) numbers to all sites requiring repair. Numbers have been assigned to 111 total sites requiring repair in Pima County. Some of these sites received emergency repairs from other agencies during the height of the flood disaster, but additional funding is needed for long-term repairs.

Past FEMA assistance criteria have included: 1) agreement between FEMA and the individual or agency seeking assistance on the project value to restore a damaged facility to its pre-flood condition, 2) a local 25% match, with the State providing 15% and the local jurisdiction 10%, and 3) a case-by-case analysis of eligibility. It typically takes a while to complete the processes and receive funding for implementation.

4.4 Red Cross

During flooding, the Red Cross meets all basic emergency disaster needs; they provide shelter, food, clothing and basic medical care to those whose homes have been damaged or who are unable to access their residences. During January 7th - 10th, five shelters were set up locally, however most remained open for less than 24 hours as they were not being used. The busiest shelter was at Tanque Verde Elementary School on Tanque Verde Loop Road. According to the Red Cross, as of January 23rd, 56 residential units in Pima County were damaged. Fifteen (15) houses received major damage, 39 minor damage, and 2 manufactured homes received minor damage (personal communication, Karen MacDonald, Red Cross, April 1993).

5.0 EMERGENCY ASSISTANCE PROVIDED

During the January 1993 Floods, major emergency assistance was provided by federal agencies and PCDOT & FCD to protect public and private property in some of the most threatened locations. Federal assistance was provided "on the spot" by the COE at the Craycroft Road bridge and at the Rillito Creek bend area; the SCS provided "on the spot" assistance to protect the Luker residence, located immediately downstream of the Craycroft Road bridge.

Emergency assistance and repairs were also provided by PCDOT & FCD Operations Division personnel at over 100 locations. Only assistance provided to the most threatened areas is discussed in this Chapter. When available, pre- and post-flood aerial photographs are provided. Please refer to Table 7.1 for a complete listing of all locations where PCDOT & FCD provided emergency repairs, the cost of the repairs, funding assistance provided, and related data.

Most locations where emergency assistance was provided are eligible for federal assistance through reimbursement from FEMA or FHWA. FEMA will reimburse PCDOT & FCD for 90% of the emergency repair cost; PCDOT & FCD is responsible for the remaining 10%. FHWA will reimburse 100% of the emergency repair cost.

5.1 Craycroft Road Bridge

Severe erosion (up to 140 feet) of the north bank of Rillito Creek under the Craycroft Road bridge caused the bridge caissons to be exposed (Figures 5.1 and 5.2). Emergency repairs were needed to prevent undermining of the north bridge approach and abutment, as additional erosion could result in the bridge being closed for weeks, causing major disruption of travel in the northeast metropolitan area.

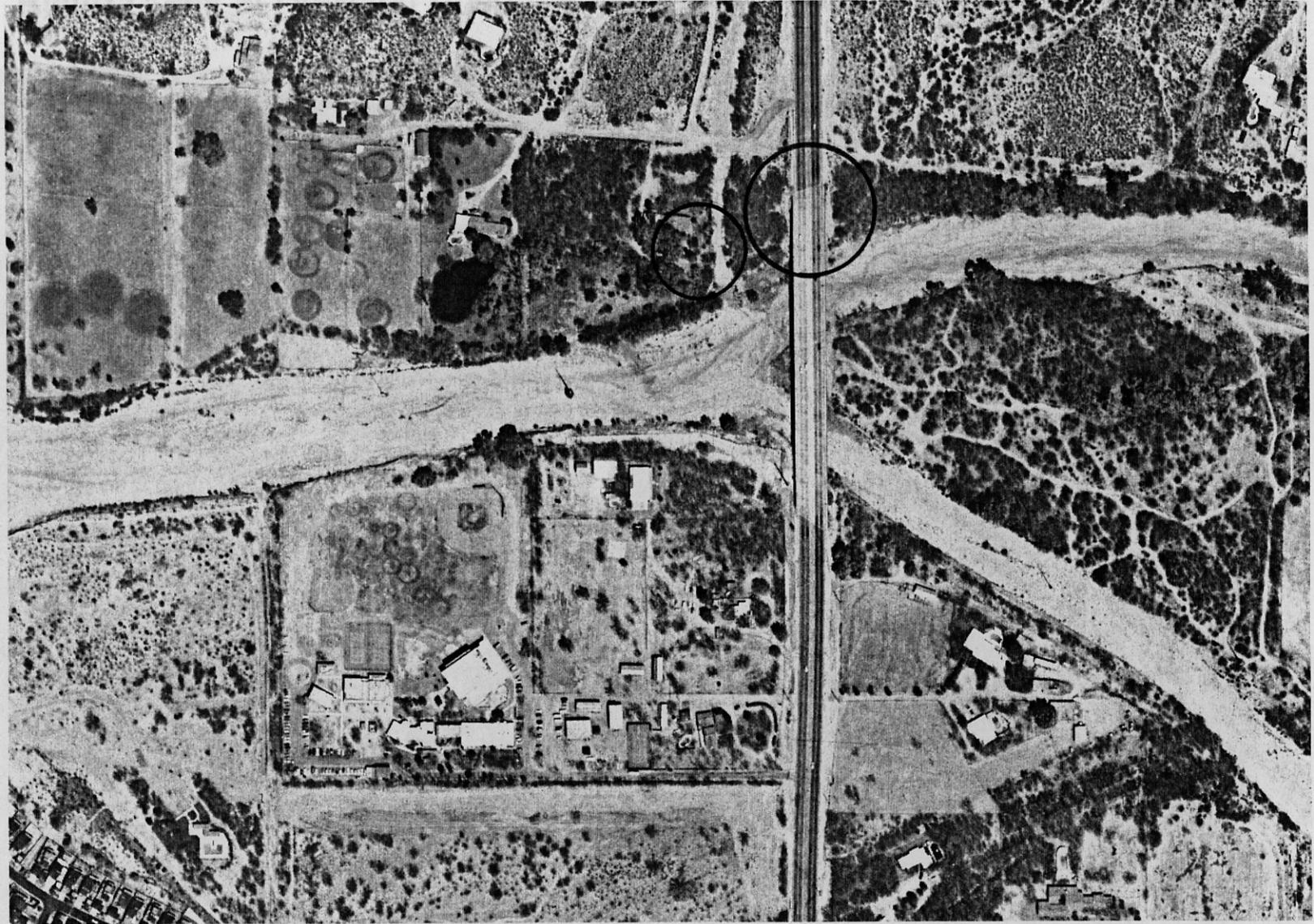
On January 8th, Pima County requested assistance from the COE under their Emergency Services Operations. PCDOT & FCD Operations Division personnel began dumping rock rip-rap to shore up the bank; within 24 hours, the COE took over and had a local contractor dump rock rip-rap along the north bank upstream, under, and immediately downstream of the bridge to prevent further erosion. Between January 9th - 15th, about 6000 tons of three-to-four foot diameter rock was placed along the north bank, at a cost to the COE of approximately \$90,000 (Figure 5.3). The bridge was reopened to traffic on January 18th.

5.2 Luker Residence along north bank of Rillito Creek

Located 300 feet downstream (west) of the Craycroft Road bridge on the north bank of Rillito Creek, approximately 120 feet of bank eroded adjacent to the Luker residence. The post-flood bank was within six feet of the residence, and the home was in danger of being severely damaged (Figures 5.1 and 5.2).

The SCS acting under the EWP provided interim bank protection similar to that provided by the COE at the Craycroft Bridge. Between January 13th - 14th, about 4000 tons of rock rip-rap with an average diameter of three-to-four feet was placed by SCS to prevent further erosion, at a cost of about \$ 60,000 (Figure 5.3).

FIGURE 5.1

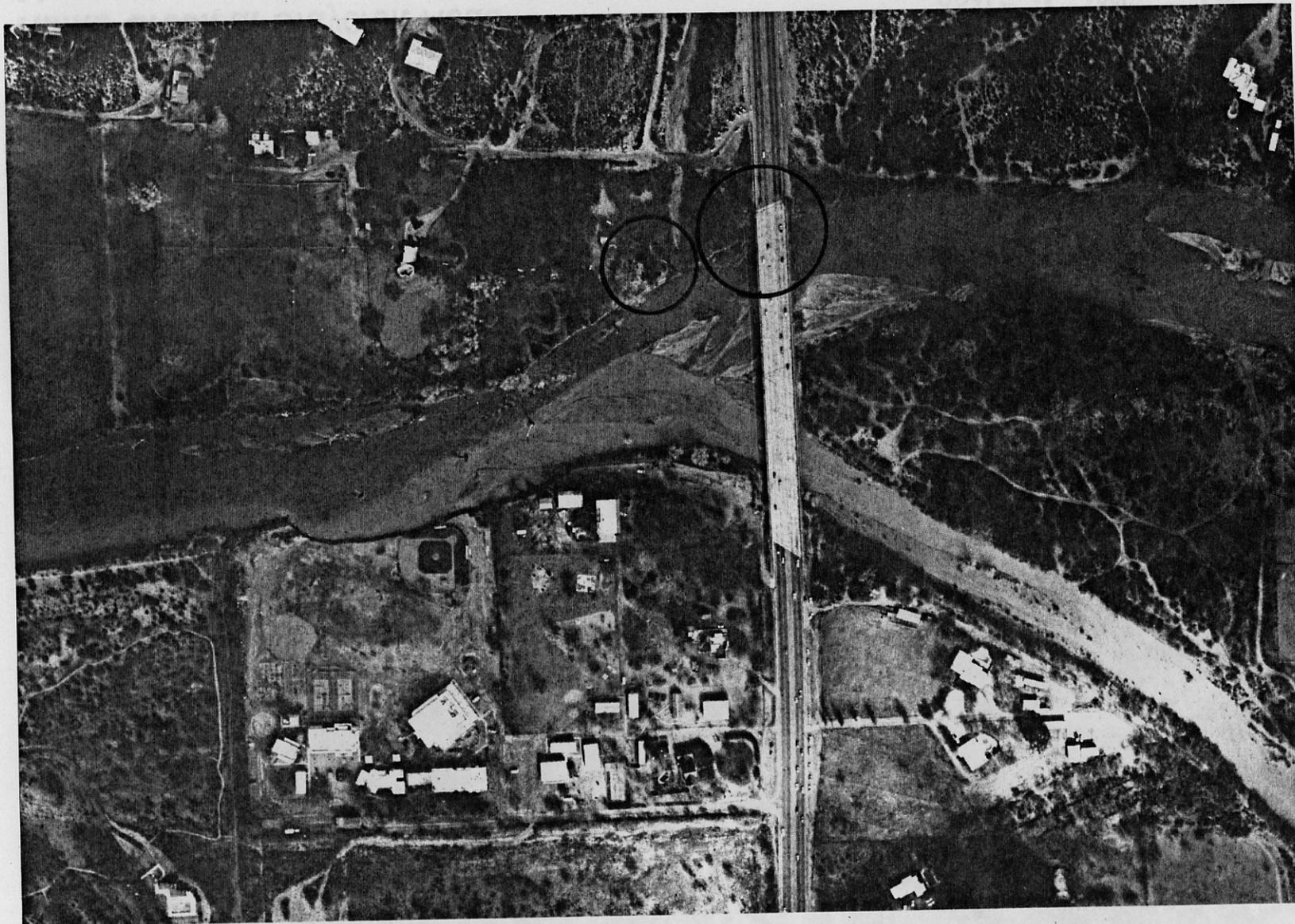


Rillito Creek at Craycroft Road
March 22, 1990

SCALE 1" = 400'



FIGURE 5.2

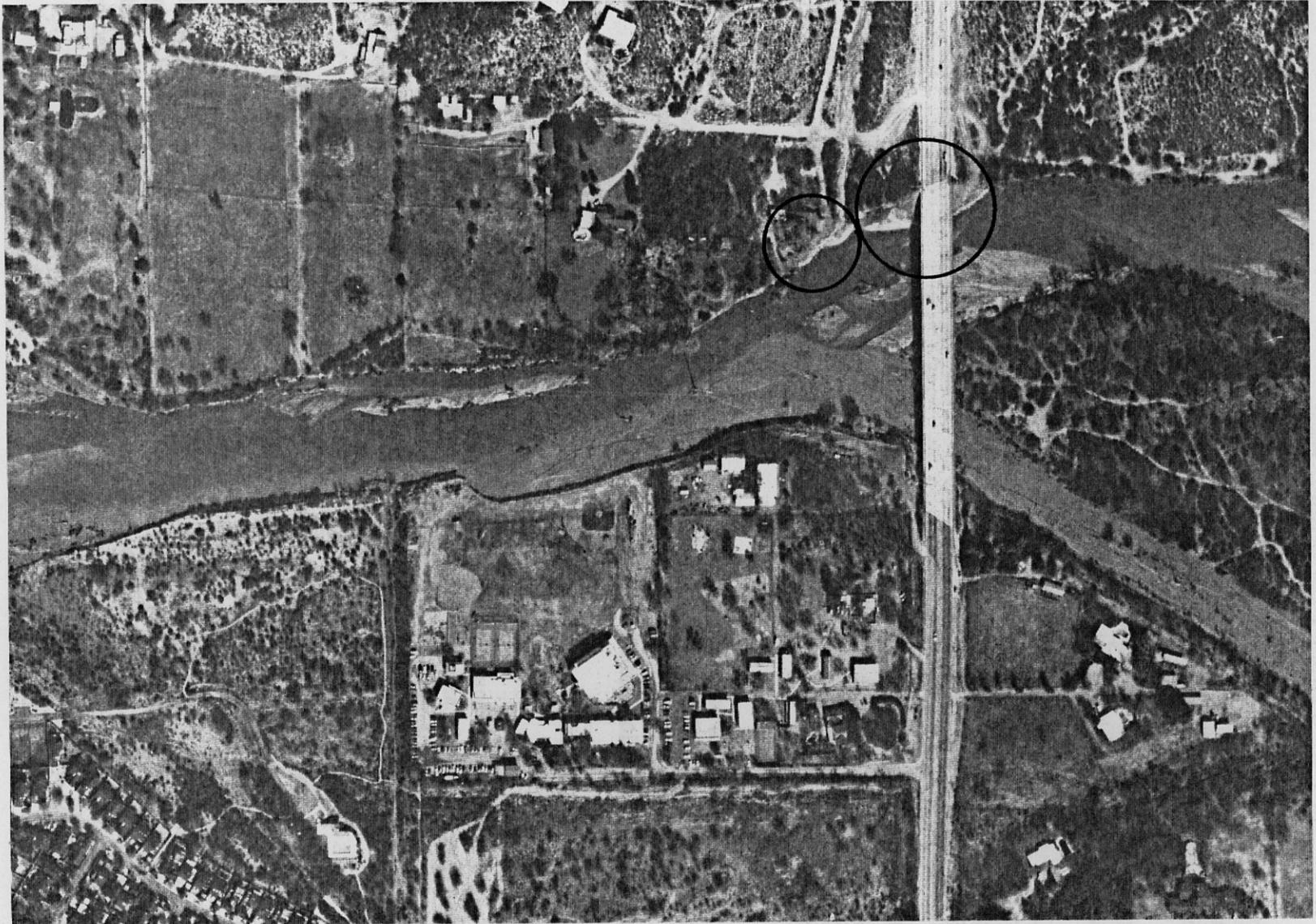


Rillito Creek at Craycroft Road
January 9, 1993

SCALE 1" = 400'



FIGURE 5.3



Rillito Creek at Craycroft Road
January 20, 1993

SCALE 1" = 400'



5.3 Country Club Road "Bend Area" of Rillito Creek

Up to 300 feet of erosion outward from the channel along the north bank in the bend area caused the channel bottom to widen considerably (Figures 5.4 and 5.5). Several non-habitable buildings, primarily greenhouses and animal housing, fell into Rillito Creek; and the north bank eroded to within 70 feet of a residence at 3100 East River Road. Immediately downstream of the bend, the upstream key-in of the soil-cement bank stabilization along the north bank was in danger of being eroded, threatening the bank stabilization.

The COE arranged for emergency action to protect the bank stabilization and a sewer interceptor line located behind the bank stabilization. Rock rip-rap jetties were constructed on the north bank between January 9th - 12th, upstream of the residence at 3100 East River Road to divert flow away from the eroded north bank; the cost to the COE was about \$ 75,000 (Figure 5.6).

After the jetties were constructed, predictions of continuing heavy rain caused concern that additional large flows would undermine the jetties and further erode the bank. Operations Division staff of PCDOT & FCD working with a contractor constructed an earthen low flow channel within the main Rillito Creek channel, to divert flow away from the threatened north bank.

Long-term protection will be provided to this area by an SCS EWP soil-cement bank stabilization project. SCS will fund 80% of the construction cost. Figure 5.7 shows the pre-and post-flood banks, the alignment of the future soil cement bank stabilization as of March 2nd, and the distribution of construction projects from Dodge Boulevard to Campbell Avenue.

5.4 Pima County/University of Arizona (U of A) Cooperative Extension Building at Campbell Avenue

Beginning the night of January 7th, severe erosion along the south bank of Rillito Creek immediately upstream of Campbell Avenue left the one-year old U of A building within 30 feet of the south bank; on the morning of January 8th, as the bank continued to erode, the building was evacuated. Continued flows in Rillito Creek placed the building in imminent danger (Figures 5.8 and 5.9).

Additionally, the severe erosion along the south bank caused a meander to begin forming along the north bank at the Campbell Avenue bridge. Due to the meander forming and shallow piers, the Campbell Avenue bridge was closed.

Starting at noon, PCDOT & FCD's Operations Division personnel began dumping heavy rock and concrete slabs to protect the remaining bank and building. The cost to PCDOT & FCD for emergency repairs was \$22,200, reimbursable by FEMA. At 2:30 that afternoon, the Campbell Avenue bridge was reopened. Long-term protection for this area will ultimately be provided by the SCS under the EWP.

FIGURE 5.4



Rillito Creek at Country Club Road "Bend Area"
March 19, 1990

SCALE 1" = 400'



FIGURE 5.5



Rillito Creek at Country Club Road "Bend Area"
January 9, 1993

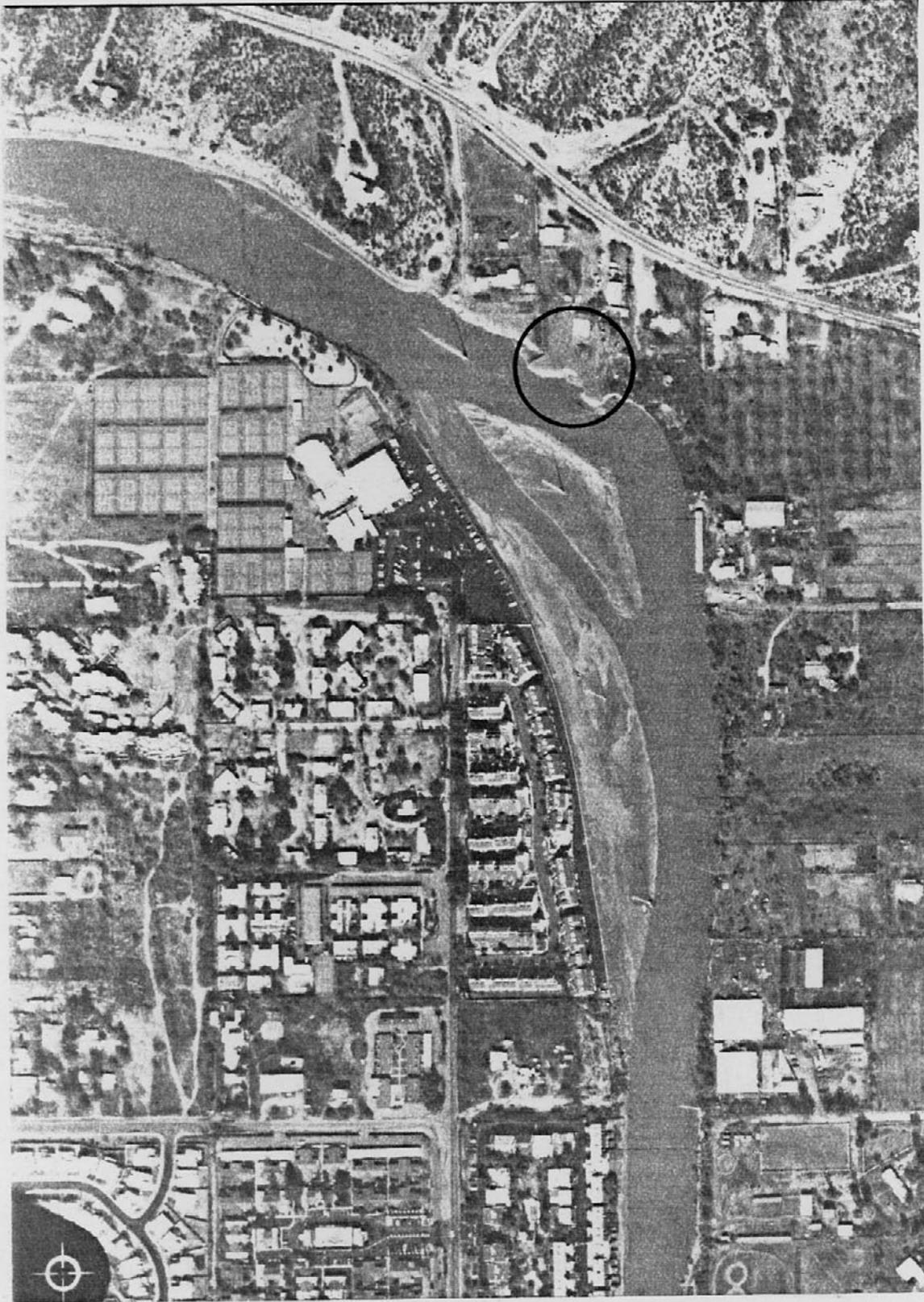
5-7

SCALE 1" = 400'



033

FIGURE 5.6



Rillito Creek at Country Club Road "Bend Area"
January 20, 1993

5-8

SCALE 1" = 400'



FIGURE 5.7

RILLITO CREEK - Campbell Ave. to Dodge Blvd.
 After January 9th, 1993 Flood

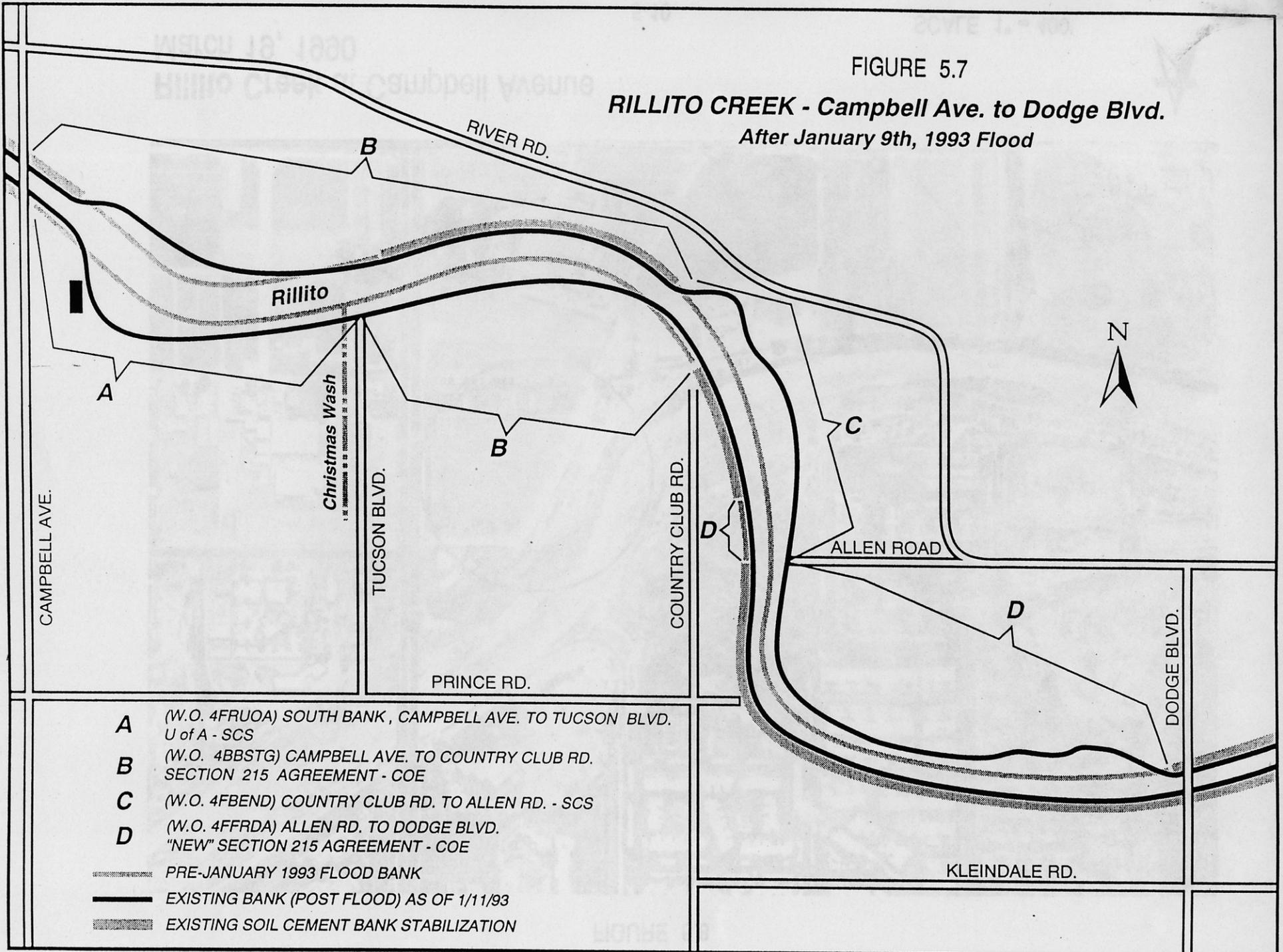
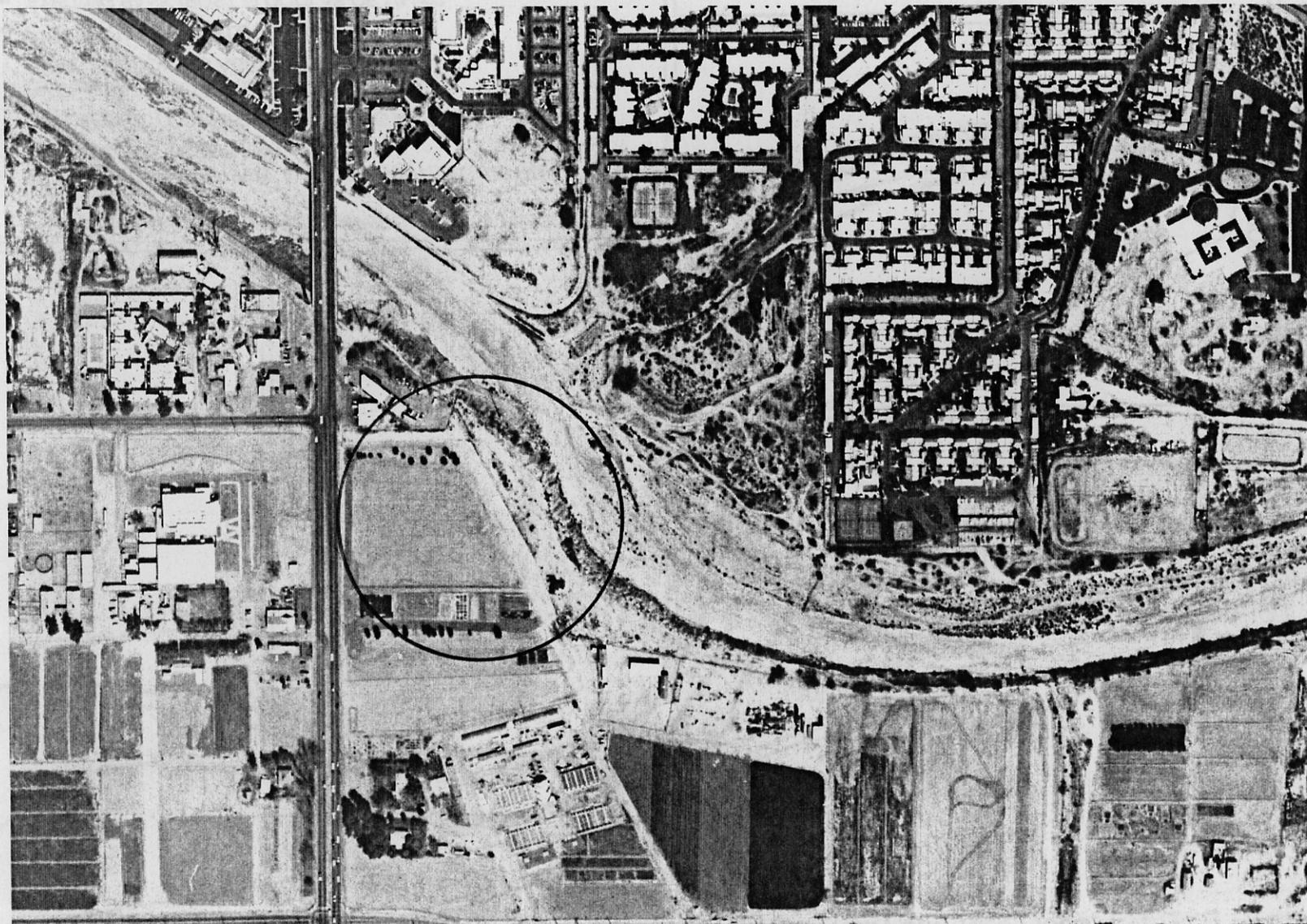


FIGURE 5.8



Rillito Creek at Campbell Avenue
March 19, 1990

5-10

SCALE 1" = 400'



036

FIGURE 5.9



Rillito Creek at Campbell Avenue
January 9, 1993

SCALE 1" = 400'



5.5 Pegler Wash/South Bank of Rillito Creek at Camino de la Tierra

a) Pegler Wash

On January 7th, breakout flow from Rillito Creek and drainage from Pegler Wash combined to inundate the Pegler Wash box culvert under Camino de la Tierra. The box culvert quickly became blocked by debris, and flows backed up behind and around the culvert; much sediment was deposited upstream of the box culvert in the Pegler Wash channel. About 15 homes along the north bank of the Pegler Wash were threatened by floodwaters (Figures 5.10 and 5.11).

PCDOT & FCD Operations Division personnel cleaned out the Pegler Wash channel upstream of the box culvert, and excavated a new channel around the south side of the box culvert to provide conveyance to the Rillito Creek for potential floodwater resulting from predicted rain. An earthen berm was also constructed along the north bank of Pegler Wash to protect adjacent residences (Figure 5.12). The emergency assistance repair work cost PCDOT & FCD about \$56,043; FEMA will reimburse the District for approximately \$20,000, however no decision has been made regarding the remainder. See Figure 5.13 for a schematic showing the proposed realignment of the Pegler Wash channel.

b) South Bank of Rillito Creek

In response to severe erosion which had occurred along the south bank adjacent to an auto salvaging business upstream of Camino de la Tierra, PCDOT & FCD's Operations Division personnel had a contractor dump four-to-six foot diameter rock rip-rap to protect the remaining bank (Figures 5.10 - 5.12). The cost of this emergency repair work was about \$ 125,000, to be reimbursed by FEMA. Long-term plans call for erosion control bank stabilization on both the north and south banks in the vicinity of Camino de la Tierra, under the SCS's EWP; construction is scheduled to begin in August 1993 (Figure 5.13).

5.6 KTKT Radio Tower, Santa Cruz River north of Grant Road

One of the three supporting tie lines for the KTKT radio tower was endangered by west bank erosion along the outer bend of the meander north of Grant Road (Figures 5.14 and 5.15). PCDOT & FCD's Operations Division staff worked with contractors to construct an earthen low-flow channel within the main channel of the Santa Cruz River, to divert flow away from the threatened bank. Emergency construction costs were about \$ 5,220.

FIGURE 5.10



Rillito Creek / Pegler Wash
at Camino de la Tierra
March 19, 1990

SCALE 1" = 400'



FIGURE 5.11



Rillito Creek / Pegler Wash
at Camino de la Tierra
January 9, 1993

SCALE 1" = 400'



FIGURE 5.12



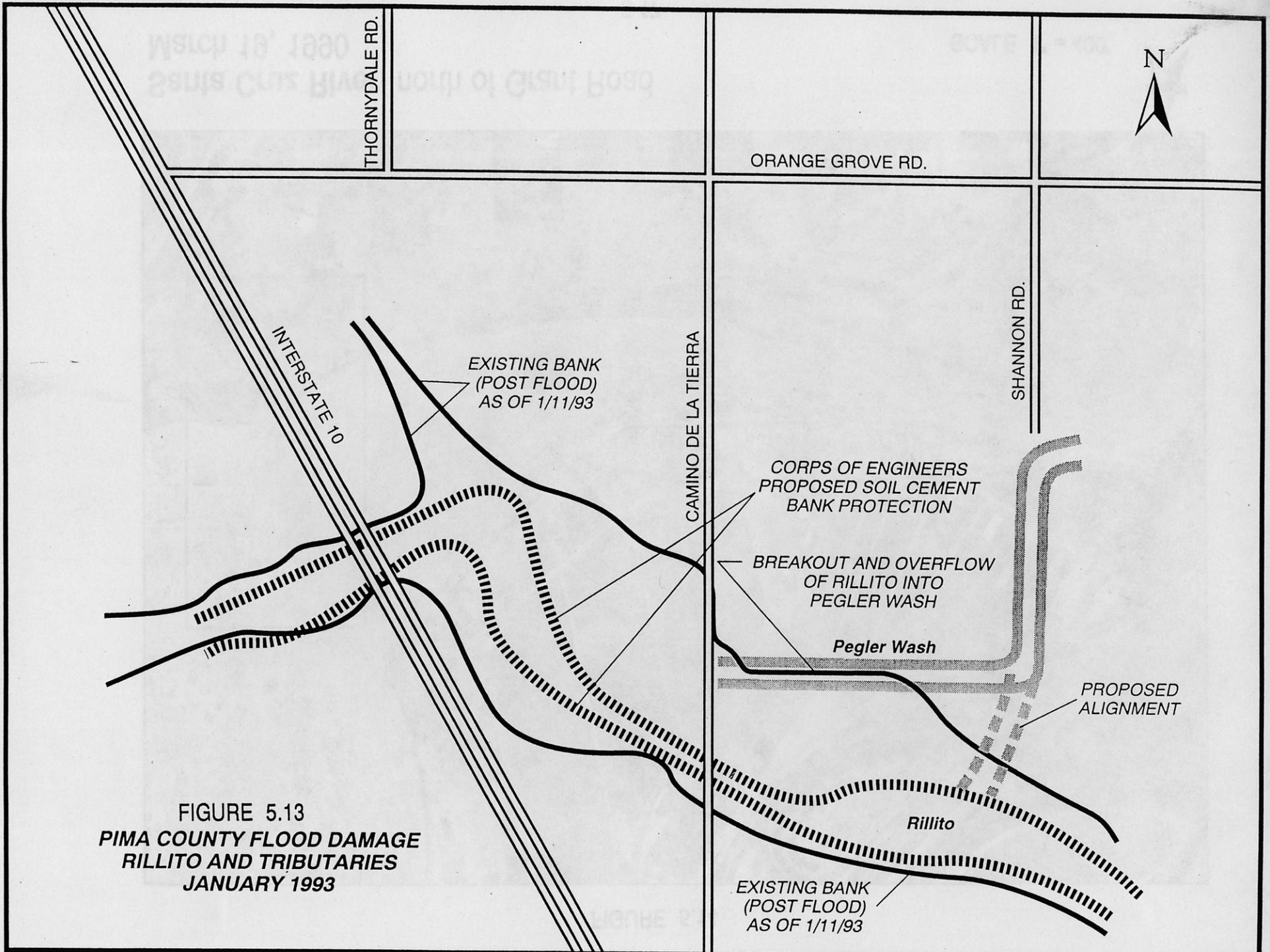
Rillito Creek / Pegler Wash
at Camino de la Tierra
January 20, 1993

5-15

SCALE 1" = 400'



041



**FIGURE 5.13
PIMA COUNTY FLOOD DAMAGE
RILLITO AND TRIBUTARIES
JANUARY 1993**

FIGURE 5.14

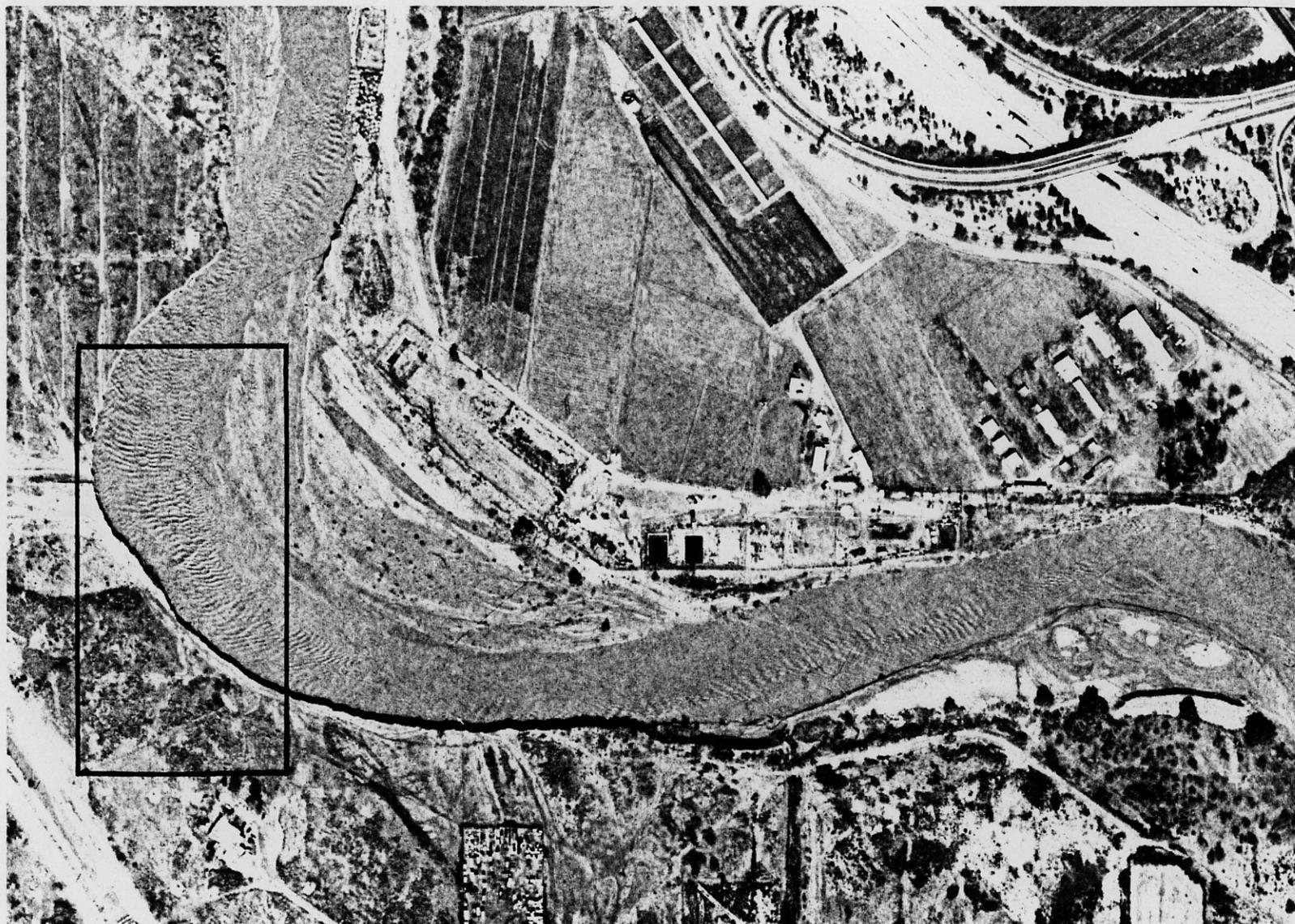


Santa Cruz River, north of Grant Road
March 19, 1990

SCALE 1" = 400'



FIGURE 5.15



Santa Cruz River, north of Grant Road
January 20, 1993

SCALE 1" = 400'



6.0 GENERAL DAMAGE ASSESSMENT

Perhaps the most noteworthy item about the January 1993 Floods is that locally no lives were lost, no conventional homes were lost, and no manufactured homes were swept away. Much damage to public infrastructure was sustained, however.

This chapter provides an overview of flood and erosion damage incurred along the major watercourses. Damage to flood control and transportation infrastructure is emphasized, with some discussion of damage to private property. Details of site-specific damage are provided in Chapter 7.0. Damage to wastewater infrastructure and utilities (electric, gas, water distribution systems) is not mentioned in this report.

As mentioned in Chapter 1.0, damage is caused primarily by overbank flooding with possible sediment deposition, or by bank erosion. In locations where both banks of major watercourses are protected by soil-cement, flows were contained within the channel and little damage occurred. Overbank flooding occurred in those areas which historically experience overbank flow during large events.

Flood damage information was obtained from field investigation reports prepared by District staff, information from Operations Division and Engineering Division staff, aerial photographs, reports prepared by private consultants, and discussions with personnel from other local jurisdictions. Limitations in the assessment are as follows: 1) most field investigations were conducted during or shortly after peak flooding, hence access into flooded areas was severely limited, and 2) as ground transportation (automotive vehicles and walking) was the primary means of transportation, it was not always possible to see the "big picture." Investigations by helicopter overflight, allowing a broader perspective on the flooding, were conducted on three occasions.

6.1 General Damage By Watercourse

Although locally the brunt of the January 7th storm impacted the northeast metropolitan area, and the January 18th storm impacted areas primarily along the Santa Cruz River, rainfall was widespread across the southern part of the state, and flood damage was reported throughout Pima County. Except for the Town of Green Valley, the population centers outside the metropolitan area and within unincorporated Pima County are relatively small, and less public infrastructure and private property was affected by the flooding. Relatively little damage occurred within the City of Tucson, and in areas south and west of the Tucson metropolitan area. This report focuses on flood and related damage in unincorporated portions of the greater metropolitan area.

Erosion along portions of the Santa Cruz River and Rillito Creek resulted in significant damage or loss to public infrastructure and private property. Overbank flooding caused damage along the Agua Caliente Wash, Sabino Creek, lower Finger Rock Wash, Tanque Verde Creek, Rincon Creek, and Rillito Creek; and along the Santa Cruz River upstream and downstream of the Tucson metropolitan area. An overview of damage along the major watercourses follows. Aerial photographs are provided when available.

6.2 Santa Cruz River

A. Upper (Santa Cruz County line to I-19 at Martinez Hill)

Although on July 7th - 8th the Santa Cruz River was flowing significantly, the larger peak discharge and greater damage occurred on January 18th. During January 18th - 19th, the river was flowing bankfull and in some locations overbank from the Santa Cruz County line north to I-19. Natural channel banks prevail throughout this reach, except for a few locations in the Green Valley area and near I-19 at Martinez Hill, where soil-cement bank stabilization has been constructed.

Bank erosion occurred along the natural channel banks throughout the upper reach, eroding some agricultural land and damaging transportation infrastructure. Specifically, two bridge crossings were damaged (Elephant Head and Sahuarita Roads, Figures 6.1 - 6.4), however the recently constructed Continental Road bridge was essentially unscathed.

Overbank flow occurred to the east and west in several locations from Green Valley to upstream of Martinez Hill, inundating primarily vacant land or pecan orchards. A major breakout occurred upstream of Pima Mine Road; east overbank flow returned to the main channel via the Lee Moore Wash a few miles downstream. Flow was fully contained within the main channel upstream of the I-19 bridge.

B. Middle (I-19 to Cortaro Road)

Two of the most striking features in this reach were 1) that almost no damage occurred in the urban area where flow was contained within soil-cement bank stabilization, and 2) the relatively large contribution of tributary flow from the Rillito Creek to the total flow in the Santa Cruz River during the storm event of January 7th (Figure 6.5). Much less flow was contributed from the Cañada del Oro Wash to the Santa Cruz River during the entire two-week period between January 5th - 19th.

Upstream of the Rillito confluence, flow was contained within the main channel banks of the Santa Cruz River. Bank erosion occurred at the outside of unprotected bend areas downstream of Grant Road and El Camino del Cerro Road, however structures were generally undamaged. Flow was mostly contained within the main channel from the Rillito confluence to Ina Road, with minor overbank flooding of sand and gravel pits (Figure 6.6).

FIGURE 6.1



Santa Cruz River at Elephant Head Road
April 20, 1990



SCALE 1" = 400'

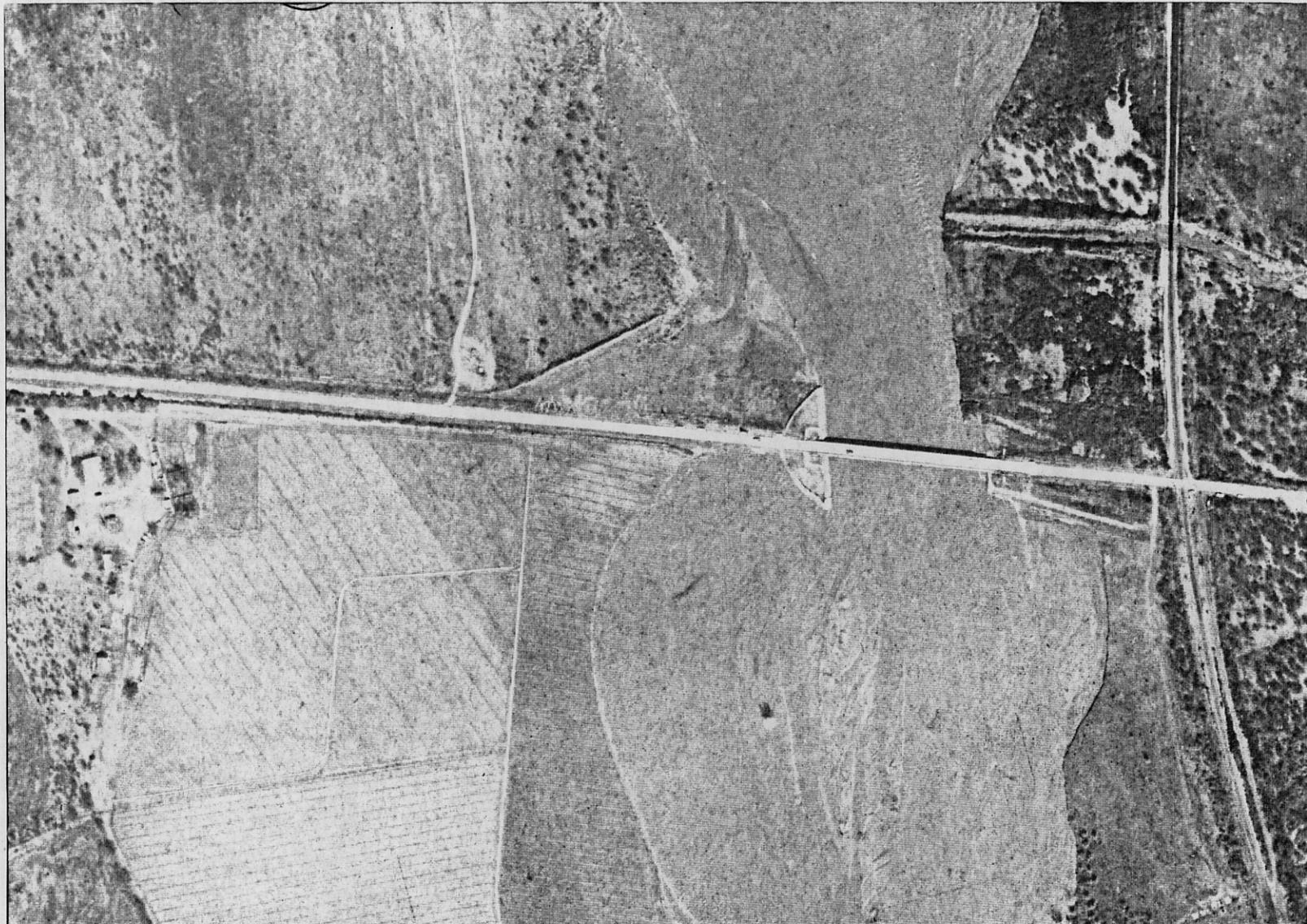
6-3

047

MARCH 10' 1980

FIGURE 6.2

ROUTE 11 - 100



Santa Cruz River at Elephant Head Road
January 20, 1993

SCALE 1" = 400'



048

FIGURE 6.3



Santa Cruz River at Sahuarita Road
March 19, 1990

SCALE 1" = 400'



6-5

049

FIGURE 6.4



Santa Cruz River at Sahuarita Road
January 20, 1993

SCALE 1" = 400'



FIGURE 6.5



Santa Cruz River at Rillito Creek Confluence
January 9, 1993

SCALE 1" = 1250'



FIGURE 6.6



Santa Cruz River at CDO Wash Confluence
January 9, 1993



SCALE 1" = 1250'

Seepage and overbank flow into large sand and gravel pits located between Ina and Cortaro Roads contributed to the shifting to the east of the main channel of the Santa Cruz River. Overbank flooding occurred primarily to the east with some to the west. Bank erosion caused extensive damage to the west approach at the Ina Road bridge (Figures 6.7 and 6.8), and the upstream soil-cement key-in along the east bank at Cortaro Road (Figures 6.9 and 6.10).

C. Lower (Cortaro Road to Pinal County line)

Except for the peak discharge, flow downstream of Cortaro Road through Continental Ranch was generally contained within the low-flow soil cement bank stabilization. The peak discharge overtopped the low-flow bank protection but was well-contained within the 100-year bank stabilization (Figure 6.11). Some of the bank stabilization was damaged just downstream of Cortaro Road.

Because the natural channel lacks conveyance downstream of Continental Ranch, the floodplain becomes very wide and is characterized by much overbank flow. New alignments of the main flowpath typically form at meanders.

After passing through the bank stabilization at Continental Ranch, confining mountainous topography to the west and lack of main channel conveyance caused flow to spread out primarily to the east upstream of Avra Valley Road, inundating the east approach (Figures 6.12 and 6.13). Downstream of Avra Valley Road, overbank flows to the east and west inundated primarily agricultural and vacant land. Upstream of Sanders Road, breakout to the north flooded some yards in the Honea Heights subdivision, however no residences were damaged. Overbank flows inundated the south approach to the Sanders Road bridge (Figures 6.14 and 6.15).

Breakouts to the west and mostly to the east within the Town of Marana inundated agricultural and vacant land downstream of Sanders Road. Significant overbank flow to the south at the meander upstream of Trico-Marana Road, as well as lateral migration of the main flowpath to the south, endangered the south roadway approach (Figures 6.16 - 6.18). No damage to the insides of residential or commercial buildings was reported.

Massive flow breakouts to the north and south upstream of Trico Road caused inundation and sediment deposition on the approach road. Large quantities of sediment and debris were also deposited under the Trico Road bridge, and sediment deposition covered the north and south approach roads for about one-half mile in each direction (Figures 6.19 and 6.20). The Trico Road bridge and approach roads reopened in early May. Photographs of the Avra Valley Road, Sanders Road, and Trico-Marana Road areas taken from a helicopter are shown in Figures 6.21 and 6.22.

FIGURE 6.7



Santa Cruz River at Ina Road
March 19, 1990

6-10

SCALE 1" = 400'



054

FIGURE 6.8

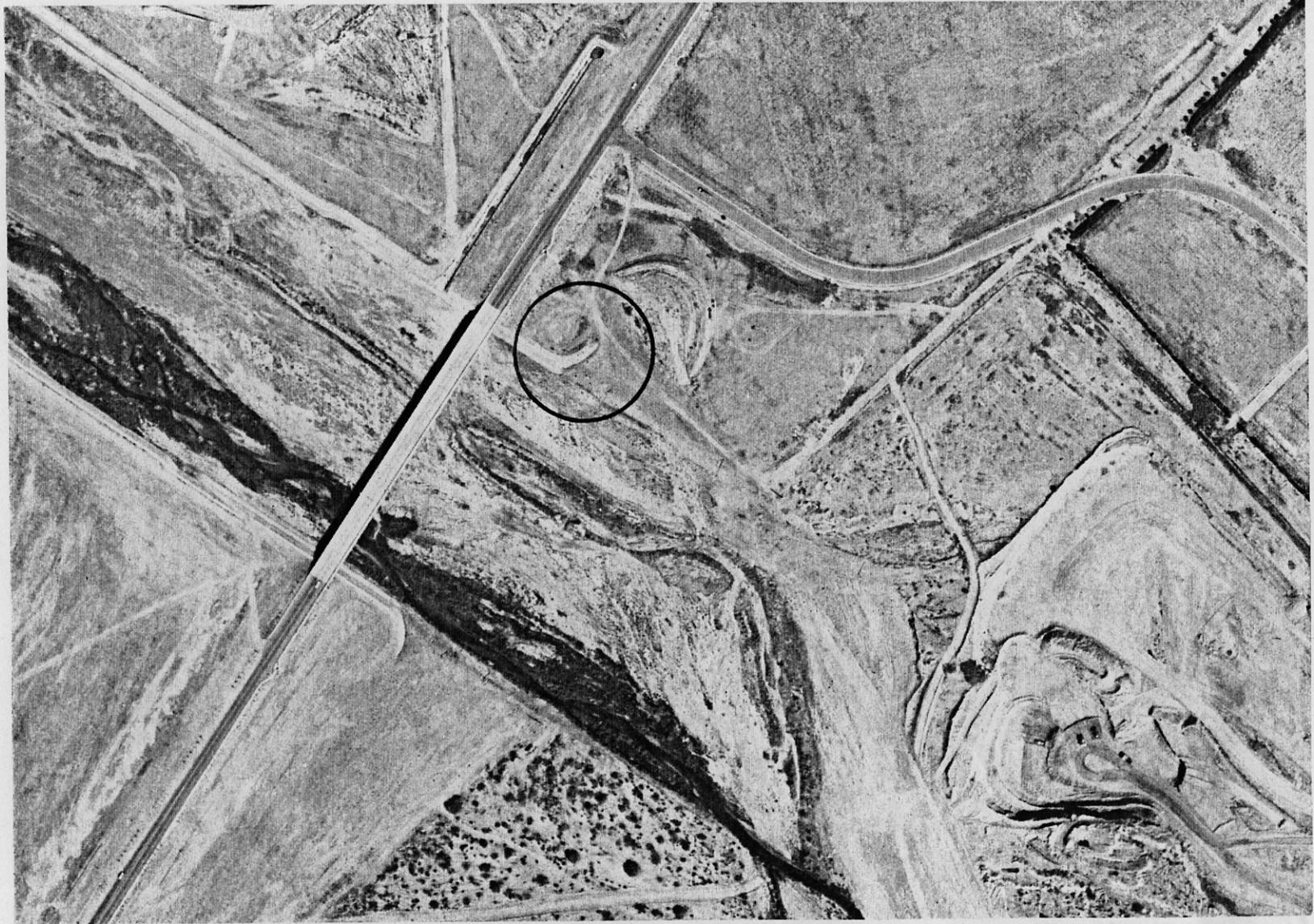


Santa Cruz River at Ina Road
January 20, 1993

SCALE 1" = 400'



FIGURE 6.9



Santa Cruz River at Cortaro Road
March 19, 1990

SCALE 1" = 400'



6-12

056

FIGURE 6.10



Santa Cruz River at Cortaro Road
January 20, 1993

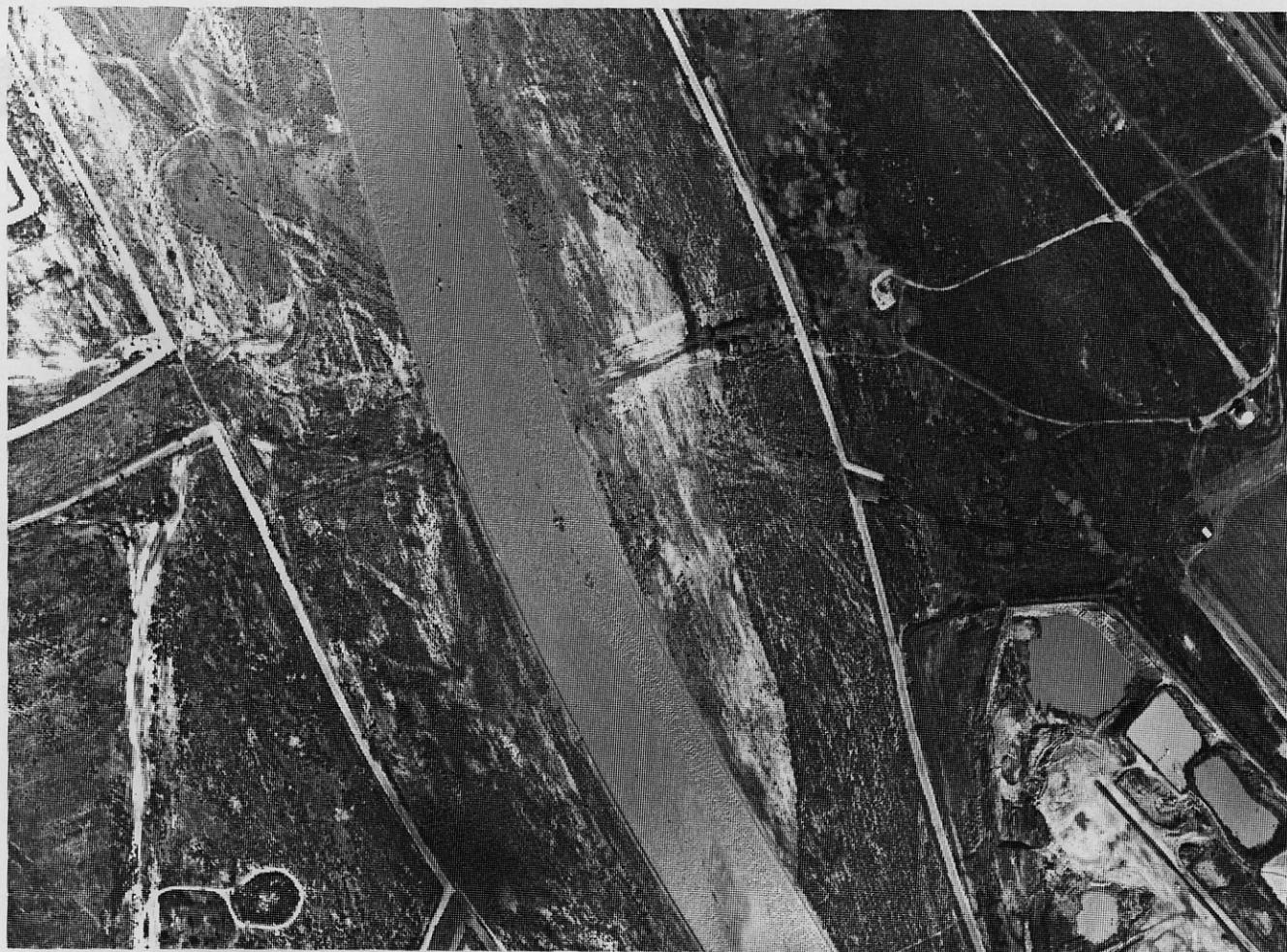
6-13

SCALE 1" = 400'



057

FIGURE 6.11



Santa Cruz River at Continental Ranch
January 9, 1993

6-14

SCALE 1" = 1250'



FIGURE 6.12



Santa Cruz River at Avra Valley Road
July 14, 1988



SCALE 1" = 1000'

FIGURE 6.13



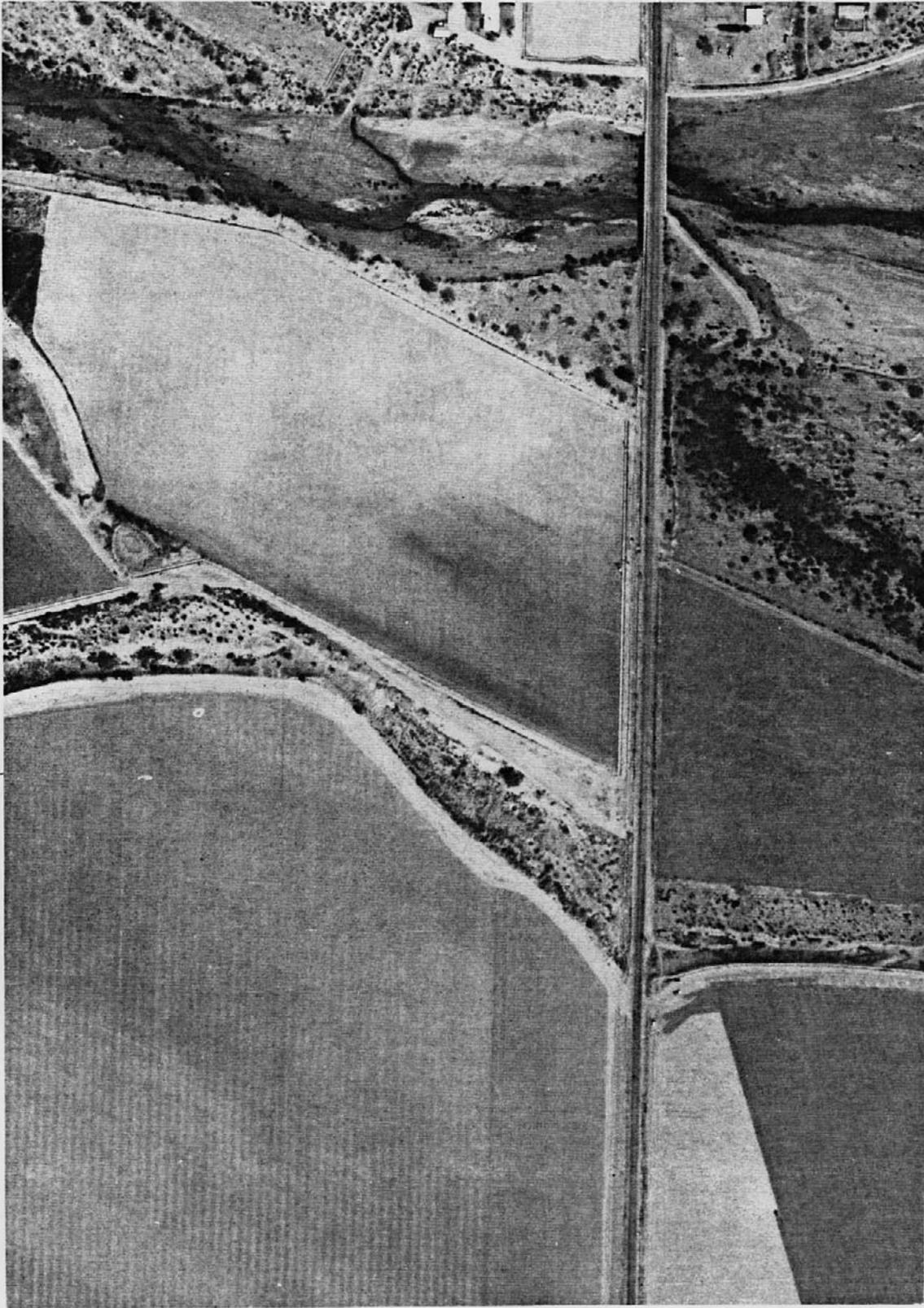
Santa Cruz River at Avra Valley Road
January 20, 1993



SCALE 1" = 1250'

6-16

FIGURE 6.14



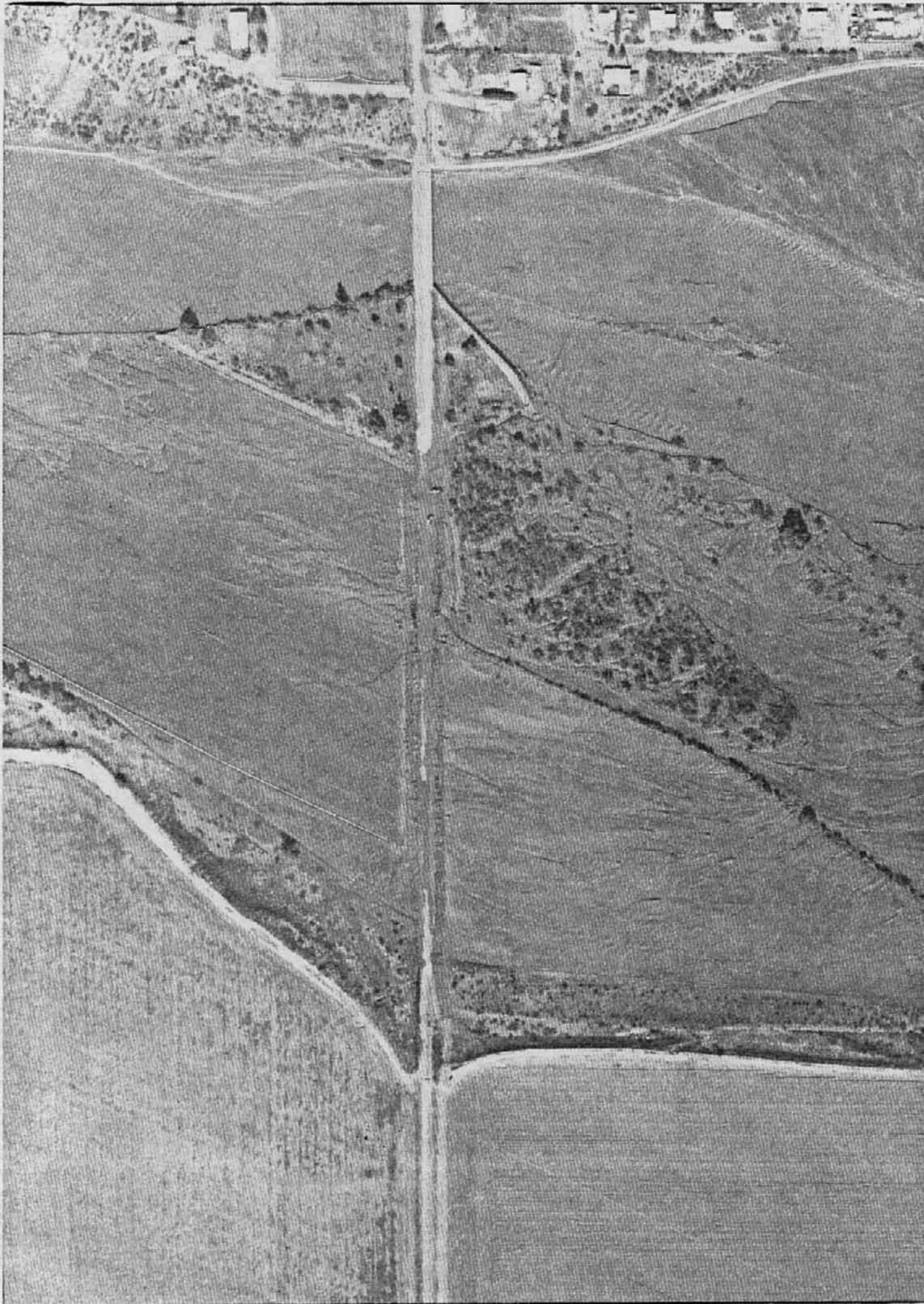
Santa Cruz River at Sanders Road
March 19, 1990

SCALE 1" = 400'



Del

FIGURE 6.15



Santa Cruz River at Sanders Road
January 20, 1993

6-18

SCALE 1" = 400'



062

FIGURE 6.16



Santa Cruz River at Trico-Marana Road
March 19, 1990

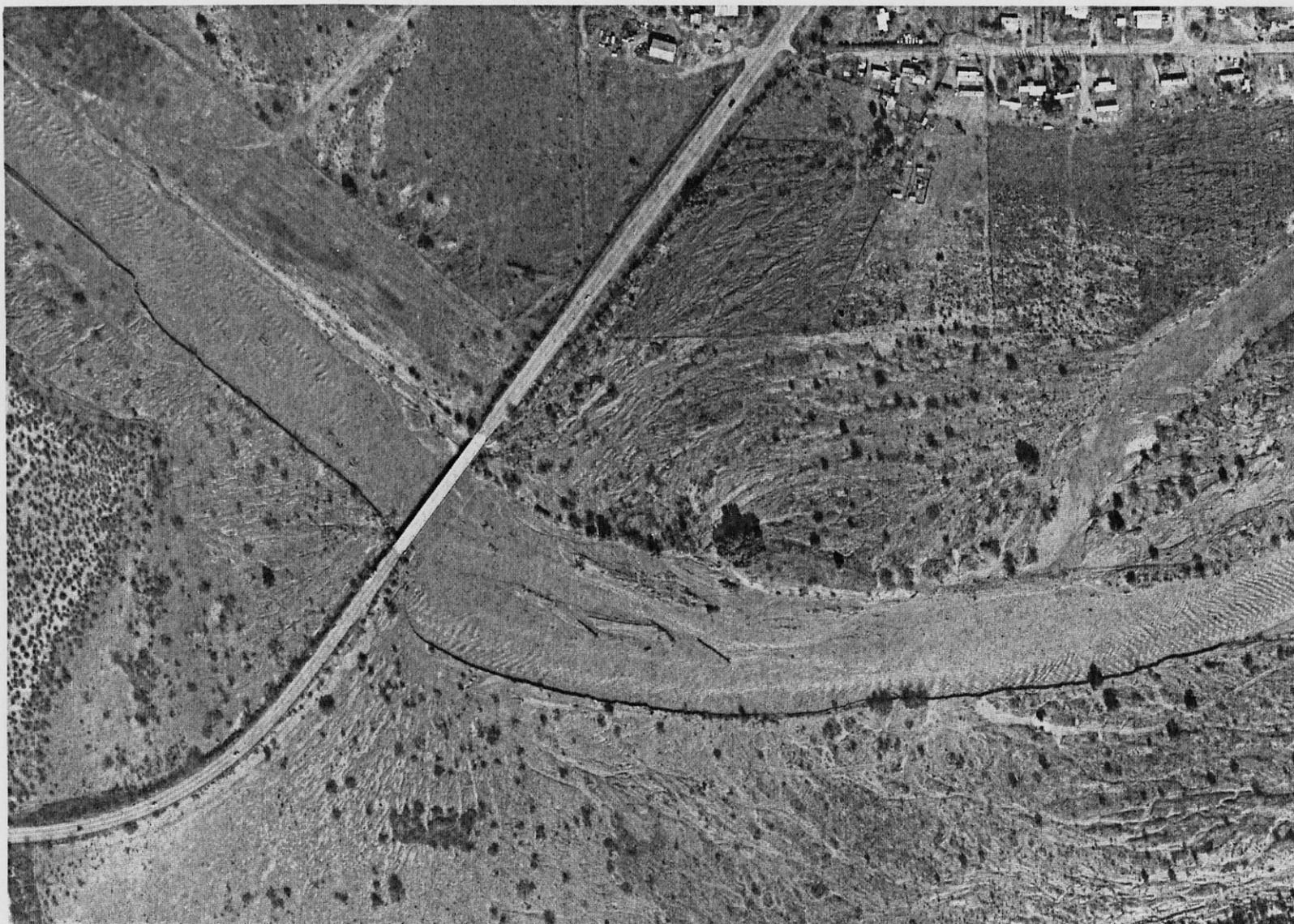
SCALE 1" = 400'



6-19

063

FIGURE 6.17



Santa Cruz River at Trico-Marana Road
January 9, 1993

6-20

SCALE 1" = 400'



064

FIGURE 6.18



Santa Cruz River at Trico-Marana Road
January 20, 1993

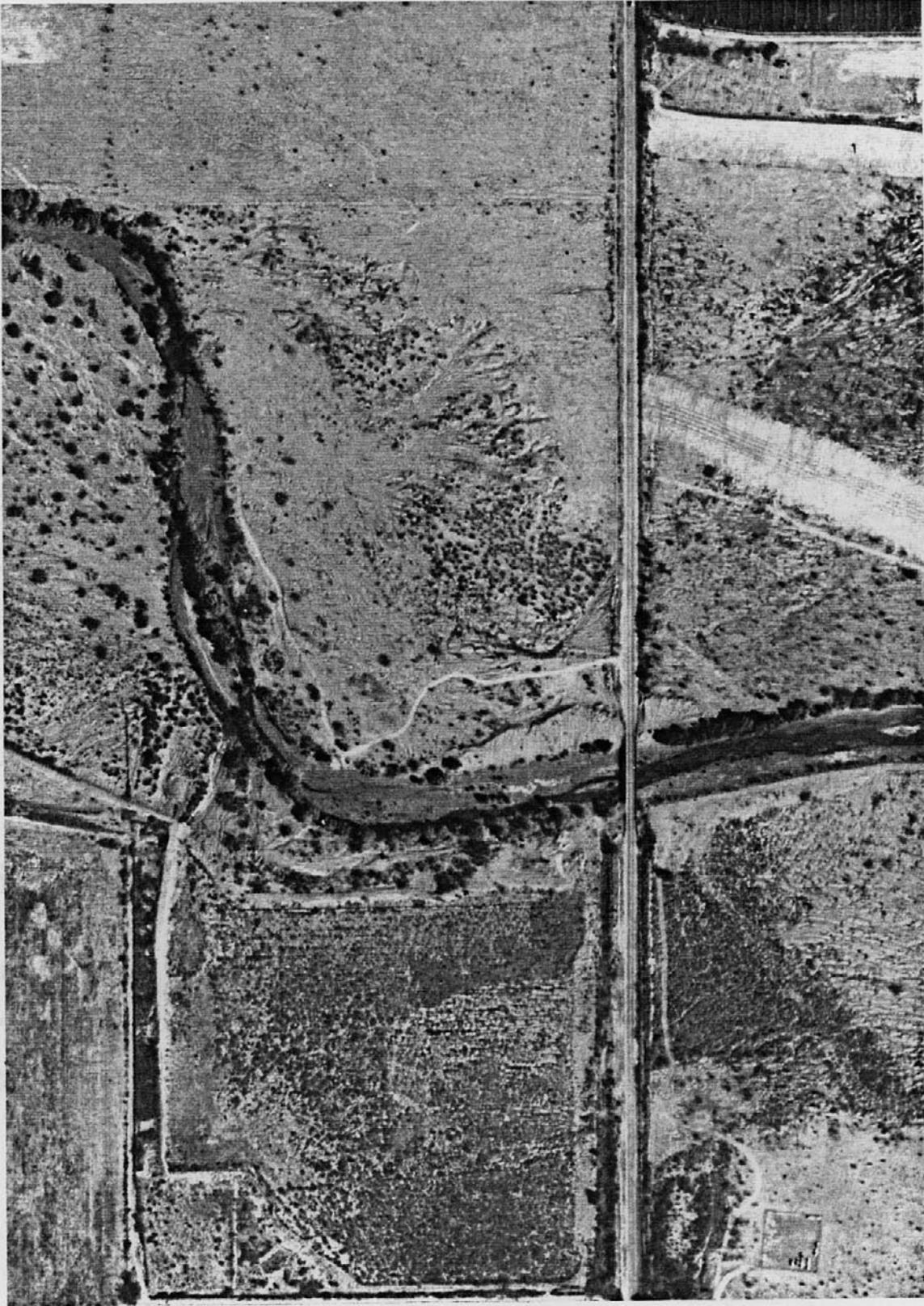
6-21

SCALE 1" = 1250'



005

FIGURE 6.19



Santa Cruz River at Trico Road
March 19, 1990

6-22

SCALE 1" = 400'



dele

FIGURE 6.20



Santa Cruz River at Trico Road
January 9, 1993

SCALE 1" = 1250'



FIGURE 6.21a



6.21a) Avra Valley Road—looking to the northwest, downstream along the Santa Cruz River. January 19, 1993.

FIGURE 6.21b



6.21b) Avra Valley Road—looking to the southeast, upstream along the Santa Cruz River. Notice the flow breaking out of bank downstream of Avra Valley Road. January 19, 1993.

FIGURE 6.22a



6.22a) Sanders Road—looking to the east, upstream along the Santa Cruz River. Notice the soil-cement bank stabilization protecting the Honca Heights subdivision. January 19, 1993.

FIGURE 6.22b



6.22b) Trico-Marana Road—looking to the southeast, upstream along the Santa Cruz River. Soil-cement bank stabilization protecting the Berry Acres subdivision. January 19, 1993.

6.3 Rillito Creek

Tanque Verde Creek, receiving runoff from Agua Caliente Wash and Sabino Creek, contributed substantially to flows in the Rillito; the Pantano Wash contributed minimally. On January 7th and 8th, Rillito Creek was flowing bankfull and in some locations overbank from Craycroft Road to the Santa Cruz River. Overbank flow to the north occurred upstream and downstream of the Dodge Boulevard bridge, impacting the bend area upstream of Country Club Road; some residences were damaged (Simons, Li & Associates, Inc., March 1993). Downstream of the Shannon Road alignment, flow broke out to north and into the Pegler Wash channel.

After the 1983 Flood, bank stabilization was constructed along several reaches of the Rillito. Flow was well-contained within the stabilized banks and little damage occurred. Unfortunately, although design plans were completed for protecting the remaining reaches, the flooding occurred before the project was constructed and virtually all unprotected banks along the Rillito were eroded.

Severe erosion occurred on January 7th and 8th from Swan Road to Alvernon Way, downstream of Dodge boulevard (Figures 6.23 and 6.24), along the north bank at the Country Club bend, upstream of the Campbell Avenue bridge on the south bank, and from La Cholla Boulevard downstream to the Santa Cruz River. Areas along the south bank upstream and downstream of Camino de la Tierra were heavily eroded. Residences were threatened downstream of the Craycroft Road bridge on the north bank, and opposite the Tucson Racquet Club on the north bank in the bend area.

Continuing rains caused substantial but less flooding on the Rillito on January 18th. No overbank flooding was observed, but banks which had eroded during January 7th - 8th continued to erode.

6.4 Agua Caliente Wash

The main channel of the Agua Caliente Wash has limited capacity to convey flood flows in its natural condition and historically experiences overbank flooding during large events. On January 7th and 8th, flow broke out of the main channel to the east and west in several locations, inundating several properties and depositing sediment over large areas. Water was reported inside a few scattered residences and other buildings on private property. Transportation infrastructure was heavily damaged, resulting in loss of access to residences located between the Tanque Verde Creek and Agua Caliente Wash; approximately 2500 residents were affected.

Upstream of Tanque Verde Road, all roadway dip crossings were heavily damaged and one (Soldier Trail) remained closed until mid-April. Much of the flow breakout downstream of Fort Lowell Road impacted the Tanque Verde Road box culvert, causing widespread inundation along the east approach (Figures 6.25 and 6.26). Flows which broke out to the southeast drained toward Houghton Road, which is elevated above grade to provide all-weather access, then drained south to Tanque Verde Creek. Breakout to the southwest flowed west along the north side of Tanque Verde Road then southwest, crossing Tanque Verde Road west of Houghton Road. These flows rejoined the Agua Caliente Wash upstream of the confluence with Tanque Verde Creek.

FIGURE 6.23



Rillito Creek downstream of Dodge Blvd.
March 19, 1990

6-27

SCALE 1" = 400'



071

FIGURE 6.24

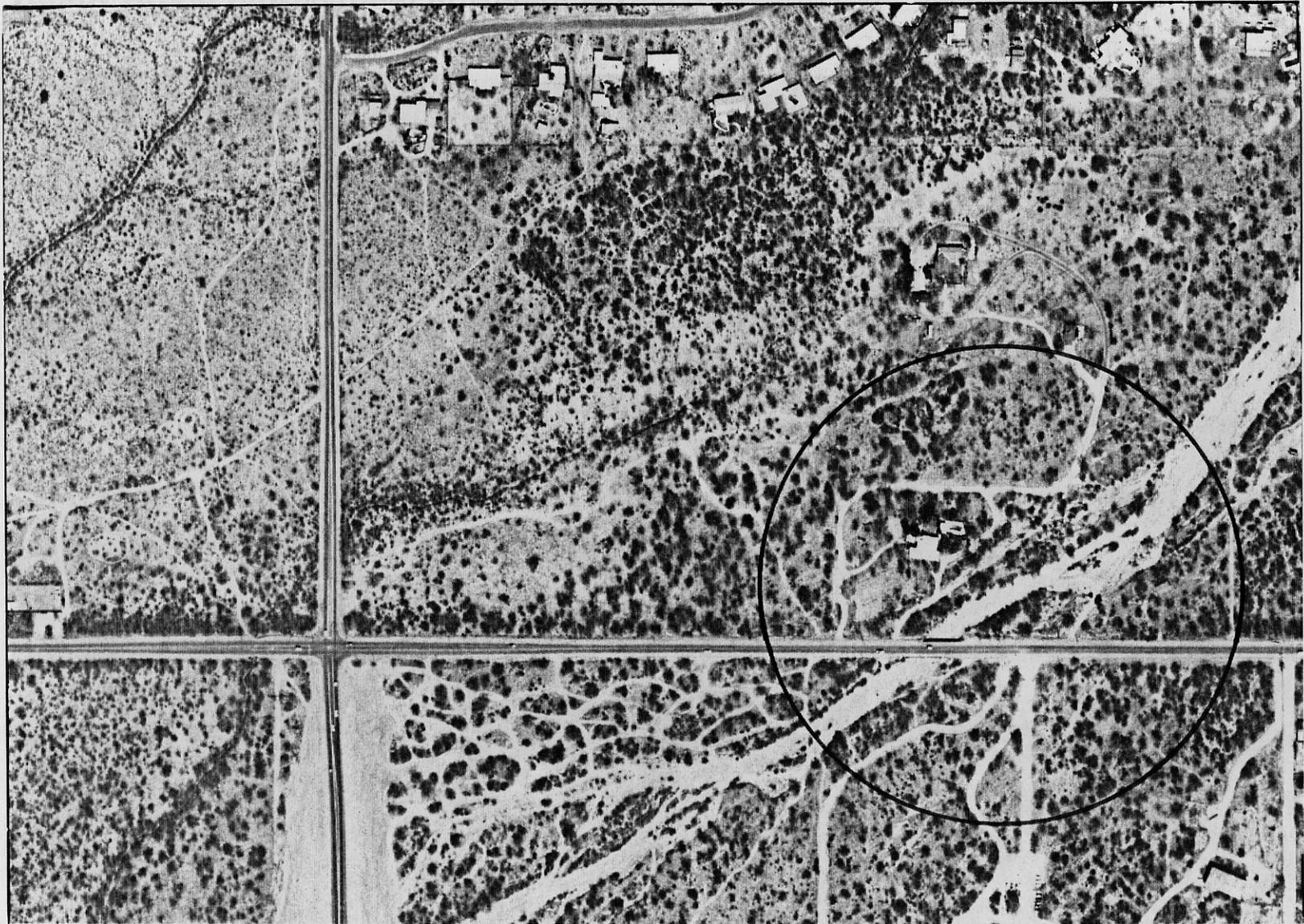


Rillito Creek downstream of Dodge Blvd.
January 9, 1993

SCALE 1" = 400'



FIGURE 6.25



Agua Caliente Wash at Tanque Verde Road
March 22, 1990



6-29

SCALE 1" = 400'

073

FIGURE 6.26



Agua Caliente Wash at Tanque Verde Road
January 9, 1993

SCALE 1" = 400'



Considerable erosion occurred along much of the main channel bank and near at-grade roadway crossings; several accessory structures were lost, and many others were threatened. Between Limberlost and Fort Lowell Roads, the main channel almost doubled in width (Figures 6.27 and 6.28). Based on the number of private properties that were damaged and residents who were affected by loss of access, the Agua Caliente Wash area was the residential area most heavily affected by the January 1993 Floods.

6.5 Tanque Verde Creek

Much like the Agua Caliente Wash, the Tanque Verde Creek typically flows overbank in several locations during large flow events. On January 7th and 8th, overbank flows occurred to the north downstream of Monument Wash, at Fortyniners Country Club Estates, the Lakes at Castle Rock subdivision (within COT), and along Woodland Road (within COT); breakout to the south occurred downstream of Tanque Verde Loop Road. Several accessory structures and yards were flooded, however little damage was reported to the inside of residences.

Except for the reach between Tanque Verde Road and Ventana Canyon Wash, the banks of the Tanque Verde Creek are natural and most eroded. Substantial erosion occurred along the north bank downstream of the Wentworth Wash confluence, and along the south bank at Tucson Country Club Estates. Although no residences were actually damaged at Tucson Country Club Estates, several were threatened, accessory structures were lost, and a sewer line was damaged (Figures 6.29 and 6.30).

Access to areas along the north bank was lost for a few days as the Tanque Verde Loop Road and Agua Caliente Wash crossings were damaged. The Wentworth Road crossing was also closed. The Tanque Verde Loop Road crossing reopened to traffic in early May.

6.6 Rincon Creek

The main channel of Rincon Creek has limited capacity to convey large discharges; on January 7th and 8th, overbank flow occurred to the south from upstream of Camino Loma Alta to the Old Spanish Trail crossing. Access within the Rincon Valley was limited as both roadway crossings are at-grade and were damaged. Access across several private roads also was lost. Overbank flooding and sediment deposition damaged at least one residence located at the intersection of Old Spanish Trail and Avenida de la Potranca (Figures 6.31 and 6.32).

6.7 Finger Rock Wash

Snowmelt combined with rain-induced runoff resulted in large flows in watercourses draining the south face of the Santa Catalina Mountains. Flooding and sediment deposition at the downstream end of Finger Rock Wash were especially severe on January 7th and 8th as no defined channel exists to convey flow to the Rillito Creek.

Downstream of Alvernon Way just north of River Road flow spread out in an alluvial fan, inundating several residences along Sutton Lane and depositing sediment over broad areas (Figures 6.33 and 6.34). The feasibility of providing positive conveyance from Finger Rock Wash to Rillito Creek is being investigated, to remove the threat of flooding from this area.

FIGURE 6.27



Agua Caliente Wash between Limberlost
and Fort Lowell Road
July 14, 1988



SCALE 1" = 1000'

076

FIGURE 6.28

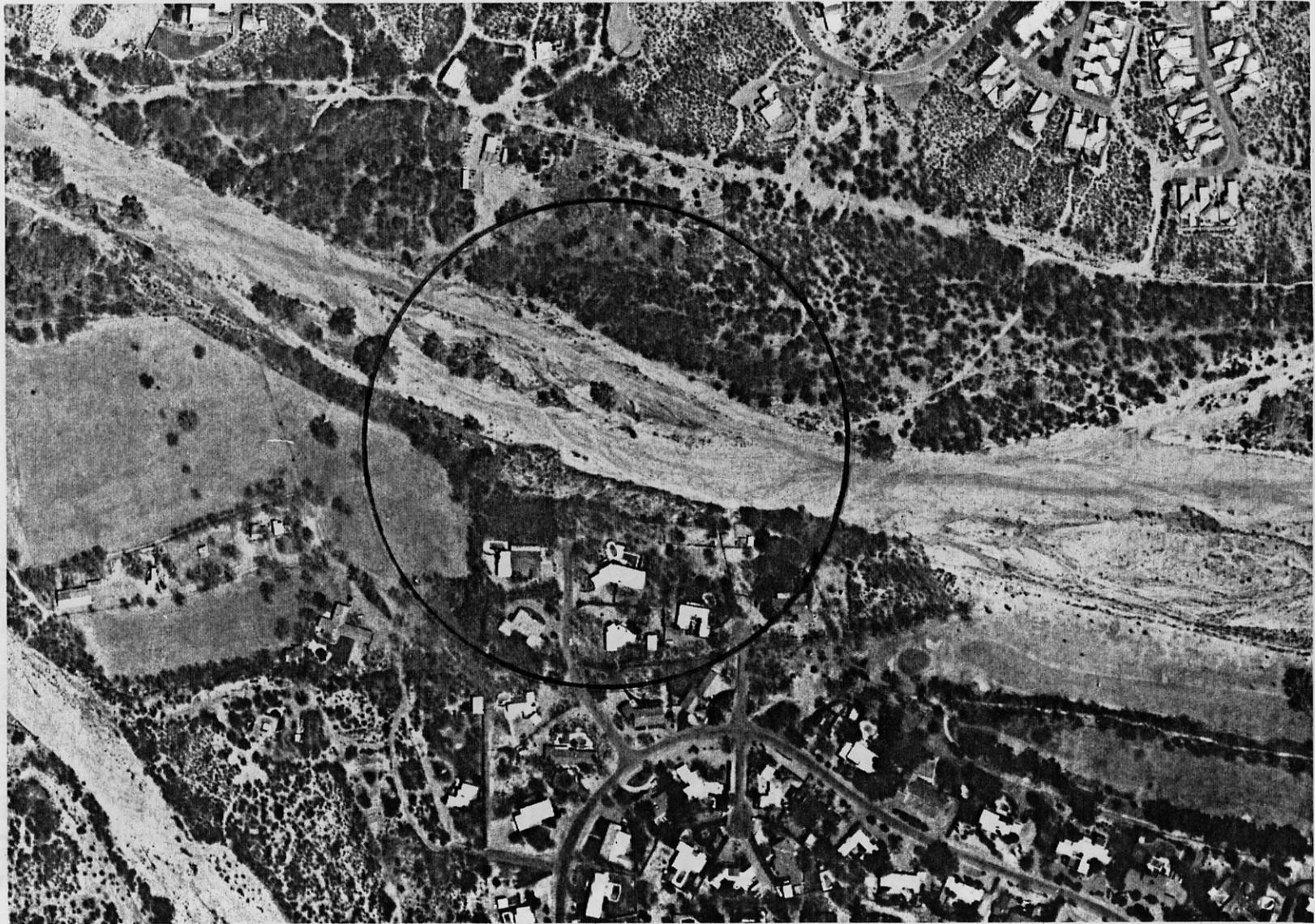


Agua Caliente Wash between Limberlost
and Fort Lowell Road
January 20, 1993

SCALE 1" = 1250'



FIGURE 6.29

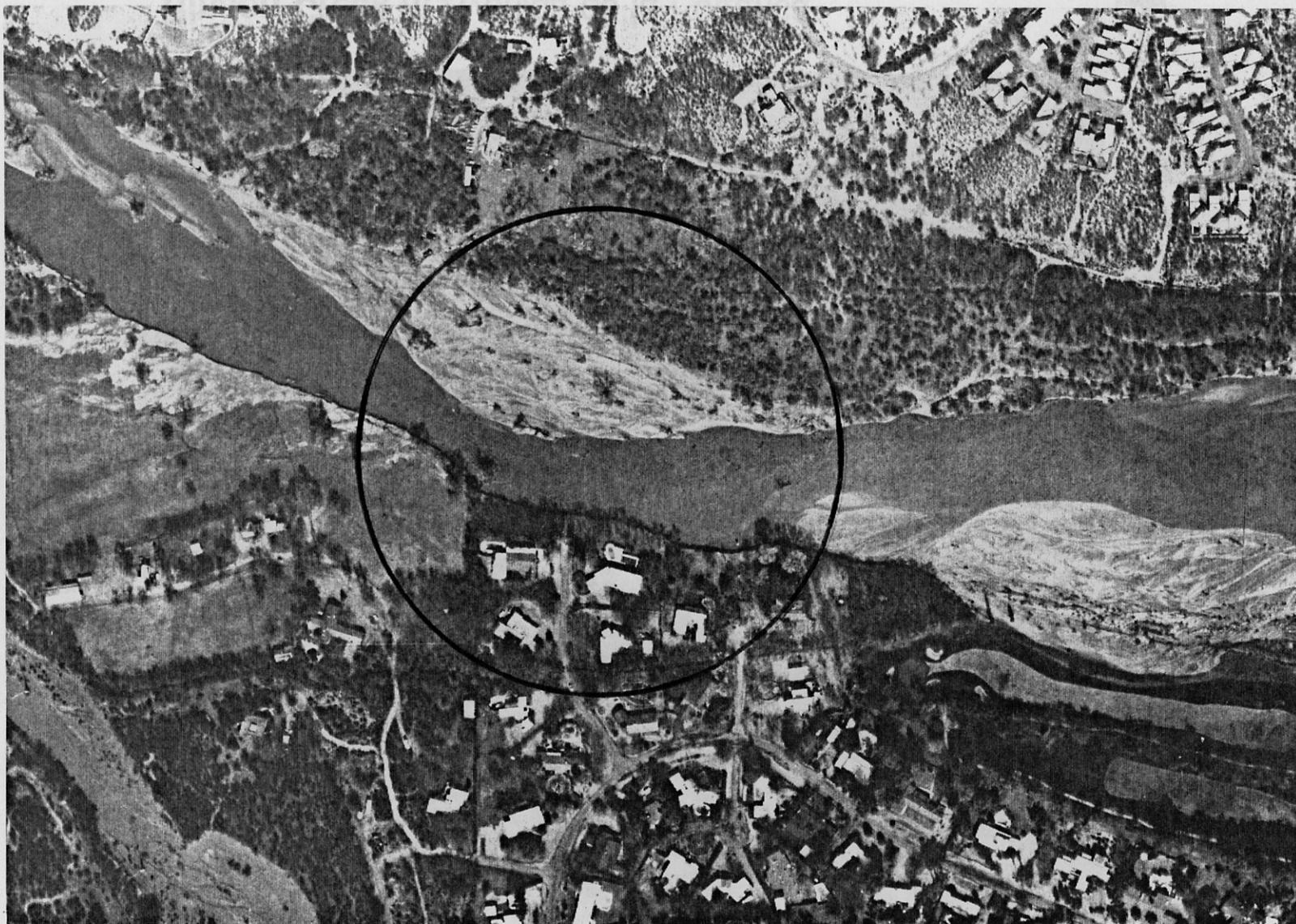


Tanque Verde Creek at Tucson Country Club Estates
March 22, 1990

SCALE 1" = 400'



FIGURE 6.30

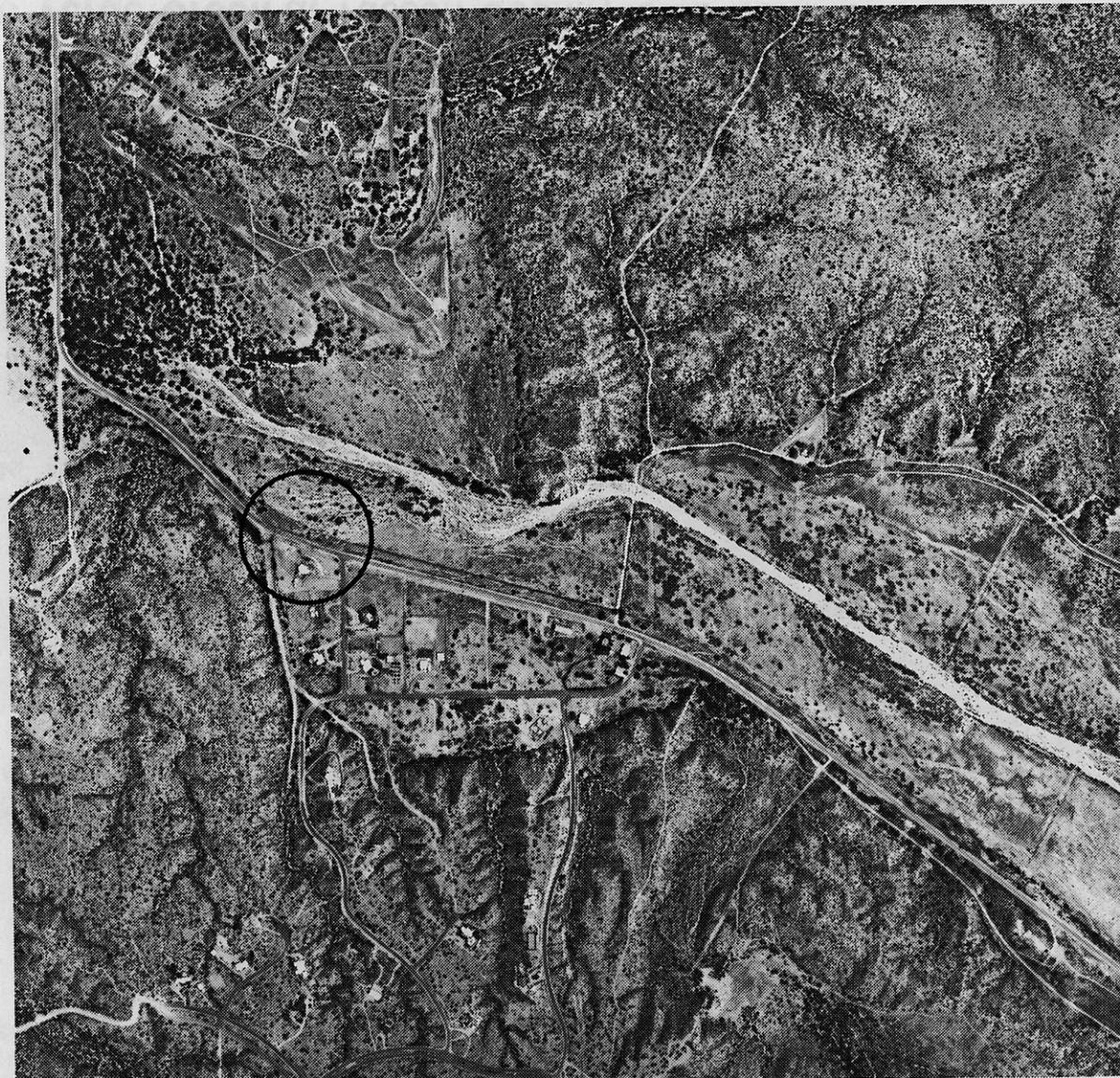


Tanque Verde Creek at Tucson Country Club Estates
January 20, 1993

SCALE 1" = 400'



FIGURE 6.31



Rincon Creek at Avenida de la Potranca
July 14, 1988

SCALE 1" = 1000'



6-36

080

FIGURE 6.32



Rincon Creek at Avenida de la Potranca
January 20, 1993

SCALE 1" = 1250'



FIGURE 6.33



Finger Rock Wash at Sutton Lane
March 19, 1990

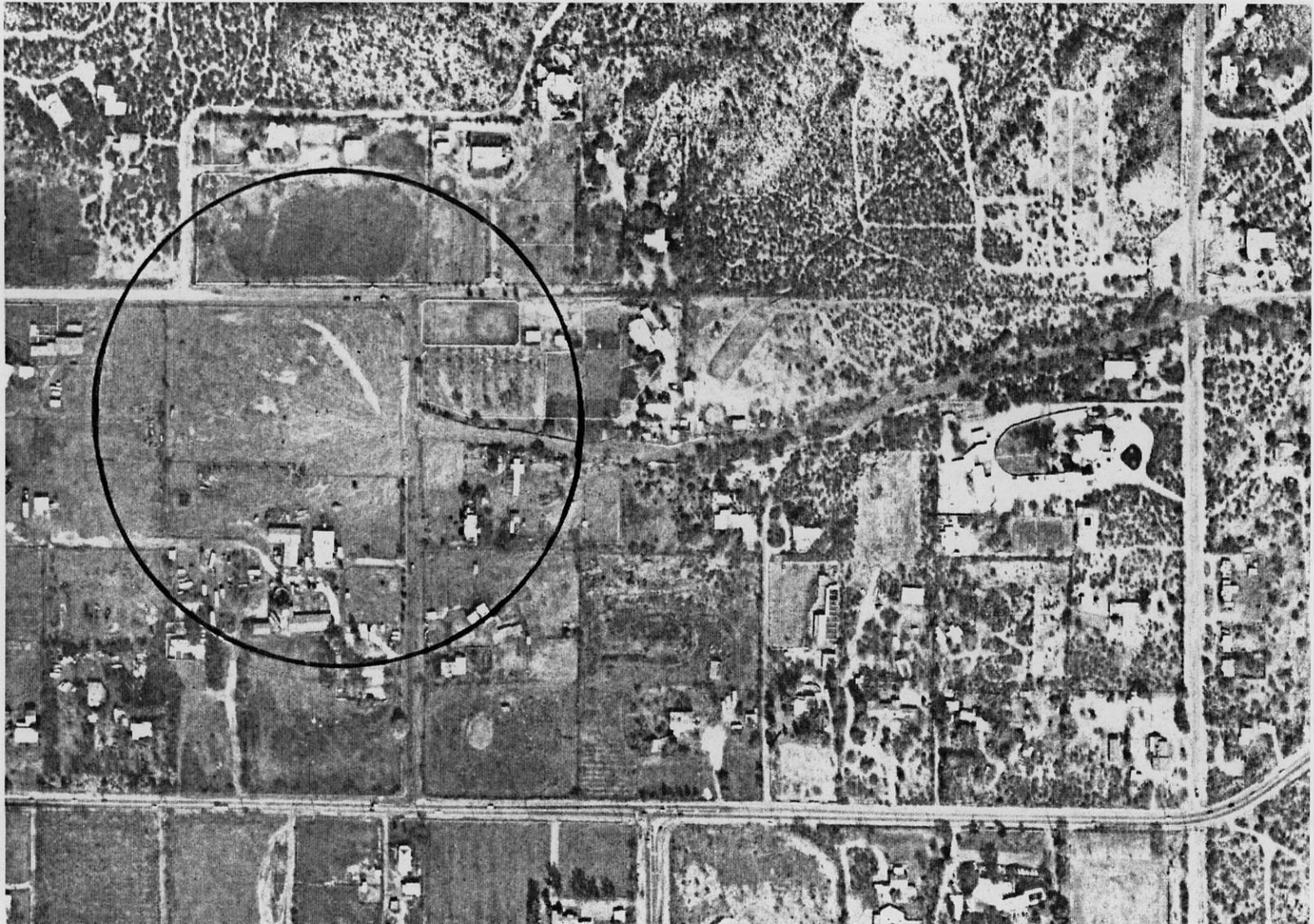
6-38

SCALE 1" = 400'



082

FIGURE 6.34



Finger Rock Wash at Sutton Lane
January 20, 1993

SCALE 1" = 400'



6.8 Sabino Creek

Sabino Creek is characterized by a relatively broad floodplain within a confined canyon. Breakout typically occurs where the main channel lacks conveyance for large flows. On January 7th and 8th, property around a few residences located in the creek was eroded; breakout to the south resulted in over a foot of water flowing through one residence.

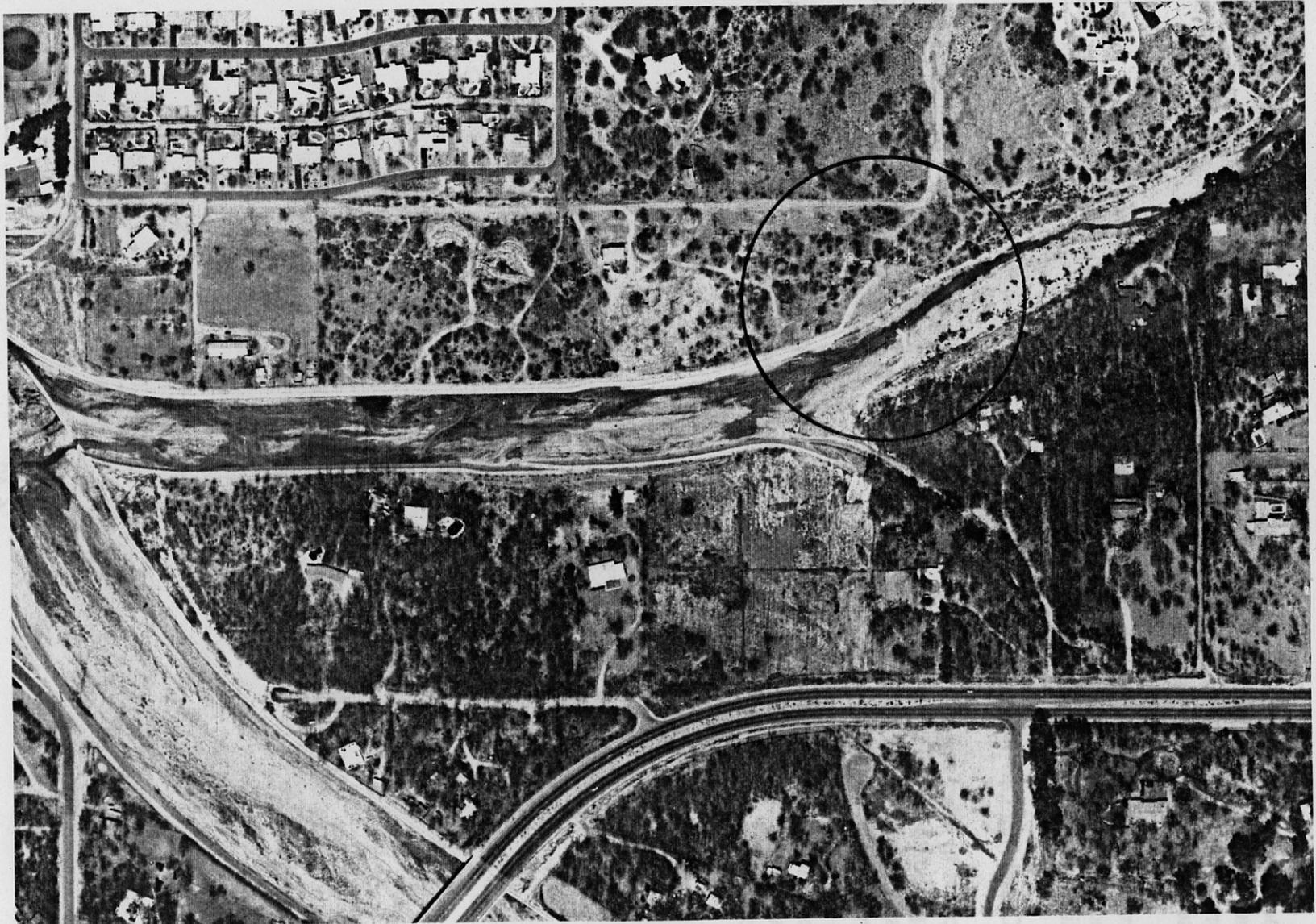
Upstream of the confluence at Tanque Verde Creek, Sabino Creek was flowing bankfull. Erosion behind the upstream key-in on the north bank soil-cement bank stabilization caused the bank stabilization to fail (Figures 6.35 and 6.36).

6.9 Cañada del Oro Wash (CDO)

Compared to other major watercourses, flow in the CDO was much less and resulted in little damage. South of the Pinal County line, breakout to the east was observed near Catalina between Wilds Road and Trotter Road. Access was limited, however, no damage to residential structures and very minor damage overall was reported.

Downstream, at-grade crossings at Overton Road and La Cholla Boulevard were closed but relatively little roadway damage occurred. At Tucson National, minor erosion occurred along the golf course.

FIGURE 6.35



Sabino Creek at Webster Avenue
March 22, 1990

SCALE 1" = 400'



6-41

085

FIGURE 6.36



Sabino Creek at Webster Avenue
January 20, 1993

SCALE 1" = 400'



7.0 SITE-SPECIFIC DAMAGE ASSESSMENT

Damage to transportation infrastructure, primarily roads, was widespread throughout Pima County. Damage to bridge approaches and abutments was mostly confined to those on the Santa Cruz River, except for the Craycroft Road and Dodge Boulevard bridges on Rillito Creek. Although bridge approaches and abutments were damaged, the bridge structures did not sustain any damage.

Flood control infrastructure, primarily soil-cement bank stabilization, held up remarkably well during the flooding, with relatively little damage incurred. The most notable locations where bank stabilization failed are the upstream west bank key-in on Sabino Creek, upstream of the confluence with Tanque Verde Creek; the south bank of Rillito Creek immediately downstream of the confluence of Alvernon Wash; and portions of the low-flow bank stabilization within Continental Ranch.

Due in part to the District's a) bank stabilization projects which have been constructed along vulnerable reaches of major watercourses since the 1983 flood; b) Floodprone Land Acquisition Program, whereby at-risk properties have been acquired and buildings demolished; and c) Floodplain and Erosion Hazard Management Ordinance No. 1988-FC2, which restricts construction in floodprone areas; no conventional residential or commercial buildings were lost during this flood in unincorporated Pima County. However, it is believed that the insides of up to two dozen residences were damaged due to flooding and sediment deposition.

Usually hardest hit due to proximity to floodprone areas and the vulnerability of the supporting structure, no manufactured homes were lost. However, one located on the west bank of the Santa Cruz River south of Ina Road, in the Casas Arroyo subdivision, was moved off the property to a safer location. Several accessory buildings, mostly animal barns/housing, sheds and greenhouses, were damaged due to bank erosion; fencing was lost or damaged in many locations; some vehicles which were driven into flooded wash crossings were heavily damaged; and much acreage was lost due to erosion. Figures 7.1 through 7.6 show selected flood damage sites along the major watercourses.

Section 7.1 lists the limitations inherent in this assessment of site-specific damage. Information regarding damage to public infrastructure is presented in Section 7.2, including costs to repair damaged sites to pre-flood conditions and cost estimates for long-term improvements to mitigate future flood loss. Sections 7.3 through 7.7 provide a brief overview of site specific damage by the following categories: 1) bridges, 2) roadway crossings other than bridges (major watercourses), 3) roads, 4) bank erosion (major watercourses), and 5) private property. Except for damage to roads, the information is listed by watercourse.

FIGURE 7.1a



Direction of flow →

7.1a) Santa Cruz River at Ina Road Bridge— looking to the southwest. Note damaged soil-cement abutment on northwest side of bridge. January 15, 1993.

FIGURE 7.1b



Direction of flow →

7.1b) Santa Cruz River at Ina Road Bridge— View east to west, from bottom to top of photo. Note erosion behind northwest abutment and under west approach road. January 15, 1993.

088

FIGURE 7.2a



↖ Direction of flow

7.2a) Bank erosion at the Luker residence, north bank of Rillito Creek downstream of Craycroft Road Bridge—looking northwest. January 11, 1993.

FIGURE 7.2b



7.2b) Rillito Creek at the Country Club Road "bend area"—looking to the northeast from the Tucson Racquet Club parking lot. January 15, 1993.

↖^x
Direction of flow

089

FIGURE 7.3a



← Direction of flow

7.3a) Rillito Creek at the Country Club Road "bend area"—looking downstream to the northwest. Note erosion at outside of bend. January 8, 1993.

FIGURE 7.3b



Direction of flow →

7.3b) South bank of Rillito Creek upstream of Camino de la Tierra. January 15, 1993.

090

090

FIGURE 7.4a



7.4a) Pegler Wash box culvert at Camino de la Tierra—looking southeast across Camino de la Tierra. January 15, 1993. Direction of flow →

FIGURE 7.4b



↙ Direction of flow

7.4b) House located on north bank of Pegler Wash, east of Camino de la Tierra. Note sandbags under sliding door. January 15, 1993.

FIGURE 7.5a



Direction of flow ↗

7.5a) Agua Caliente Wash at Tanque Verde Road—looking to the southeast. Note flooding at residence on north side of Tanque Verde Road; also note flooding at Amity on south side of road, at top center of photograph. January 8, 1993.

FIGURE 7.5b



Direction of flow →

7.5b) Looking south along Houghton Road bridge at Tanque Verde Creek crossing.

092

FIGURE 7.6a



Direction of flow

7.6a) Erosion behind upstream key-in of bank stabilization along Sabino Creek, north west bank, near Webster Avenue—looking to the southwest. January 9, 1993.

FIGURE 7.6b



Direction of flow

breakout

Rincon Creek

7.6b) Residence located on southwest corner of intersection of Old Spanish Trail and Avenida de la Potranca—looking to the southwest. Flooded by overbank flows from Rincon Creek. January 8, 1993.

7.1 Limitations

The listing of damage to public infrastructure is fairly comprehensive; although repair cost estimates and sources of funding are continually being updated, most sites where significant damage occurred are listed. The listing of damage to private property, however, is less complete. Data were compiled from all sources readily available including field investigation reports; drainage complaints called in to the office; newspaper articles; and conversations with property owners, and County and City staff. At the time of writing of this report, an exhaustive search for all damaged private property was not conducted. For this reason, it is very helpful to District staff when property owners call in and notify us of damage incurred.

7.2 Emergency Repairs and Long-Term Improvements

Emergency repairs, those needed to restore sites to the pre-flood condition, were completed at over 70 locations, as shown in Table 7.1 prepared by Operations Division personnel. Entries in the table include the location of the damaged sites, repair costs or cost estimates for those sites where repairs have not yet been completed, funding sources, the status of the repairs, and whether assistance is being provided and by whom. Some entries are incomplete as the table is continually being updated.

As of the writing of this report, **the total estimated cost of emergency repairs is \$ 2,763,876;** approximately \$ 2,395,632 in assistance is anticipated, with a cost of about \$ 436,203 to Pima County. The \$ 2,395,632 contributed by various agencies includes 10% of the total agency contribution which will be paid by Pima County for FEMA projects.

In several locations, new improvements will be constructed to mitigate future flood damage. This includes sites where little or no flood and erosion protection exists, as well as sites where the existing level of protection will be increased. Since the level of protection to be provided will be greater than that existing prior to the January 1993 Floods, these improvement projects are referred to as long-term improvements, to differentiate them from emergency repairs which restored the damaged sites to existing conditions. Table 7.2 lists the most recently-available cost estimates for long-term improvements. As shown at the end of Table 7.2, **the total estimated cost for long-term improvements is \$ 8,650,400; with \$ 2,513,600 contributed from SCS, \$ 2,219,344 from FHWA, and \$ 3,917,456 from PCDOT & FCD.** It must be noted that these data are continually being updated as additional information becomes available.

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93)

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
1	Old Spanish Tr.	at Rincon		1	4	17-15-16	FHWA		35,000.00	35,000.00		0.00	Shoulder Work	N	
2	Camino Loma Alta	N. of Spanish Tr.		1	4	26/27-15-16	FEMA	51102	49,056.33	40,605.00	36,544.50	12,511.83	Crossing Destroyed	N	
3	Wilmot Rd.	Sahuarita	I-10	1	2	12-17-14	Local		2,007.37	0		2,007.37	Cleanup	Y	LOCAL
4	Dodge Blvd.	at Rillito Cr.		2EA	4	28-13-14	FHWA*		4,549.98	4,549.98		0.00	Major Cleanup	Y	5/13/93
5	Houghton Rd.	Tanque Verde	Speedway	2EB	1	35/36-13-15	FHWA		60,000.00	60,000.00		0.00	Bank Protection, Toe Exposed.	N	
6	Tanque Verde	East of Houghton		2EB	4	35/36-13-15	FHWA		45,371.00	45,371.00		0.00	Road and Shoulder wash out	Y	4/27/93
8	Wentworth	Tanque Verde Crk.		2EB	4	4/5-14-16	FEMA	50987	4,056.88	2,333.00	2,099.70	1,957.18	Crossing Washout	Y	4/13/93
9	Tanque Verde Loop	Tanque Verde Crk.		2EB	4	5/6-14-16	FHWA*		23,500.00	23,500.00		0.00	Crossing Washout	N	
10	Soldier Tr.	Agua Caliente		2EB	4	19/20-13-16	FHWA*		42,500.00	42,500.00		0.00	Crossing Washout	N	
11	Limberlost	Agua Caliente Wash		2EB	4	19/20-13-16	FEMA	50982	7,362.50	3,598.00	3,238.20	4,124.30	Crossing Washout	Y	4/13/93
11	Limberlost	Agua Caliente		2EB	4	19/20-13-16	FEMA	50983	6,989.75	6,720.00	6,048.00	941.75		Y	
12	Ft. Lowell	Agua Caliente		2EB	4	23/29/30-13-15/16	FHWA*		30,000.00	30,000.00		0.00	Damage to Bank Protection	N	
14	La Cholla	at C.D.O		2W	3	21/22-12-13	LOCAL		487.85	0.00		487.85	Dip Cleaning	Y	LOCAL
15	Overton	at C.D.O		2W	3	21/22-12-13	FHWA*		6,693.00	6,693.00		0.00	Dip Reconstruction	Y	4/27/93
16	Cmo. De La Tierra	Pegler Wash		2EA	3	8-13-13	FEMA	51118	6,007.00	6,007.00	5,406.30	600.70		Y	4/25/93
16	Cmo. De La Tierra	N. of Rillito River		2EA	3	8-13-13	FEMA	51120	18,308.00	9,768.00	8,791.20	9,516.80		Y	
16	Cmo. De La Tierra	at Rillito River		2EA	3	8-13-13	FEMA	51121	124,689.00	124,689.00	112,220.10	12,468.90		Y	
16	Cmo. De La Tierra	N. bank Pegler Wash	E. CDL Tierra	2EA	3	8-13-13	FEMA	51122	31,616.00	24,693.00	22,223.70	9,392.30		HOLD	
16	Cmo. De La Tierra	Pegler Wash		2EA	3	8-13-13	FEMA	51123	18,420.24	15,347.00	13,812.30	4,607.94		Y	4/25/93
19	Snyder Hill	San Joaquin	Sandario	3	3	34/35/36-14-11/12	FEMA	51115	6,282.30	6,282.00	5,653.80	628.50	Erosion/Cleaning	Y	

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
19	Snyder Hill	San Joaquin	Sandario	3	3	34/35/36-14-11/12	FEMA	51116	535.00	535.00	481.50	53.50		N	
20	Mt. Lemmon Hwy.	Catalina Hwy.			4	30/31-11-16	FHWA*		160,000.00	160,000.00		0.00	Various Location	N	
22	River Road	Hacienda del Sol	Swan	2EA	1	20-13-14	LOCAL		10,541.00	10,541.00		0.00		Y	4/27/93
25	Aguirre Rd.	in Marana		3	3	5/8/9/16/17-11-10	FEMA	51109	43,350.00	7,068.00	6,361.20	36,988.80	Cleanup Erosion	N	
26	Trico	at Santa Cruz		3	3	24-11-10	FHWA*		250,000.00	250,000.00		0.00	Re-channel	N	
27	Sanders (Marana)	at Santa Cruz		3	3	32/33-11-11	FHWA		5,500.00	5,500.00		0.00	Soil Cement	?	
28	Campbell	at Rillito River		2EA	1	19/20-13-14	FEMA	51124	22,195.73	22,195.73	19,976.16	2,219.57	Temporary Bank Protection	Y	4/5/93
32	Ina (Bridge)	at Santa Cruz		3	5	1/2-13-12	FHWA		12,686.00	12,686.00		0.00	Temporary Protection	Y	4/27/93
33	Trico /Marana Bridge	at Santa Cruz		3	3	24-11-10	FHWA		35,444.61	35,444.61		0.00	Temporary Protection	Y	5/10/93
35	Sunrise	at Ambrose		2EB	4		FHWA		5,858.41	5,858.41		0.00	CMP Replaced, Shoulder re	Y	5/10/93
36	Craycroft Bridge	at Rillito		2EA	4	25/26-13-14	FHWA		360,000.00	360,000.00		0.00	Engineering Review	N	4/27/93
37	Country Club(TRC)	Rillito	Adjacent to T.R.C.	2EA	1	20/21-13-14	local		1,295.03	0.00		1,295.03	Erosion	Y	LOCAL
38	Summer Haven	General Repairs			4	25/26/30/31-11-16	FEMA	56956	8,070.57	8,070.57	7,263.51	807.06		Y	
38	Summer Haven	Phoenix Avenue			4	25/26/30/31-11-16	FEMA	57692	365.00	365.00	328.50	36.50		N	
38	Summer Haven	Carter Canyon Rd.			4	25/26/30/31-11-16	FEMA	57693	3,521.00	3,521.00	3,168.90	352.10		N	
38	Summer Haven	E. Goat Hill Rd.			4	25/26/30/31-11-16	FEMA	57694	1,646.00	1,646.00	1,481.40	164.60		N	
38	Summer Haven	Retreat Rd.			4	25/26/30/31-11-16	FEMA	57695	6,897.00	6,897.00	6,207.30	689.70		N	
38	Summer Haven	Sabino Canyon Pkwy.			4	25/26/30/31-11-16	FEMA	57696	10,011.00	10,011.00	9,009.90	1,001.10		N	
38	Summer Haven	Florence & Tempe			4	25/26/30/31-11-16	FEMA	57697	398.00	398.00	358.20	39.80		N	

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
39	GENERAL PAVEMENT						LOCAL		37,190.63	0.00		37,190.63		Y	
40	Santa Cruz River	@ Mission Street					FEMA	507690	27,500.00	27,500.00	24,750.00	2,750.00		N	
41	DIRT ROAD REPAIRS						LOCAL		7,869.86	0.00		7,869.86		Y	
45	Reddington Rd	Edgar Wash		2EB	4	2/3-14-16	FEMA	51136	2,083.75	2,083.75	1,875.38	208.38	Dips Washout/Rail-Basket	Y	
45	Reddington Rd	1/2 m. SW Six Bar Ranch Road		2EB	4	2/3-14-16	FEMA	51137	1,247.00	1,247.00	1,122.30	124.70		Y	
45	Reddington Rd	Buehman Wash		2EB	4	2/3-14-16	FEMA	51138	1,141.13	1,141.13	1,027.02	114.11		N	
45	Reddington Rd	Bellota Ranch Road		2EB	4	2/3-14-16	FEMA	51139	555.00	555.00	499.50	55.50		Y	
45	Reddington Rd	Youtey Wash		2EB	4	2/3-14-16	FEMA	51140	312.40	313.00	281.70	30.70		Y	
45	Reddington Rd	1/4 m. E. of Forest Boundry		2EB	4	2/3-14-16	FEMA	51141	277.50	278.00	250.20	27.30		Y	
45	Reddington Rd	2 m. E. Bellota Road		2EB	4	2/3-14-16	FEMA	51142	833.75	350.00	315.00	518.75		Y	
46	Redfield Canyon Rd	E. of Benson Mammoth Hwy.		2EB	4		FEMA	51134	3,560.00	3,452.30	3,107.07	452.93	Roadway Washout	N	
46	Redfield Canyon Rd	at San Pedro River		2EB	4		FEMA	51135	2,000.00	760.40	684.36	1,315.64		Y	
46	Redfield Canyon Rd	Bridge Approach	Benson Highway	2EB	4		FEMA	51133	1,680.00	1,680.00	1,512.00	168.00		N	
48	San Pedro River Rd.	Pinal Co.	Reddington Rd	2EB	4		FEMA	51131	477.60	477.60	429.84	47.76	Dip Repair	Y	4/5/93
50	San Pedro River Rd. *	At Bridge		2EB	4		FEMA	51132	25,000.00	15,050.00	13,545.00	11,455.00	Rechannel River	N	
51	Tanque Verde	500' W. Wentworth		2EB	4	4/5-14-16	FEMA	50985	2,947.03	2,947.03	2,652.33	294.70	Shoulder Washout	Y	
52	Snyder Rd.	All	Harrison	2EB	4	15/22-13-15	FHWA*		7,500.00	7,500.00		0.00	Minor Repair/ Cleanup	N	
53	Sabino Cr.	at Webster		2EB	4	16-13-15	FEMA	50979	113,000.00	113,000.00	101,700.00	11,300.00	Bank Protection/Soil Cement	N	HOLD
54	SUBDIVISION ROADS						LOCAL		5,546.13	0.00		5,546.13		Y	LOCAL
55	Wolford	S. of Snyder		2EB	4	14/23-13-15	Local		140.50	0.00		140.50	Dips Washout	Y	LOCAL

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
56	Harrison	at Prospect/Snyder		2EB	4	22/23-13-15	FHWA		6,500.00	6,500.00		0.00	Rip-Rap Exp./ Toe repair	Y	
59	Calle Primula/Tabosa	Ocotillo	Snyder	2EB	4	15-13-15	Local		4,142.63	0.00		4,142.63	Shoulder Erosion	Y	LOCAL
60	Colina	N. of Snyder		2EB	4	13/24-13-15	Local		643.25	0.00		643.25	Dip Washout	Y	LOCAL
62	Thunderbird	W. of Soldier Tr.		2EB	4	19/20-13-16	FEMA	50996	411.40	411.40	370.26	41.14	Dirt Road Washout	Y	4/5/93
63	Summer Tr.	W. of Soldier Tr.		2EB	4	19/20-13-16	FEMA	50997	326.40	282.00	253.80	72.60	Dirt Road Washout	Y	4/5/93
64	Calle de Samuel	W. of Soldeir Tr.		2EB	4	19/20-13-16	FEMA	50998	1,417.50	1,233.00	1,109.70	307.80	2 Dips Washout	Y	
64	Calle de Samuel	W. of Soldeir Tr.		2EB	4		FEMA	50999	1,806.88	1,421.00	1,278.90	527.98		Y	
65	Sneller Vist Dr.	S. of Samuel		2EB	4	19-13-16	FEMA	51000	1,741.50	1,188.45	1,069.61	671.90	Dip Washout	Y	
68	Mona Lisa	Carmac Wash		2W	1	33-12-13	FEMA	50974	6,000.00	948.00	853.20	5,146.80	Bank Protection	N	
69	Tangerine Rd.	E. of Tortila		2W	3	(31-36)-11-12	Local		6,187.43	0.00		6,187.43	Road Washout	Y	LOCAL
71	Sahuarita Rd.	at Santa Cruz		4	3	12/13-17-13	FHWA*		21,620.00	21,620.00		0.00	Temporary Repairs	N	4/27/93
72	Tres Bellotas	Arivaca Cr.	Ruby Rd.	4	3	28/29-21-10	FEMA	51144	8,022.60	8,022.60	7,220.34	802.26	Road Washout	Y	4/5/93
73	Elephant Head Rd.	at Santa Cruz		4	4	29-19-13	FHWA*		18,131.86	18,131.86		0.00	Temp. Bank Protection	Y	4/27/93
74	Arivaca Sasbee Rd.	Mile post 4.3,4.5		4	3	18/19/20/28-21-10	FHWA		42,000.00	42,000.00		0.00	Box Culvert	N	
75	Sutton Lane	Finger Rock Wash		2EA	1	21/28-13-14	FEMA	51125	4,733.73	3,664.00	3,297.60	1,436.13	Dip Sections Damage	Y	
75	Roger Rd.	Finger Rock Wash		2EA	1		FEMA	51126	651.00	651.00	585.90	65.10	Shoulder Work	Y	4/25/93
76	Alvernon Wash	N of Kleindale		2EA	1	27-13-14	FEMA	50978	45,892.00	45,892.00	41,302.80	4,589.20	Bank Erosion/Soil Cement	N	HOLD
78	St. Gregory	at Pilito		2EA	1	26-13-14	Local		88,372.53	0.00		88,372.53	Bank protection	Y	LOCAL
79	4020 Alvernon			2EA	1	33-14-14	FEMA	51127	8,343.24	1,143.00	1,028.70	7,314.54	Dip Washout	Y	4/13/93
80	Cmo. De la Bajada	E. of Alvernon		2EA	1	22-13-14	FEMA	51128	10,292.75	10,292.75	9,263.48	1,029.28	Roadway Repair	Y	4/5/93

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
81	Alvernon Way	N. of Llanosa		2EA	1	22-13-14	FEMA	51129	4,940.88	1,142.00	1,027.80	3,913.08	Roadway Repair	Y	4/5/93
82	Happy Valley Rd.	Cochise Co	End	1	4	QM-QQ 257	FEMA	51101	74,153.00	74,153.00	66,737.70	7,415.30	Road Washout	N	
84	Neal Ave	North of Bopp	Claude	3	3	30-14-12	FEMA	51114	4,084.00	2,327.00	2,094.30	1,989.70	Road and Shoulder Erosion	N	
88	Pump Station	Silverbell	Avra Valley	3	3		FEMA	51146	14,250.00	2,800.00	2,520.00	11,730.00	Road and Shoulder Erosion	N	
88	Pump Station	Silverbell	Avra Valley	3	3		FEMA	51147	3,846.15	3,846.00	3,461.40	384.75		Y	
89	Twin Peak			3	3	16/17/19/20-12-11/12	FEMA	51148	2,473.68	2,473.68	2,226.31	247.37	Roadway Damage	Y	4/5/93
91	Avra Valley	E of Bridge	Frontage	3	3	8-12-12	FHWA		281,000.00	281,000.00		0.00	Erosion	N	4/27/93
92	Cortaro Bridge	at Santa Cruz		3	3	26-12-12	FHWA(MARANA)		41,090.19	41,090.19		0.00	Bank Protection	Y	5/10/93
93	TRUCKING						LOCAL		98,868.33	0.00		98,868.33		Y	
94	Ironwood Hill	West of Silverbell		3	5	33-13-13	FHWA*		10,558.95	10,558.95		0.00	Crossing Damage	N	
102	DEBRIS REMOVAL						LOCAL		200,000.00	200,000.00		0.00		N	
105	Flagstaff	Vantana Wash		2EB	4		FEMA	51143	3,000.00	753.00	677.70	2,322.30	Bank Erosion	N	
106	Homestead	1500' s. of Snyder		2EB	4		FEMA	50992	3,000.00	2,160.00	1,944.00	1,056.00	Rip-Rap Washout	N	
107	Como Dr.	N. of Moore		2W	3	28-11-13	FEMA	51105	1,092.00	1,092.00	982.80	109.20	Dip Sections Washout	Y	
108	Alley Fill	Red Wolfe		2W	3	24-12-12	FEMA	51107	2,912.25	2,810.00	2,529.00	383.25	Erosion	Y	4/5/93
110	Cole Road, Ajo			5	3		FEMA	57301	23,551.99	23,551.99	21,196.79	2,355.20		N	
111	Mead Road, Ajo			5	3		FEMA	57302	15,744.33	15,744.33	14,169.90	1,574.43		N	
							TOTAL		2,763,876.28	2,395,631.71	611,628.04	436,203.24			

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
NOTES:															
1	THE NUMBERS FOR THE LOCATIONS ARE CONTROL NUMBERS. THEREFORE SOME NUMBERS DO NOT HAVE LOCATIONS ASSIGNED.														
2	ESTIMATED COST (COLUMN 10) IS THE TOTAL ESTIMATE FOR COMPLETION OF REPAIRS AT EACH SITE. THIS ESTIMATE COMES FROM ENGINEERING , FIELD SUPERVISORS AND FEMA INSPECTORS. WHEN COMPLETED, COLUMN REFLECTS ACTUAL COST.														
3	AGENCY CONTRIBUTION (COLUMN 11) IS THE TOTAL EXPECTED REIMBURSEMENT OF COSTS FROM ANY SOURCE INCLUDING FEMA, FHWA , SCS , COE AND OTHER AGENCIES. THE FEMA AMOUNT IS THE TOTAL DSR ESTIMATE.														
4	FEMA CONTRIBUTION @ 90 % (COLUMN 12) IS THE EXPECTED REIMBURSEMENT FROM FEMA BASED ON 90 % OF THE DSR ESTIMATE. THE FUNDS ARE PAID AT 75 % BY FEMA UPON COMPLETION OF REPAIRS AND 15% PAID BY THE STATE UPON INSPECTION AND AUDIT OF RECORDS.														
5	PIMA COUNTY COST (COLUMN 13) IS THE ESTIMATED EXPENSE TO PIMA COUNTY FOR EACH LOCATION, BASED ON ESTIMATED COST AND THE EXPECTED REIMBURSEMENT FROM OUTSIDE AGENCIES. THIS COST INCLUDES THE COUNTY'S 10% SHARE OF THE DSR REPAIRS.														
6	SITES WITH FHWA* IN THE AGENCY COLUMN ARE SITES THAT ARE BEING SUBMITTED TO FHWA BUT ALSO HAVE BEEN ASSIGNED DSR NUMBERS.														
7	AMOUNT BILLED/REIMBURSEMENT COLUMN IS THE AMOUNT BILLED FOR REIMBURSEMENT TO FEMA AND FHWA. THE FEMA AMOUNT IS FIGURED AT 90 % OF THE DSR ESTIMATE, REGARDLESS OF THE ACTUAL COST OF REPAIRS. SOME OF THE FHWA SITES ARE ONLY PARTIAL BILLINGS AT THIS TIME. SITE LABELED NA ARE PIMA COUNTY PROJECTS, NOT SUBJECT TO REIMBURSEMENT.														

TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Elephant Head Road at Santa Cruz River Repair bank prot.					Received project approval from FHWA for long-term solution, including soil cement bank protection along the west bank; emergency repairs were also approved for reimbursement.
Design	60,000		55,620	4,380	
Right-of-Way					
Construction	745,000		690,615	54,385	
Field Inspection	75,000		69,525	5,475	
TOTAL	880,000	FHWA	815,760	64,240	
Ina Road at Santa Cruz River Bank protection					Approval to proceed with the engineering design for a long-term solution has been received from FHWA. Plans are completed, however additional information is required prior to receiving ADOT/FHWA approval for the plans.
(west bank)					
Design	30,000		27,810	2,190	
Right-of-Way					
Construction	320,000	FHWA	296,640	23,360	
Field Inspection	50,000		46,350	3,650	
TOTAL	400,000		370,800	29,200	
(drop structure)					
Design	36,500		26,043	10,457	
Right-of-Way	40,000	FHWA	28,540	11,460	
Construction	580,000	&	413,830	166,170	
Field Inspection	98,500	ADOT	70,280	28,220	
TOTAL	755,000		538,693	216,307	

TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Trico-Marana Road at Santa Cruz River Bank protection, SW abutment					Emergency repairs completed. Long-term solution awaiting approval by FHWA.
Design	50,000		46,350	3,650	
Right-of-Way	10,000		9,270	730	
Construction	393,000		364,311	28,689	
Field Inspection	80,000		74,160	5,840	
TOTAL	533,000	FHWA	494,091	38,909	
Trico Road at Santa Cruz River channel clean-up					Emergency repairs completed. Long-term repairs were not approved by FHWA.
Design	111,080			111,080	
Right-of-Way					
Construction	1,110,800			1,110,900	
Field Inspection	166,620			166,620	
TOTAL	1,388,500			1,388,500	

TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Rillito Creek at St. Gregory's bank protection					This location has been approved by SCS as a non-exigency project. Local sponsor funding source is yet to be identified. Design concept submitted to SCS for approval.
Design	70,000			70,000	
Right-of-Way	20,000			20,000	
Construction	432,000		345,600	86,400	
Field Inspection	65,000			65,000	
TOTAL	587,000	SCS	345,600	241,400	
Rillito Creek at Country Club Road bend bank protection					This project was added to Granite's contract for the Rillito, from Campbell Avenue to Country Club Road (with SCS concurrence).
Design	60,000			60,000	
Right-of-Way	20,000			20,000	
Construction	580,000			180,000	
Field Inspection	75,000			75,000	
TOTAL	735,000	SCS	400,000	335,000	

TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Tanque Verde Creek at Tucson Country Club Estates					Board approved agreement with SCS. RS Engineering has submitted a proposal to design the project. Contract must be awarded by 8-30-93.
Design	50,000			50,000	
Right-of-Way	20,000			20,000	
Construction	400,000		320,000	80,000	
Field Inspection	60,000			60,000	
TOTAL	530,000	SCS	320,000	210,000	

TOTALS

SCS	\$ 2,513,600
FHWA	\$ 2,219,344
PCDOT & FCD	\$ 3,917,456
SUM TOTAL	\$ 8,650,400

7.3 Bridges

Although some refer to box culverts, especially the larger ones, as bridges, in this report bridges refer only to structures consisting of a bridge deck supported by piers or pilings. No structural damage to any of the bridges occurred; at all damaged sites it was the approaches or abutments which were damaged. Most damage occurred along the Santa Cruz River, from the Elephant Head Road bridge south of Green Valley to the Trico Road bridge near the Pinal County line. As expected, the most severe damage occurred at the Trico Road bridge near Marana, where the conveyance area beneath the low chord of the bridge deck filled with sediment, and the main flowpath shifted to the north. The Trico Road bridge was reopened in early May. The Ina Road bridge was also heavily damaged.

Only two bridges along Rillito Creek received damage, the Craycroft Road and Dodge Boulevard bridges, with the former being heavily damaged. As mentioned in Chapter 5.0, the north abutment at the Craycroft Road bridge was severely eroded. Damage at the Dodge Boulevard bridge consisted primarily of debris buildup, blocking conveyance under the bridge. Because the bridge is old and was constructed with shallow piles, plans for replacing the bridge have been completed, however no funds have been programmed for this project.

No bridge approaches or abutments along Agua Caliente Wash or Tanque Verde Creek were damaged. As flows on the Cañada del Oro and Pantano Washes were relatively small, no bridge crossings were damaged. Table 7.3 lists information on damage to bridges.

7.4 Roadway Crossings Other than Bridges - Major Watercourses

Roadway crossings other than bridges on major watercourses consist primarily of at-grade (dip) crossings, and crossings with box culverts. At-grade crossings may have low-capacity pipe culverts, however during a large flow event most of the discharge flows across the roadway surface. Therefore in this report at-grade crossings with and without pipe culverts are referred to as at-grade crossings. Alternatively, box culverts are typically designed to convey larger-magnitude events. In order to achieve capacity, the top of the box culvert is generally elevated several feet above the channel invert, i.e., above grade.

Table 7.4 provides data on damage to roadway crossings other than bridges, by watercourse. Essentially all major roadway crossings were damaged; most were closed during peak flows.

TABLE 7.3 - DAMAGE ASSESSMENT, BRIDGES

LOCATION	DAMAGE DESCRIPTION	COST ESTIMATE
SANTA CRUZ RIVER		
Elephant Head Road S29-T19S-R13E	Channel alignment shifting to west; failed bank stabilization at west abutment on upstream side, west approach severely damaged; erosion threatening approach and abutment on east side	\$ 18,100 emer. repairs \$ 880,000 long-term improvements
Sahuarita Road S12/13-T17S-R13E	West abutment damaged	\$ 21,600 emer. repairs
Ina Road (S2-T13S-R12E)	West approach damaged, bank stabilization damaged upstream and downstream sides, erosion threatening west abutment	\$ 12,700 emer. repairs \$ 1,155,000 long-term improvements
Cortaro Road (S26-T12S-R12B)	Upstream east bank stabilization damaged	\$ 41,400 emer. repairs
Avra Valley Road (S8-T12S-R12E)	East abutment severely damaged	\$ 281,000 emer. repairs
Sanders Road (S32/33-T11S-R11E)	Damaged soil-cement	\$ 5,500 emer. repairs
Trico-Marana Road (S24-T11S-R10B)	Meander to west on upstream side threatening south abutment	\$ 35,400 emer. repairs \$ 533,000 long-term improvements
Trico Road S14/15-T11S-R10E	Bridge blocked by sediment deposition under structure and upstream of bridge; channel alignment has shifted to the north; extensive sediment deposition on north and south approaches	\$ 250,000 emer. repairs \$ 1,388,500 long-term improvements
RILLITO CREEK		
Craycroft Road (S25/26-T13S-R14E)	Severely eroded embankment along north abutment	\$ 360,000 emer. repair
Dodge Boulevard (S28-T13S-R14E)	Buildup of debris under bridge	\$ 4,500 emer. repair

TABLE 7.4

DAMAGE ASSESSMENT - ROADWAY CROSSINGS OTHER THAN BRIDGES

MAJOR WATERCOURSES

LOCATION	DAMAGE DESCRIPTION	COST ESTIMATE¹
RILLITO CREEK		
Camino de la Tierra (S8-T13S-R13E)	At-grade crossing severely damaged, excessive sediment deposition	\$ 125,000
PEGLER WASH		
Camino de la Tierra (S8-T13S-R13E)	Debris and sediment deposited under box culvert and in ustream channel, pavement destroyed	\$ 24,400
AGUA CALIENTE WASH		
Soldier Trail (S19/20-T13S-R16E)	At-grade crossing severely damaged	\$ 42,500
Limberlost Road (S19/20-T13S-R16E)	At-grade crossing damaged (0.2 - mile dirt road)	\$ 10,300
Fort Lowell Road (S30/31-T13S-R16E)	At-grade crossing, pavement and shoulder damaged	\$ 30,000
Tanque Verde Road (S36-T13S-R15E)	Box culvert partly filled, pavement and shoulder damaged	\$ 45,400
Houghton Road, between ACW and TV Creek, E. side (S1/2-T14S-R15E)	Elevated crossing, soil-cement toe-down damaged	\$ 60,000
Snyder Road at Homestead Avenue (S18/18-T13S-R16E)	At-grade crossing, grouted rip-rap apron damaged	\$ 3,000
Thunderbird Road west of Soldier Trail (S19-T13S-R16E)	At-grade crossing, shoulder damaged (0.5-mile dirt road)	\$ 400
Summer Trail west of Soldier Trail (S19-T13S-R16E)	At-grade crossing, shoulder damaged (0.5-mile dirt road)	\$ 325

¹ Cost estimates are for emergency repairs only

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TABLE 7.4 - CONTINUED

DAMAGE ASSESSMENT - ROADWAY CROSSINGS OTHER THAN BRIDGES

MAJOR WATERCOURSES

LOCATION	DAMAGE DESCRIPTION	COST ESTIMATE ¹
Calle de Samuel west of Soldier Trail (S19-T13S-R16E)	At-grade crossing, shoulder and/or pavement damaged	\$ 1400
Sneller Vista Drive south of Calle de Samuel (S19-T13S-R16E)	At-grade crossing, shoulder and/or pavement damaged	\$ 1750
TANQUE VERDE CREEK		
Wentworth Road (S4/5-T15S-R16E)	At-grade crossing damaged (0.15-mile dirt road)	\$ 4,050
Tanque Verde Loop Road (S6-T14S-R16E)	At-grade crossing severely damaged, soil-cement destroyed	\$ 23,500
RINCON CREEK		
Camino Loma Alta (S14/15-T15S-R16E)	At-grade crossing severely damaged, dirt road	\$ 49,050
Old Spanish Trail (S8-T15S-R16E)	At-grade crossing severely damaged	\$ 35,000
CANADA DEL ORO WASH		
Overton Road (S22-T12S-R13E)	At-grade crossing, pavement damaged, shoulder severely eroded	\$ 6,700
La Cholla Boulevard (S21/22-T12S-R13E)	At-grade crossing, pavement damaged	\$ 500
VENTANA CANYON WASH		
Snyder Road (S17/20-T13S-R15E)	At-grade crossing, grouted rip-rap shoulder damaged	\$ 7,500

1 Cost estimates are for emergency repairs only

TABLE 7.4 - CONTINUED
DAMAGE ASSESSMENT - ROADWAY CROSSINGS OTHER THAN BRIDGES
MAJOR WATERCOURSES

LOCATION	DAMAGE DESCRIPTION	COST ESTIMATE ¹
FINGER ROCK WASH		
Sutton Lane (S28-T13S-R14E)	At-grade crossing, excessive sediment deposition	\$ 4,700
Camino de la Bajada (S22-T13S-R14E)	At-grade crossing, sediment deposition and erosion (dirt road)	\$ 10,300
Alvernon Way, N. of Cmo. Llanoso (S22-T13S-R14E)	At-grade crossing, sediment deposition and erosion (dirt road)	\$ 5,000

1 Cost estimates are for emergency repairs only

The largest number of damaged crossings occurred along the Agua Caliente Wash, where the only bridge crossing is located on Houghton Road. During the height of the flooding, the north approach road to this bridge was flooded, precluding use of the bridge. As mentioned in Chapter 6.0, access was severely limited, and at times eliminated, to areas on the east side of Houghton Road along the Agua Caliente Wash. Both crossings of the Tanque Verde Creek including and east of Tanque Verde Loop Road were damaged, as were both crossings of Rincon Creek.

At most major watercourse roadway crossings, the shoulders were damaged; in several locations, pavement was also damaged. Short-term repair estimates range from as little as \$ 325 to repair a dirt road crossing of Agua Caliente Wash to as much as \$ 125,000 to repair the Rillito Creek crossing at Camino de la Tierra. Please note that these estimates are for short-term repairs only. In some locations this will be all that is needed; however in other locations additional monies may be required for long-term repair.

7.5 Other Roadway Crossings

Numerous roads throughout Pima County were damaged by floodwaters. In many locations the roadway shoulders were damaged; in several locations pavement was damaged. The majority of entries in Table 7.1 refer to damaged roads. Due to the many locations where damage occurred, the Operations Division has been and will continue to be extremely busy in the near future. In order to repair the damage in a timely manner, much work has been and continues to be awarded to private contractors in the community.

7.6 Bank Erosion

Due to the large magnitude of flood peak discharges and the occurrence of two floods within 15 days, significant erosion occurred along most unprotected banks of all major watercourses, except the Pantano, Cañada del Oro, and Black Washes. In order to thoroughly assess the extent of bank erosion, aerial photographs before and after the floods must be compared. Although large-scale (1 inch = 1000⁺ feet) post-flood aerial photographs are available, a smaller scale (such as 1 inch = 400 feet) is necessary to accurately compare pre-and post-flood bank locations. At the time of writing of this report, only selected coverage is available at a scale of 1 inch = 400 feet. Therefore only the areas where the most dramatic erosion occurred are listed in Table 7.5.

TABLE 7.5
DAMAGE ASSESSMENT - BANK EROSION
MAJOR WATERCOURSES

LOCATION	DAMAGE DESCRIPTION	COST ESTIMATE
RILLITO CREEK		
Craycroft Road Bridge (S25/26-T13S-R14E)	Severe erosion along north bank upstream and downstream of bridge	\$ 360,000 for protecting embankment and abutment
St. Gregory's High School west of Craycroft Road (S26-T13S-R14E)	Erosion along south bank downstream of Craycroft Road bridge	\$ 88,400
Alvernon Wash (S28-T13S-R14E)	Failure of soil-cement bank stabilization along south bank of Rillito downstream of confluence	\$ 46,000
Country Club Road at Tucson Racquet Club (S28-T13S-R14E)	Erosion along south bank	\$ 1,300
Country Club Road bend area (S21,28-T13S-R14E)	Severe erosion along north bank	\$ 75,000
Campbell Avenue SE of bridge; U of A Agricultural Ext. Bldg. (S20-T13S-R14E)	Severe erosion along south bank upstream of Campbell Avenue; building threatened	\$ 22,200
Camino de la Tierra (S8-T13S-R13E)	Severe erosion along south bank Upstream and downstream of Camino de la Tierra	\$ 125,000
TANQUE VERDE CREEK		
Tucson Country Club Estates Miramar Place (S36-T13S-R14E)	Severe erosion along south bank; private property damaged; sewer line damaged	not to exceed \$ 75,000 for design and construction
AGUA CALIENTE WASH		
from Limberlost Road to Fort Lowell Road	Erosion along both banks	no County action anticipated
SABINO CREEK		
Webster Avenue (S33-T13S-R15E)	Erosion/failure of upstream key-in and soil- cement bank stabilization	\$ 113,000

7.7 Private Property

As mentioned in Section 7.1, most but not all damage to private property is listed in Table 7.6 as follows. Although no conventional or manufactured homes or businesses were destroyed, several accessory structures, primarily animal housing, i.e., barns and stalls, and some greenhouses were lost.

Bank erosion along the Rillito Creek resulted in significant loss of property in some areas, particularly between Swan Road and Alvernon Way, at the Country Club Road bend area, and near Camino de la Tierra. Bank erosion also resulted in property loss along Tanque Verde Creek and Agua Caliente Wash. Overbank flooding, particularly along the Agua Caliente Wash, resulted in damage to structures. At least one residence located in Sabino Creek had water running through the building. Several residences at the downstream end of Finger Rock Wash received water and sediment damage.

TABLE 7.6

DAMAGE TO PRIVATE PROPERTY

LOCATION	DAMAGE DESCRIPTION
RILLITO CREEK	
5490 E. River Road; west of Craycroft Road, north bank (S26-T13S-R14E)	Severe bank erosion, residence threatened
St. Gregory High School; west of Craycroft Road, south bank (S26-T13S-R14E)	Bank erosion, ball fields threatened
3362 E. River Road; north bank opposite Tucson Racquet Club (S28-T13S-R14E)	Severe bank erosion; several barns lost
3235 E. Allen Road; north bank opposite Tucson Racquet Club (S28-T13S-R14E)	Severe bank erosion; greenhouses lost
3565 N. Edith Boulevard; east of Country Club Road, north bank (S28-T13S-R14E)	Severe bank erosion, sinkholes formed on property
3100 E. River Road; north bank at Country Club Road (S20-T13S-R14E)	Bank erosion
3132 E. River Road; north bank at Country Club Road (S20-T13S-R14E)	Bank erosion
Southwest Auto and Truck Salvage; south bank near Camino de la Tierra (S8-T13S-R13E)	Severe bank erosion
AGUA CALIENTE WASH	
11630 E. Snyder Road, west of Soldier Trail (S18/19-T13S-R16E)	Erosion around residence
4425 Soldier Trail, north of Limberlost (S19/20-T13S-R16E)	Water inside residence
11221 E. Fort Lowell Road, east of Melpomene Way; west overbank (S30/31-T13S-R16E)	Erosion
Bel Air Ranch Estates, south of Fort Lowell Road, east overbank (S31-T13S-R16E)	Less damage than anticipated; about seven lots flooded with minor damage
3980 Homestead Avenue, south of Limberlost Road; west bank breakout (S19-T13S-R16E)	Bank erosion

TABLE 7.6 (CONTINUED)

DAMAGE TO PRIVATE PROPERTY

LOCATION	DAMAGE DESCRIPTION
11480 E. Prince Road, east of Melpomene Way; west overbank (S30-T13S-R16E)	One barn lost due to bank erosion, other barns threatened
2841 Melpomene Way, south of Fort Lowell Road (S31-T13S- R16E)	Water in residence
10650 Sundance Circle, east of Houghton Road; west overbank (S36-T13S-R15E)	Manufactured home lifted off supports
Amity, 10500 E. Tanque Verde Road east of Houghton Road (S1-T14S-R15E)	Severe flood damage; several residential and support buildings had water in them; part of driveway washed out; erosion around decorative piers
La Mariposa, west of Houghton Road between Agua Caliente Wash and Tanque Verde Creek (S2-T14S-R15E, within COT)	Stables flooded
SABINO CREEK	
3720 N. Camino Seco; north of Cloud Road (S28-T13S-R15E)	Erosion; water in residence
2968 N. Webster Avenue, north of Tanque Verde Road; west overbank (S33-T13S-R15E)	Erosion
FINGER ROCK WASH	
Sutton Lane, between River and Roger Roads, (S28-T13S-R14E)	A large area was inundated and much sediment was deposited; it is likely that several residences had water and sediment inside
TANQUE VERDE CREEK	
Fortyniners Country Club Estates, west of Wentworth Road, north bank breakout (S5-T14S-R16E)	Erosion and flooding on golf course, erosion along Barbary Coast Road
1500 N. Freeman Road, north of Speedway, along south bank (S5/6-T14S-R16E)	Erosion

TABLE 7.6 (CONTINUED)
DAMAGE TO PRIVATE PROPERTY

LOCATION	DAMAGE DESCRIPTION
Speedway Boulevard E. of Houghton Road, south overbank (S1-T14S-R15E)	Bank erosion at several properties
Lakes at Castle Rock, Powder Horn Ranch subdivisions, north overbank (S2-T14S-R15E, within COT)	Several backyards flooded, water in some guest houses in Powder Horn Ranch (10095 Powder Horn Drive)
Fountain Park, north of Wrightsdown Road on south bank (S3-T14S-R15E, within COT)	Bank erosion
Woodland Hills Road, south of Tanque Verde Road, north overbank (S33/34-T13S-R15E); within COT	Roadway inundated
Tucson Country Club Estates, east of Craycroft Road, south overbank (S36-T13S-R14E)	Bank erosion adjacent to several properties, golf course flooded; corrals and fencing lost (6042 Miramar Drive)
RINCON CREEK	
12310 E. Old Spanish Trail, at Avenida de la Potranca (S17-T15S-R16E)	Lot inundated, water in residence
PEGLER WASH	
Schumaker Drive east of Camino de la Tierra, homes along north bank (S8-T13S-R12E)	Back yards flooded up to back doors, no reports of water in residences (breakout from Rillito and flow from Pegler)
SANTA CRUZ RIVER	
6688 N. Silberbell Road, south of Ina Road along west bank (S1-T13S-R12E)	Severe bank erosion; manufactured home moved off pad
CANADA DEL ORO WASH	
14220 Lao del Oro Parkway, Catalina; between Trotter Place and Rollins Road; west overbank (S15-T11S-R14E)	Stalls and barnyard flooded

8.0 COMPARISON TO OCTOBER 1983 FLOOD

From Continental near Green Valley to the confluence with the Gila River, the October 1983 Flood is the largest flood of record (since 1915) on the Santa Cruz River. Locally, four died in flood-related incidents. Due to its distinction as the costliest flood to date in Pima County in terms of damage to public infrastructure and private property, the October 1983 Flood is the "yardstick" to which local floods are compared.

8.1 Rainfall

Overall rainfall totals for the October 1983 and January 1993 storms were similar, however more rainfall was recorded in 1983, with an average of between 6-1/2 - 7-1/2 inches falling in the Tucson area (USGS Water Resources Investigations Report 85-4225-C), as compared to approximately 5 - 7 inches in January 1993 (ALERT data). In 1983, however, the highest rainfall depths in eastern Pima County occurred over the upper (southern) Santa Cruz River watershed near Green Valley, and the weather system moved north, providing an opportunity for peak flows to concentrate on the lower Santa Cruz River. Consequently, the greatest flood and erosion damage occurred along the lower Santa Cruz River. In January 1993, the highest rainfall depths were recorded over the northeast metropolitan area in early January; accordingly, areas along Agua Caliente Wash, Tanque Verde Creek, and Rillito Creek were most heavily damaged on January 7th and 8th. Although the highest rainfall depths preceding the January 18th -19th flood occurred over the upper Santa Cruz River watershed, they were much less than in the 1983 Flood.

Significant differences in the temporal distribution of rainfall occurred as well. In October 1983 rainfall occurred over five days, from September 28th through October 3rd, and resulted in one distinct flood peak. During the January 1993 Floods the rainy period was prolonged, occurring from January 5th through the 19th. Two distinct flood peaks occurred, on January 8th and January 19th. Flooding in January 1993 was compounded by snowmelt runoff from the Santa Catalina Mountains, which impacted the foothills in the northeast (Agua Caliente Wash and Sabino Creek areas) and north central (Finger Rock Wash environs) metropolitan area.

8.2 Peak Discharges and Runoff Volumes

Due primarily to the greater overall rainfall received during the October 1983 flood, peak discharges on most major watercourses were greater in October 1983 than in January 1993, except as indicated below. Two noteworthy comparisons are: 1) peak discharges on Rillito Creek during the 1983 and 1993 floods were very similar, approximately 25,000 cfs. This similarity was corroborated by staff conversations with residents along the Rillito bend at Country Club Road who observed both flood events; and 2) although comparative discharge data are not available for Agua Caliente Wash, Sabino Creek, and Finger Rock Wash, based on rainfall data, damages incurred, and conversations with residents and District staff, peak discharges on these watercourses were higher in January 1993 than in October 1983.

OCTOBER 1983 FLOOD

PEAK FLOW ESTIMATES (DISTRICT)

<u>RIVER</u>	<u>QUANTITY (cfs)</u>	<u>RETURN PERIOD*</u>
Santa Cruz, Green Valley	30,000	100 yr.
Santa Cruz, Tucson	40 - 45,000	100+ yr.
Santa Cruz, Marana	60,000	100+ yr.
Rillito Creek	25,000	50+ yr.
Tanque Verde Creek	20,000	50 yr.
Pantano Wash	15,000	25 yr.
Cañada del Oro Wash	10,000	10 yr.

* Based on flood frequency analyses and hydrologic studies conducted since the 1983 Flood, the return periods have been revised. Return periods shown above were those used prior to the revisions. Those shown below reflect the revisions.

JANUARY 1993 FLOOD

PEAK FLOW ESTIMATES (DISTRICT unless noted)

<u>RIVER</u>	<u>QUANTITY (cfs)</u>	<u>RETURN PERIOD</u>
Santa Cruz, Green Valley	35,800 (1/19/93, USGS)	50+ yr.
Santa Cruz, Valencia Rd.	22,000 (1/18/93)	10+ yr.
Santa Cruz, Marana	38,000 (1/8/93)	25+ yr.
Rillito Creek	28,000 (1/8/93)	50+ yr.
Tanque Verde Creek	16,800 (1/8/93, USGS, prelim.)	25 - 50 yr.
Pantano Wash	2,230 (1/8/93, USGS)	< 2 yr.
Cañada del Oro Wash	1,590 (1/8/93)	< 2 yr.
Agua Caliente Wash	5,800 (1/8/93, USGS)	25 yr.

Although peak discharges were in general higher in the October 1983 Flood due to the relatively larger "burst" of rainfall received, the prolonged excessive rainfall over fifteen days in 1993 caused longer duration floods, resulting in much greater volumes of runoff throughout the greater Tucson area. According to the U.S. Geological Survey, the January 1993 floods resulted in the largest volume of floodwater runoff recorded on Rillito Creek (Arizona Daily Star, March 10, 1993).

8.3 Damage

Perhaps the most significant distinction between the October 1983 Flood and the January 1993 Floods is that no human lives were lost in the January 1993 Floods, while four died locally during the October 1983 Flood: one man was swept away while trying to cross Monument Wash at Speedway Boulevard; one man was swept away after his truck stalled in high water in the Marana area, and he got out of his truck; and two Department of Public Safety officers were killed when their helicopter crashed near Marana, as they were attempting to evacuate a woman near Catalina. In the January 1993 Floods, several successful rescues were reported, most involving people who drove vehicles into flooded washes.

Overall damage to public infrastructure and private property was much greater in 1983 than in January 1993, although damage along certain watercourses was greater in 1993. The decrease in overall damage in 1993 can be attributed to several factors:

- 1) Many watercourses had larger peak discharges in 1983, especially the Santa Cruz River, where more infrastructure was damaged;
- 2) Construction of soil-cement bank stabilization after and in response to the 1983 Flood removed many residential and commercial buildings from flood and erosion hazard;
- 3) Residential properties in extremely vulnerable locations were acquired after the 1983 Flood, as part of the District's Floodprone Land Acquisition Program. Two areas where the largest number of residential properties were acquired were along the Pegler Wash just east of Camino de la Tierra, and at the La Puerta del Norte subdivision along the Santa Cruz River south of Avra Valley Road in Marana. Approximately 100-120 lots were acquired, the residents relocated to safer areas, and the structures demolished; and
- 4) Improved design and construction practices developed in response to the 1983 floods also helped to minimize the amount of damage incurred.

A comparison of damage on selected watercourses is as follows:

Greater Damage in October 1983 Flood

Santa Cruz River - Structural damage to bridges and roadways; and private property damage due to bank erosion, and overbank flooding and sediment deposition was much greater in the October 1983 Flood than in the January 1993 Floods. Soil-cement bank stabilization which has been constructed along several reaches of the Santa Cruz River through the urbanized area since the October 1983 Flood protected many areas from flood and erosion damage during the January 1993 Floods. October 1983 and January 1993 Flood photographs are shown for comparison purposes in Figures 8.1 - 8.13.

Rillito Creek - Although damage along the Rillito was extensive in January 1993, in some locations exceeding that which occurred in 1983, overall greater damage was incurred in October 1983, when residential and commercial building were lost at Country Club Road and First Avenue, respectively. Damage to infrastructure, including roads, bridges, and rip-rap bank stabilization was much greater in the October 1983 Flood, and acreage lost to erosion was also higher. See Figures 8.14 - 8.25 for October 1983 and January 1993 Flood photographs.

FIGURE 8.1

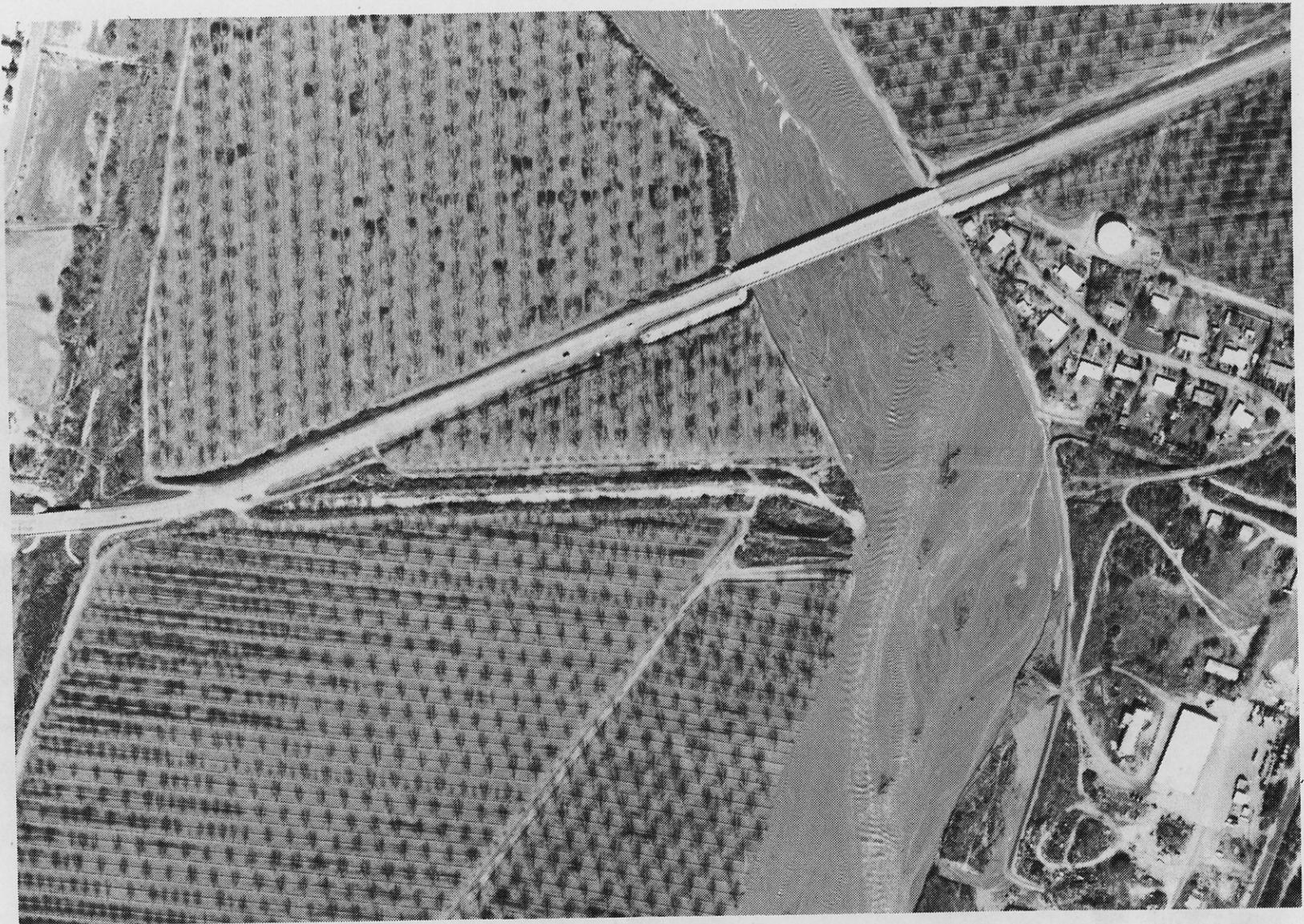


Santa Cruz River at Continental Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.2

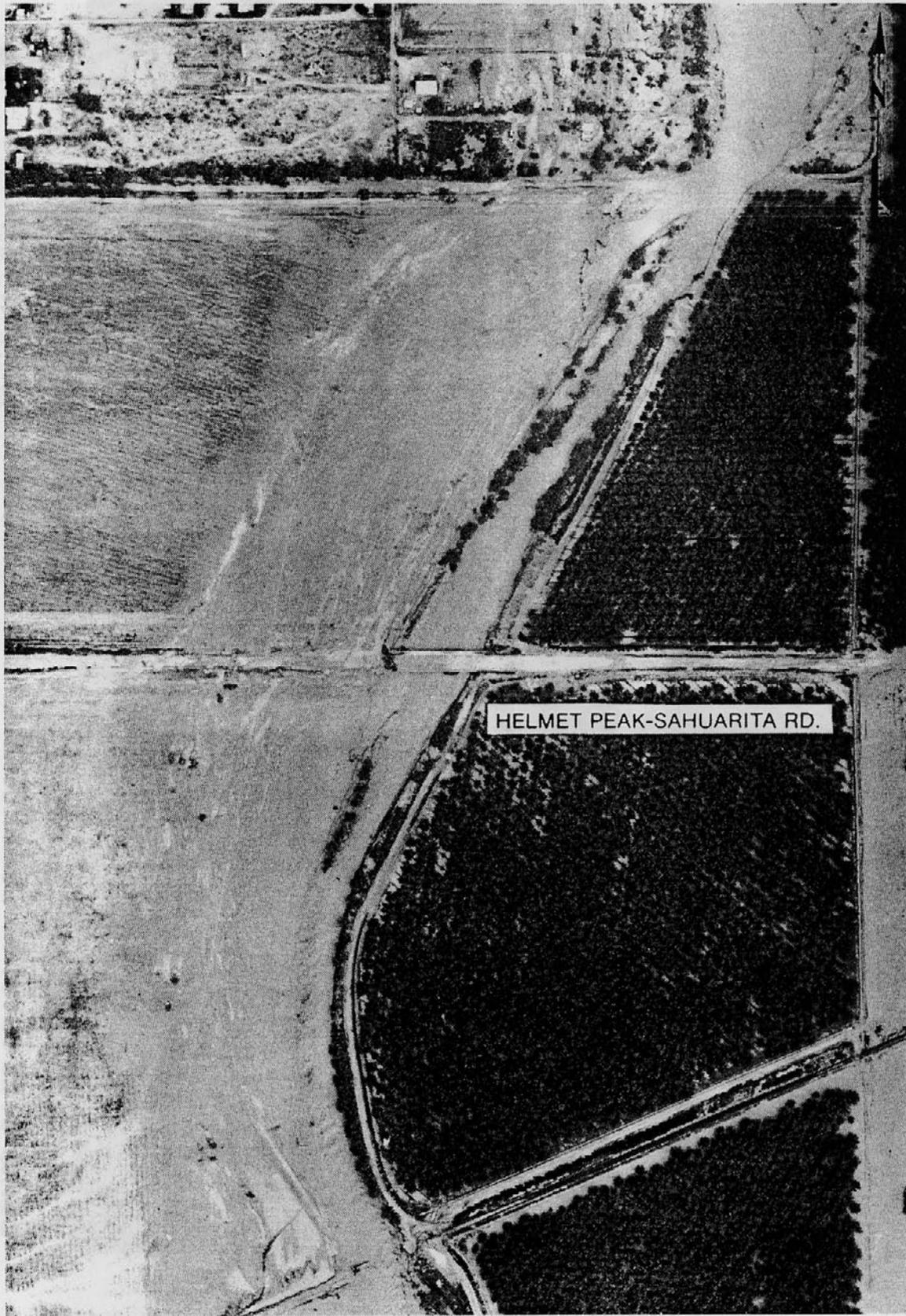


Santa Cruz River at Continental Road
January 20, 1993

SCALE 1" = 400'



FIGURE 8.3



Santa Cruz River at Sahuarita Road
October 3, 1983

8-6

SCALE 1" = 400'



FIGURE 8.4

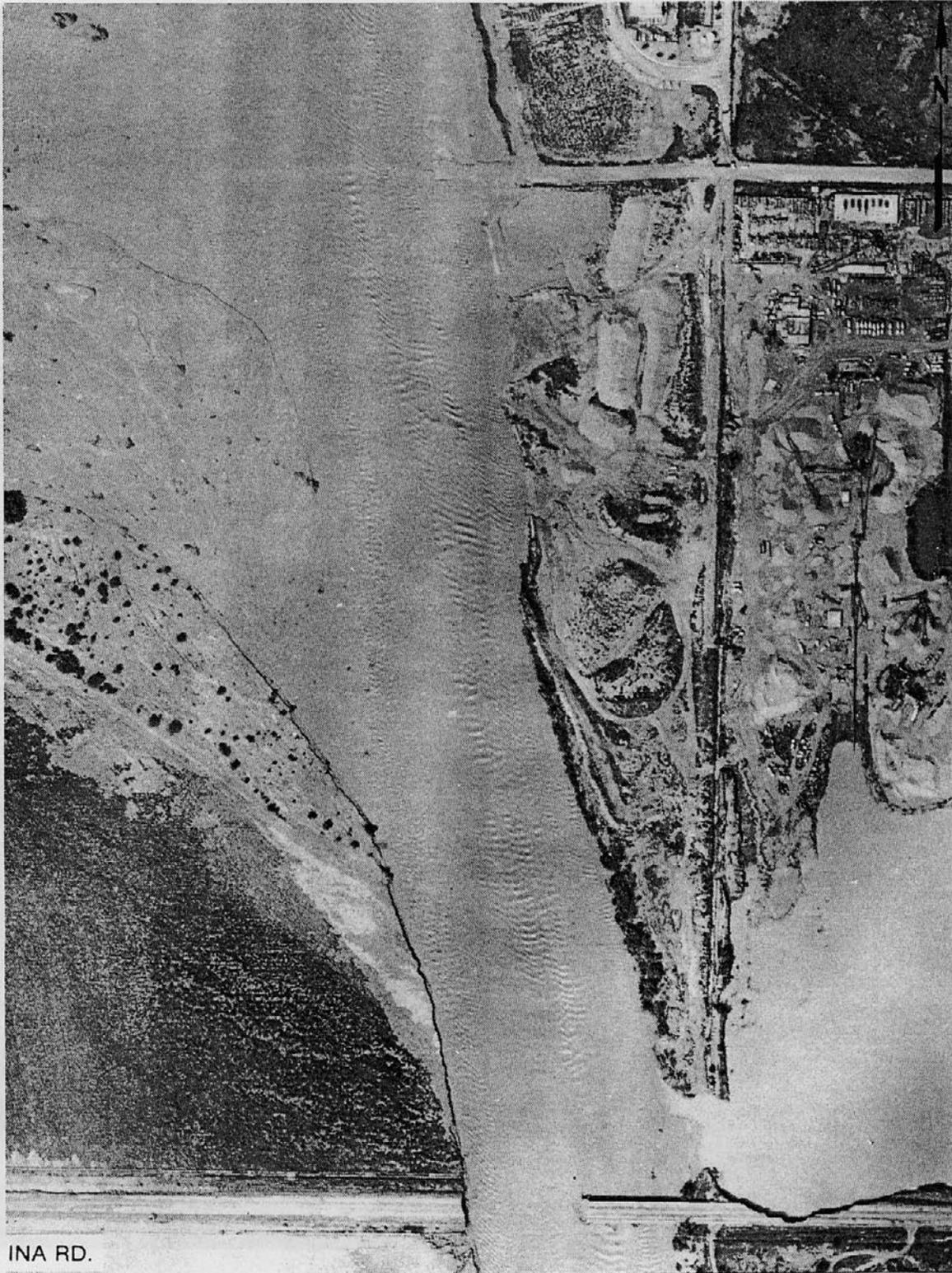


Santa Cruz River at Sahuarita Road
January 20, 1993

SCALE 1" = 400'



FIGURE 8.5



INA RD.

Santa Cruz River at Ina Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.6



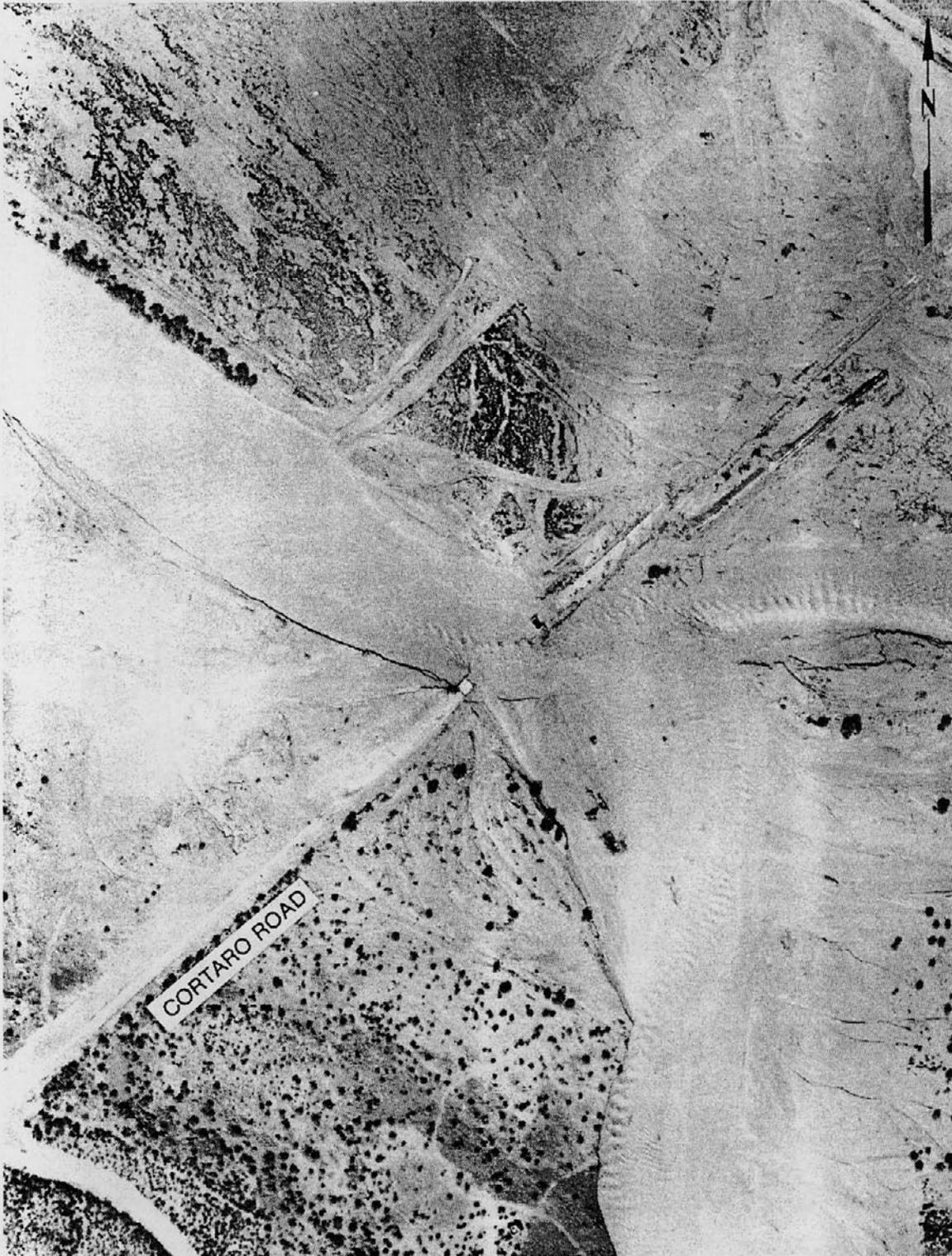
Santa Cruz River, at Ina Road
January 20, 1993

SCALE 1" = 400'



8-9

FIGURE 8.7



Santa Cruz River at Cortaro Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.8



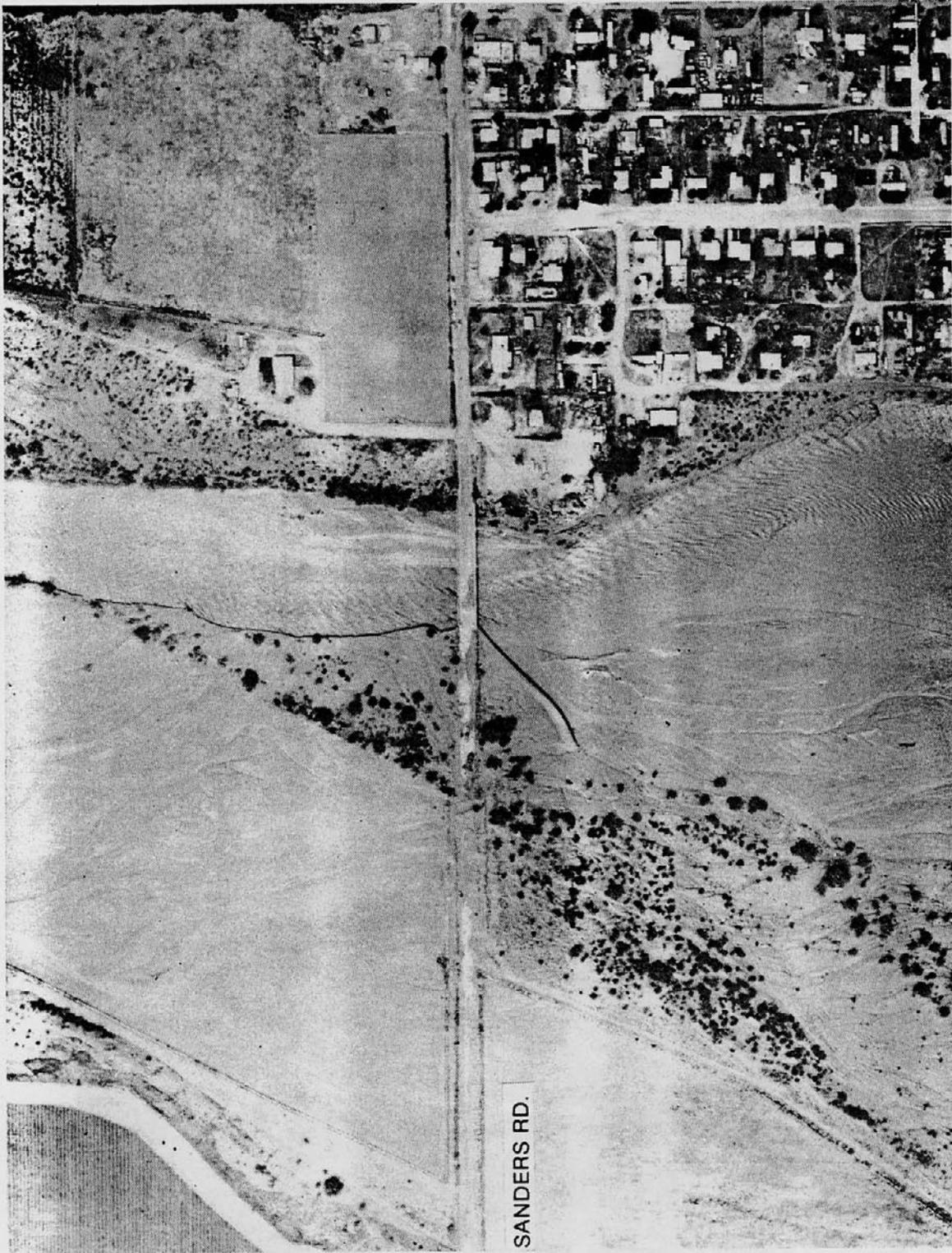
Santa Cruz River at Cortaro Road
January 20, 1993

SCALE 1" = 400'



8-11

FIGURE 8.9

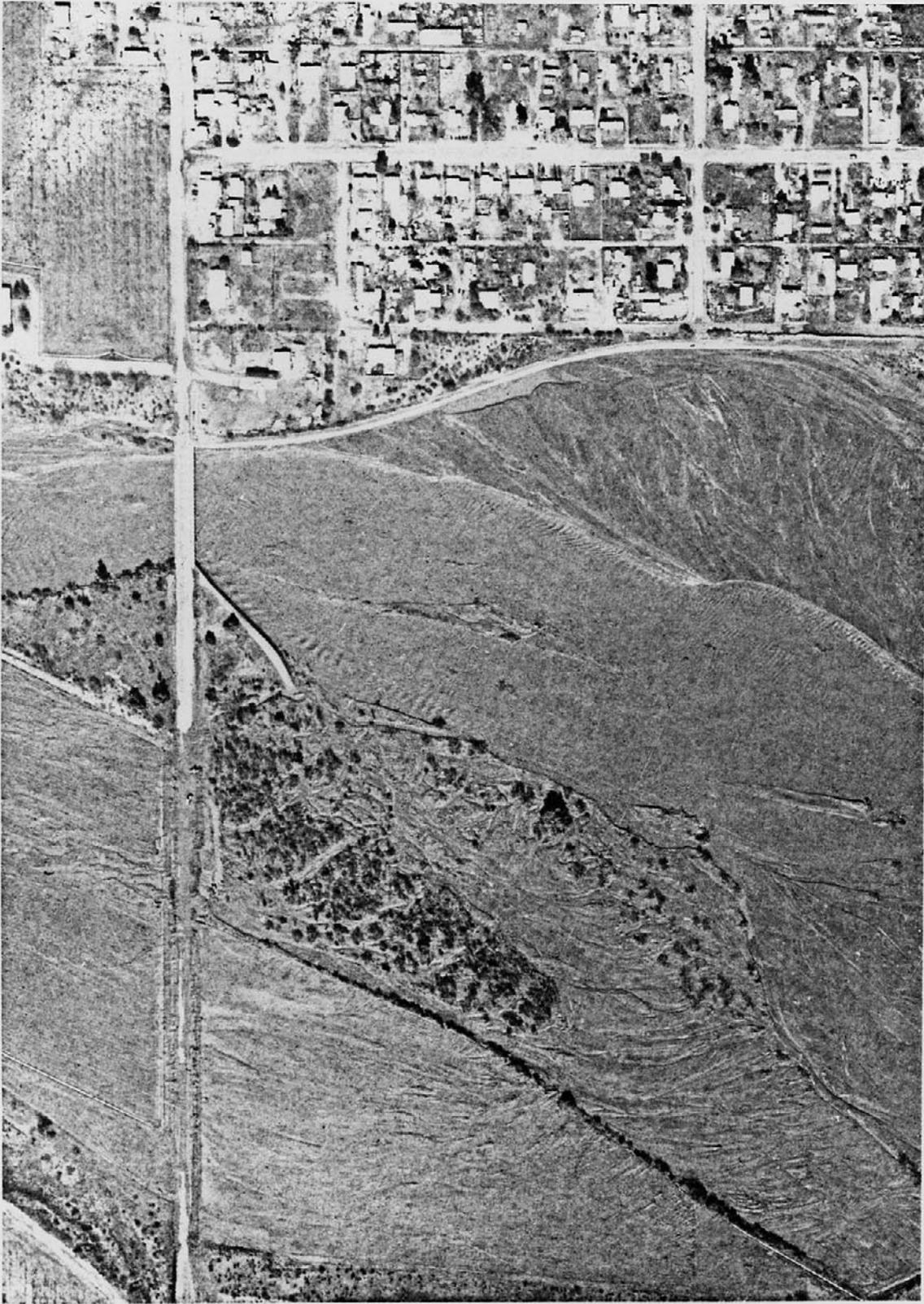


Santa Cruz River at Sanders Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.10



Santa Cruz River at Sanders Road
January 20, 1993

SCALE 1" = 400'



8-13

FIGURE 8.11

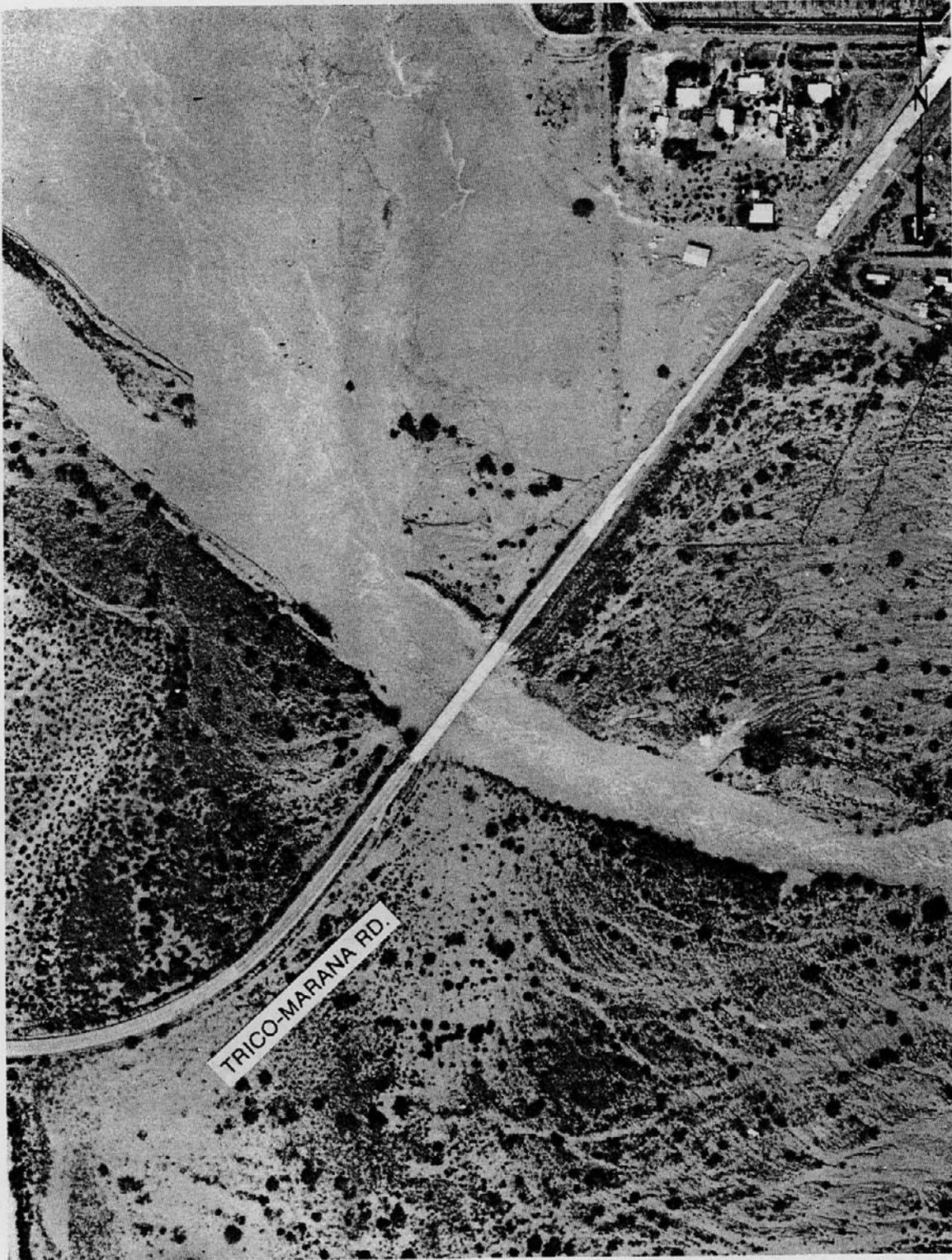


Santa Cruz River at Trico Marana Road
October 3, 1983

SCALE 1" = 1250'



FIGURE 8.12

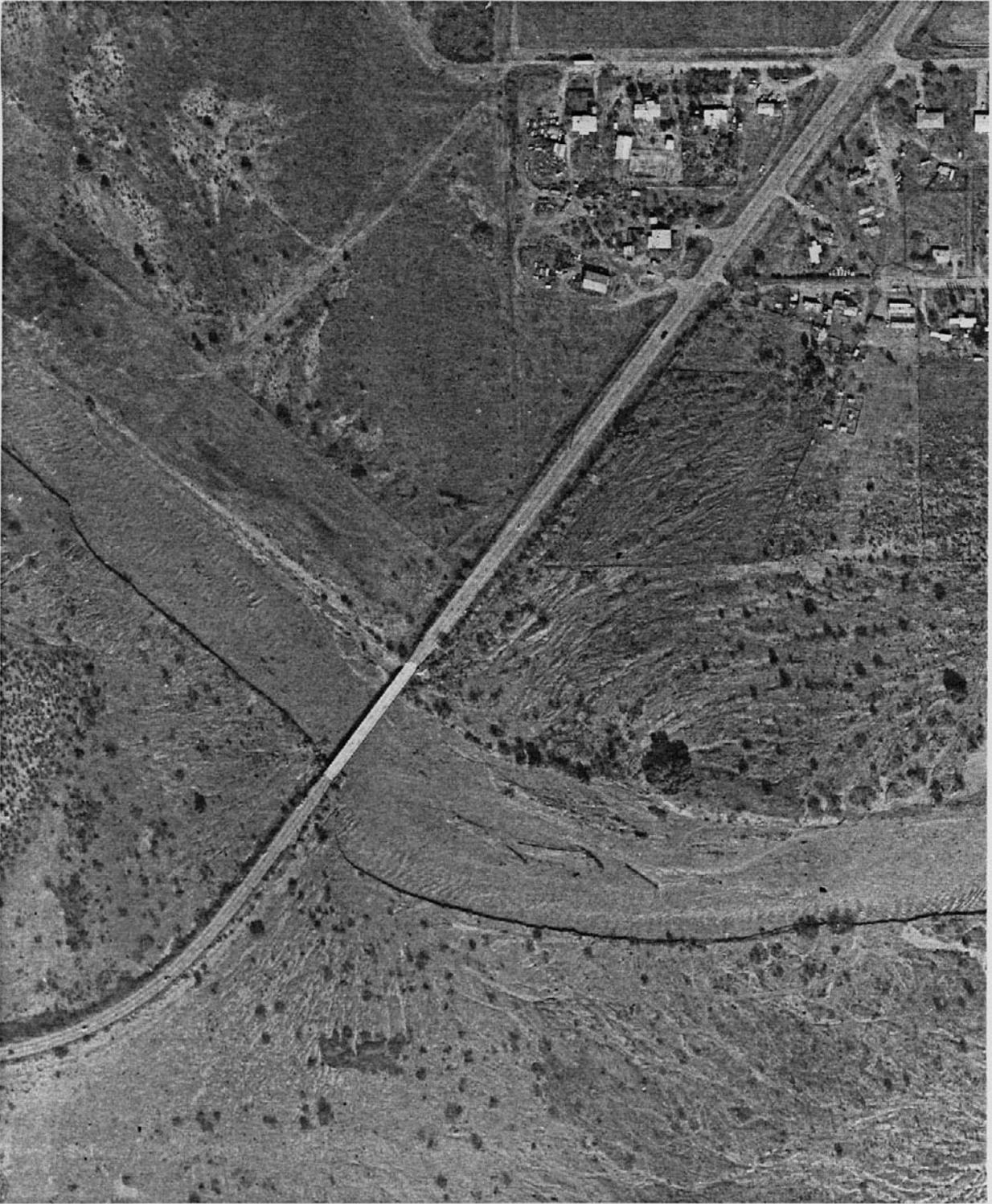


Santa Cruz River at Trico - Marana Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.13

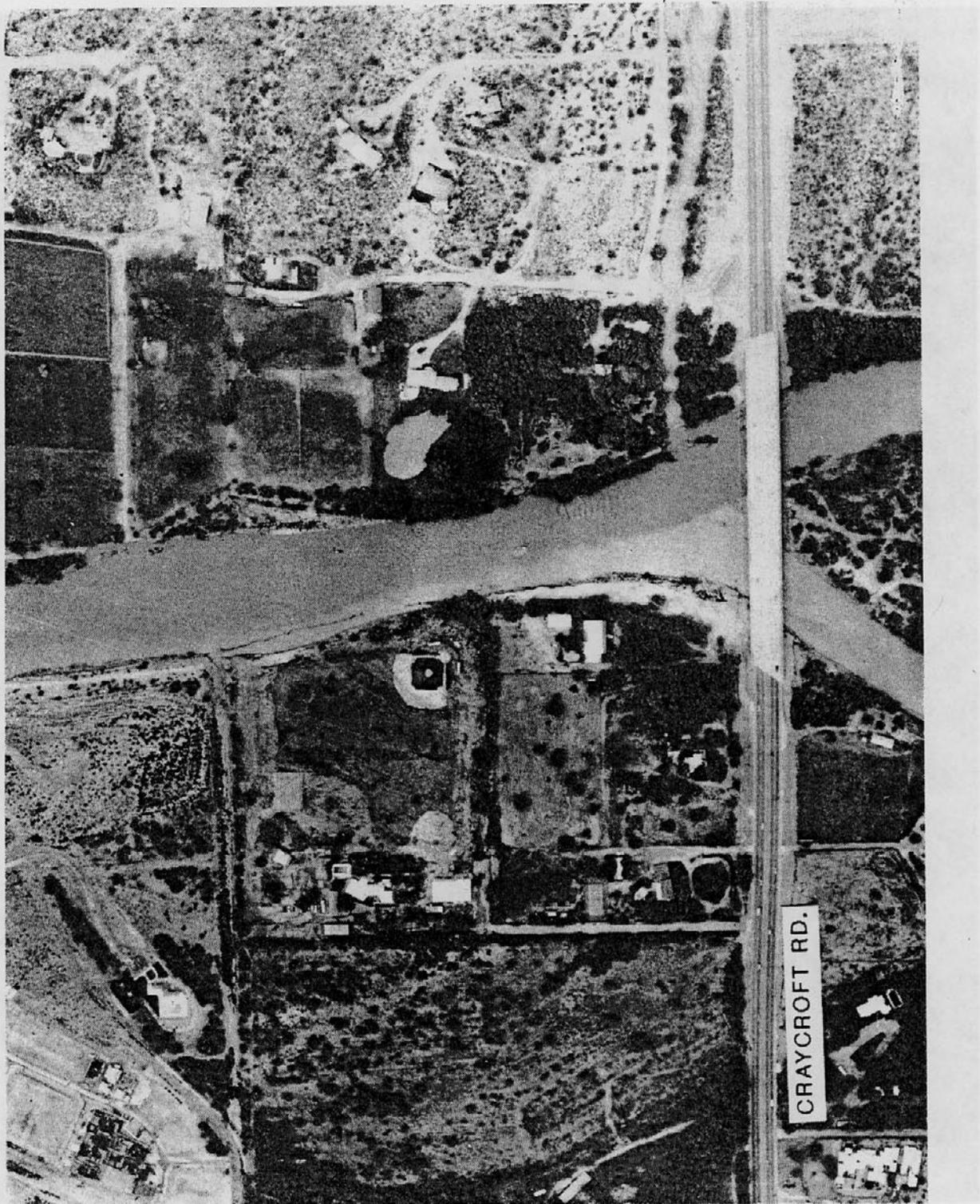


Santa Cruz River at Trico - Marana Road
January 9, 1993

SCALE 1" = 400'



FIGURE 8.14

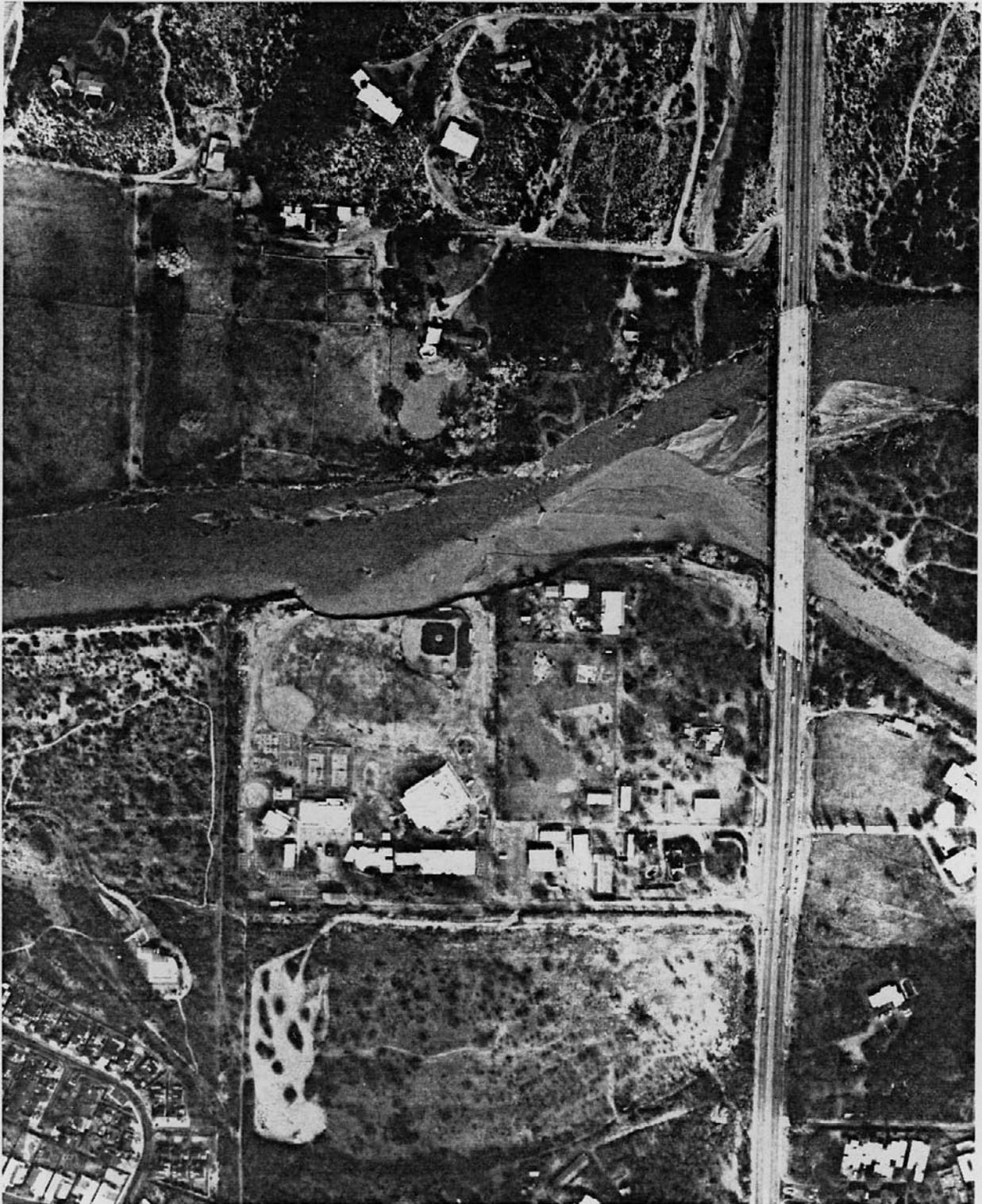


Rillito Creek at Craycroft Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.15



Rillito Creek at Craycroft Road
January 9, 1993

SCALE 1" = 400'



FIGURE 8.16

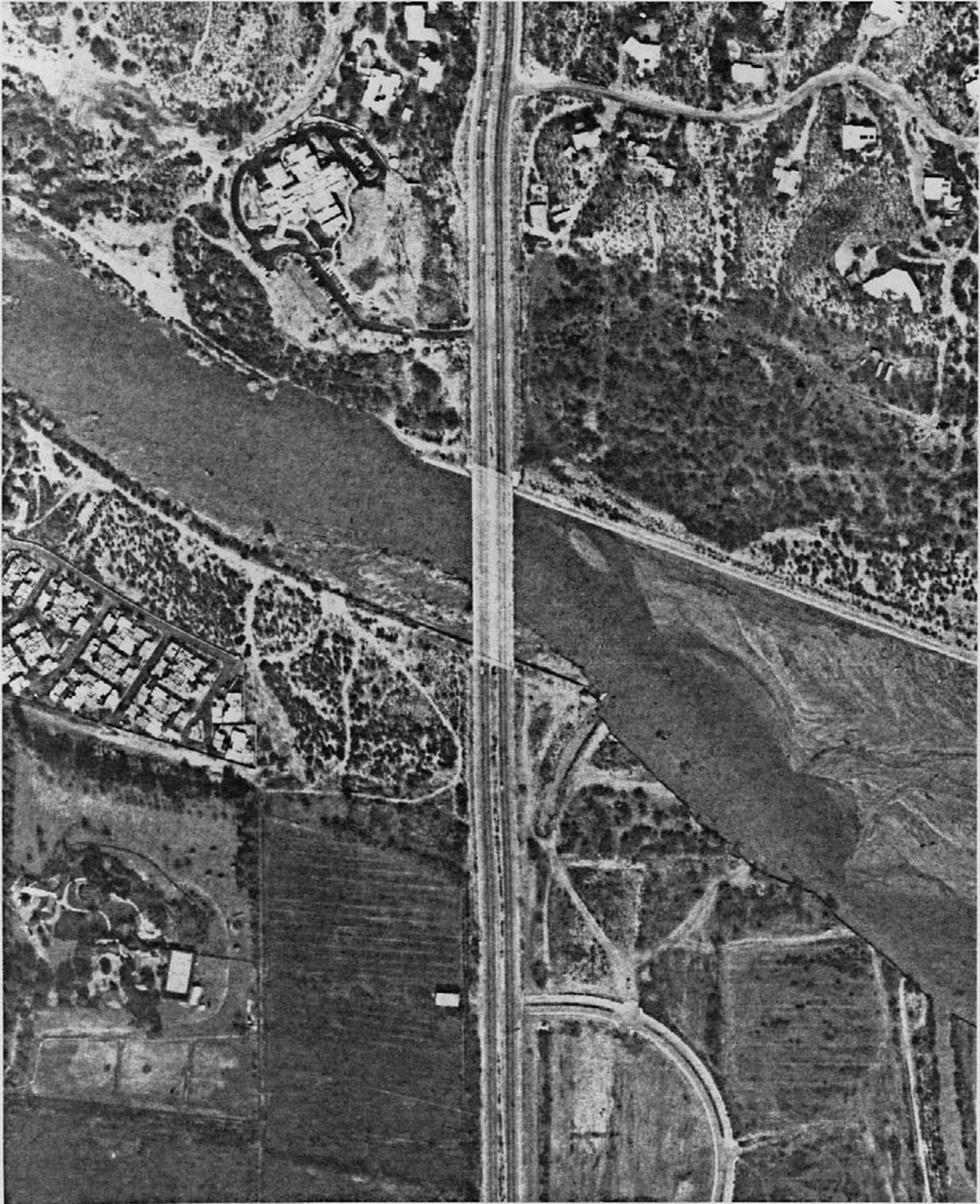


Rillito Creek at Swan Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.17



Rillito Creek at Swan Road
January 20, 1993

SCALE 1" = 400'



FIGURE 8.18



Rillito Creek at Dodge Boulevard
October 3, 1983

SCALE 1" = 400'



FIGURE 8.19



Rillito Creek at Dodge Boulevard
January 9, 1993

SCALE 1" = 400'



FIGURE 8.20

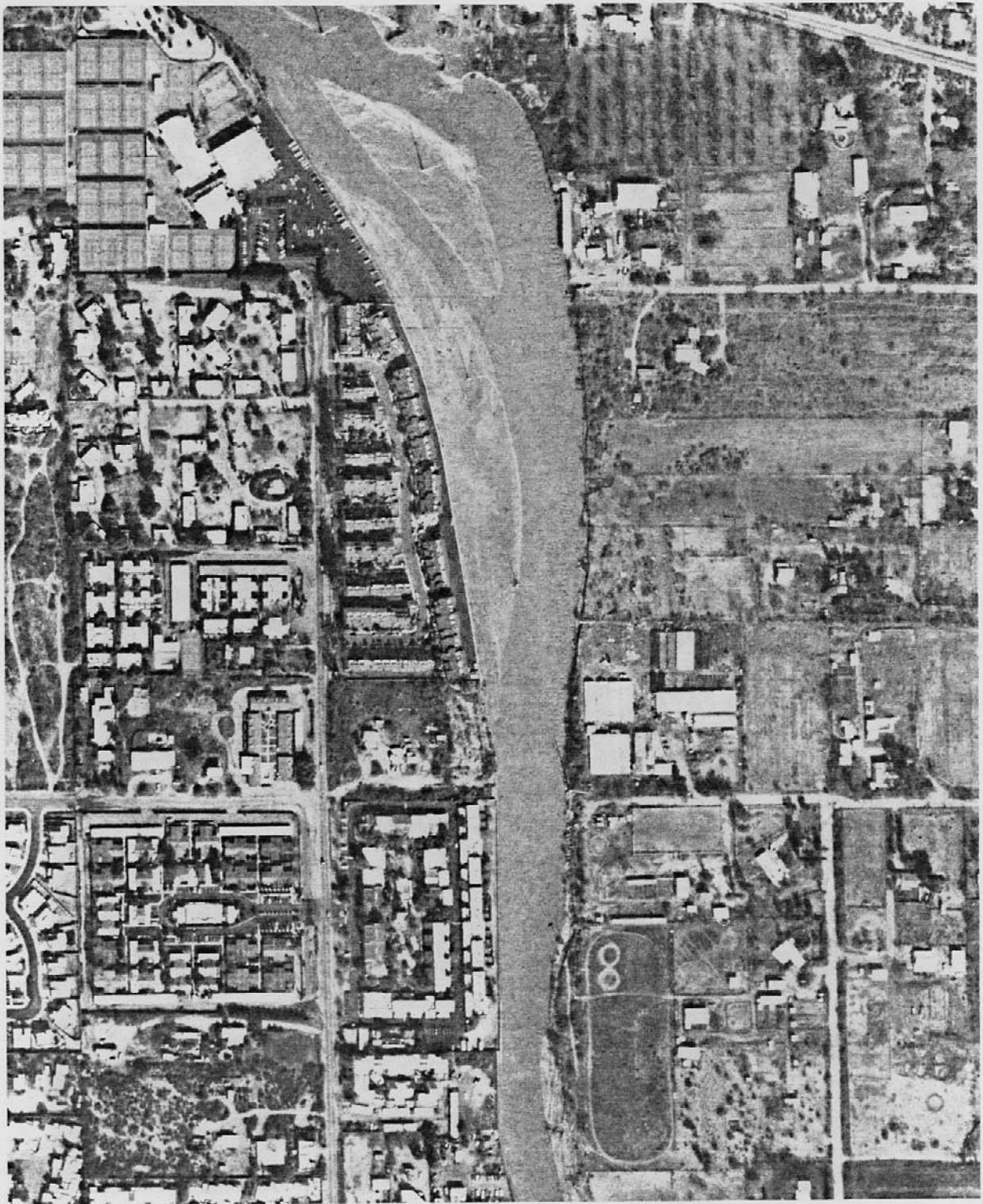


Rillito Creek at Country Club Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.21

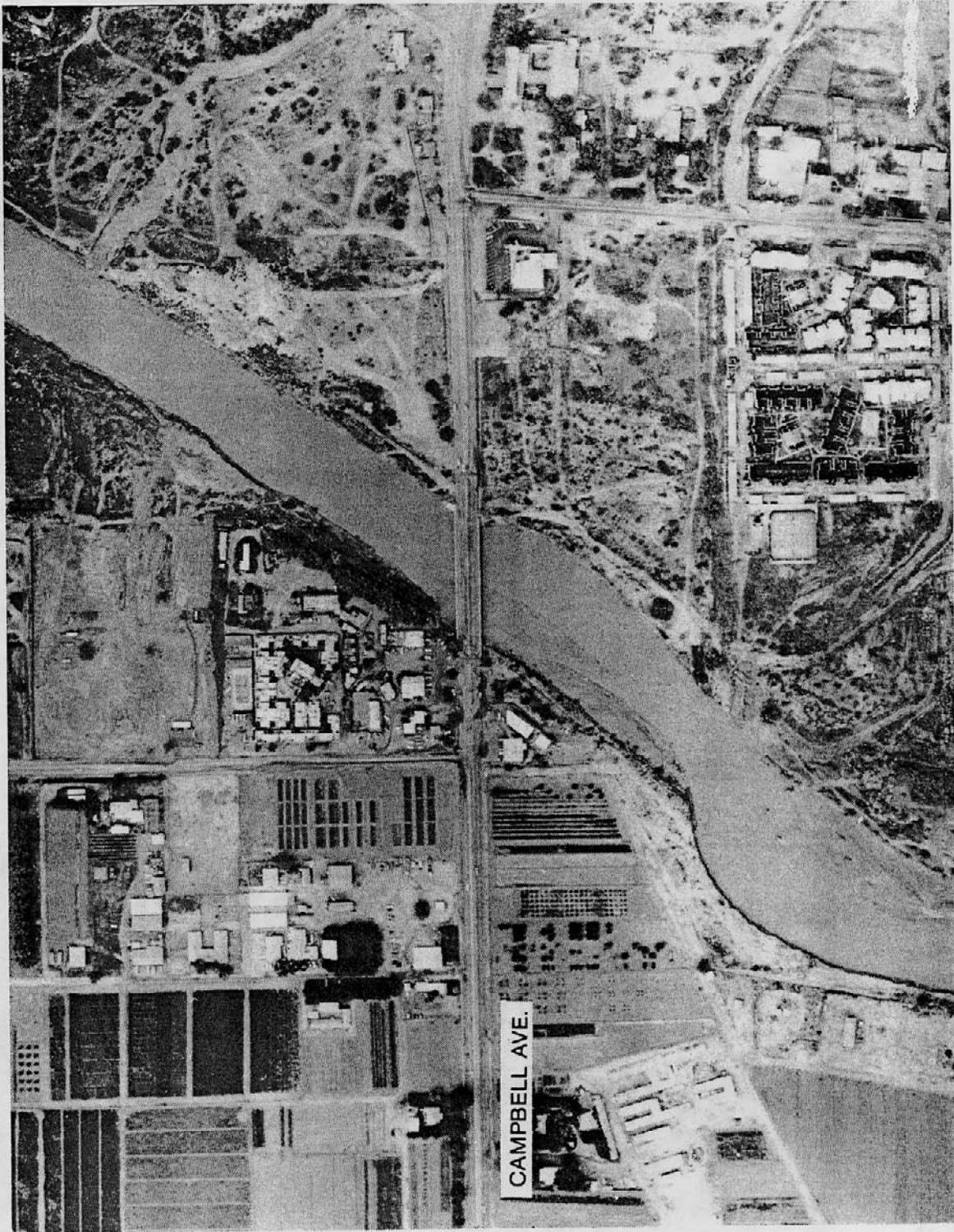


Rillito Creek at Country Club Road
January 20, 1993

SCALE 1" = 400'



FIGURE 8.22



Rillito Creek at Campbell Avenue
October 3, 1983

SCALE 1" = 400'



FIGURE 8.23



Rillito Creek at Campbell Avenue
January 9, 1993

SCALE 1" = 400'



ES.8 FIGURE 8.24



Rillito Creek at First Avenue
October 3, 1983

SCALE 1" = 400'



FIGURE 8.25

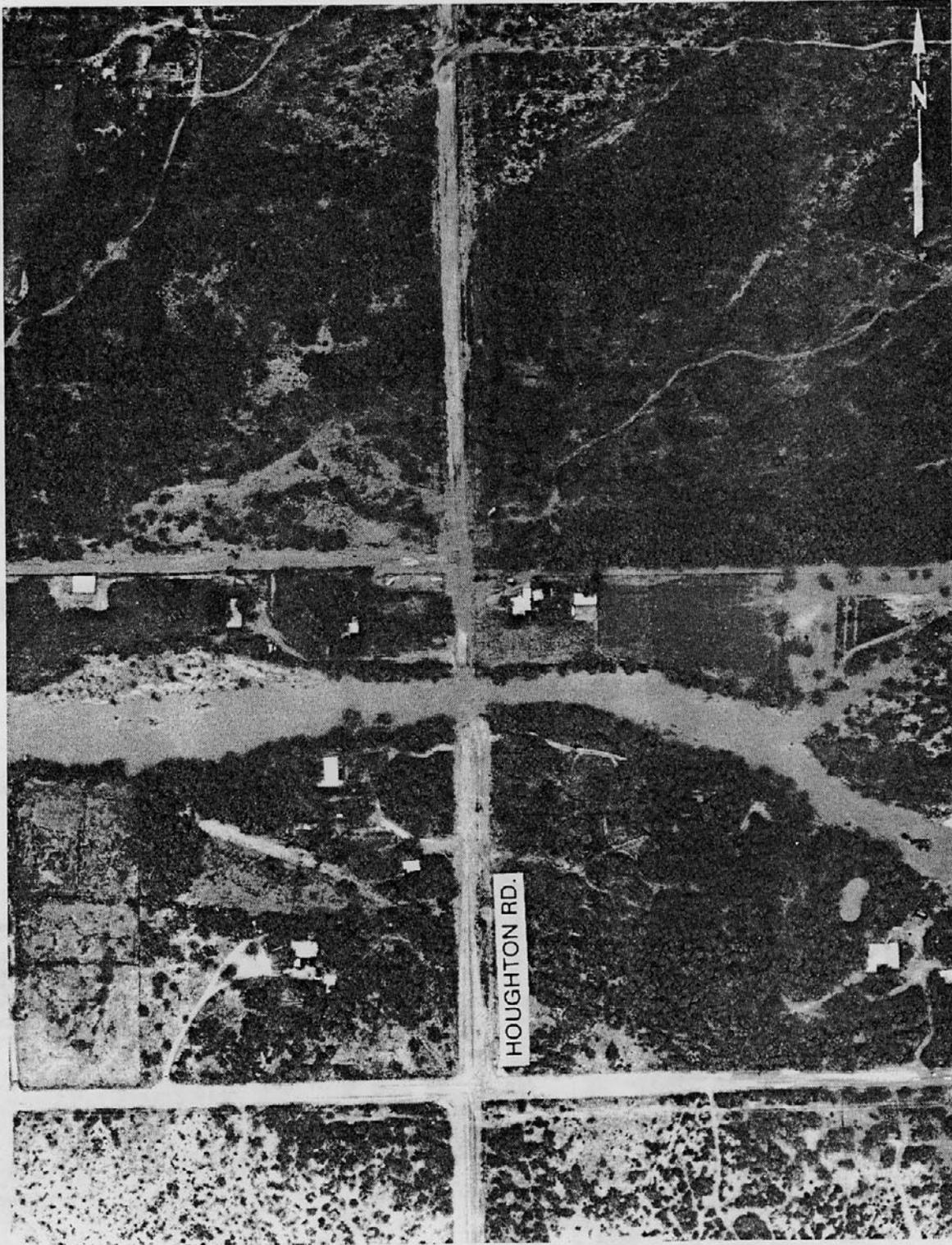


Rillito Creek at First Avenue
January 9, 1993

SCALE 1" = 400'



FIGURE 8.26

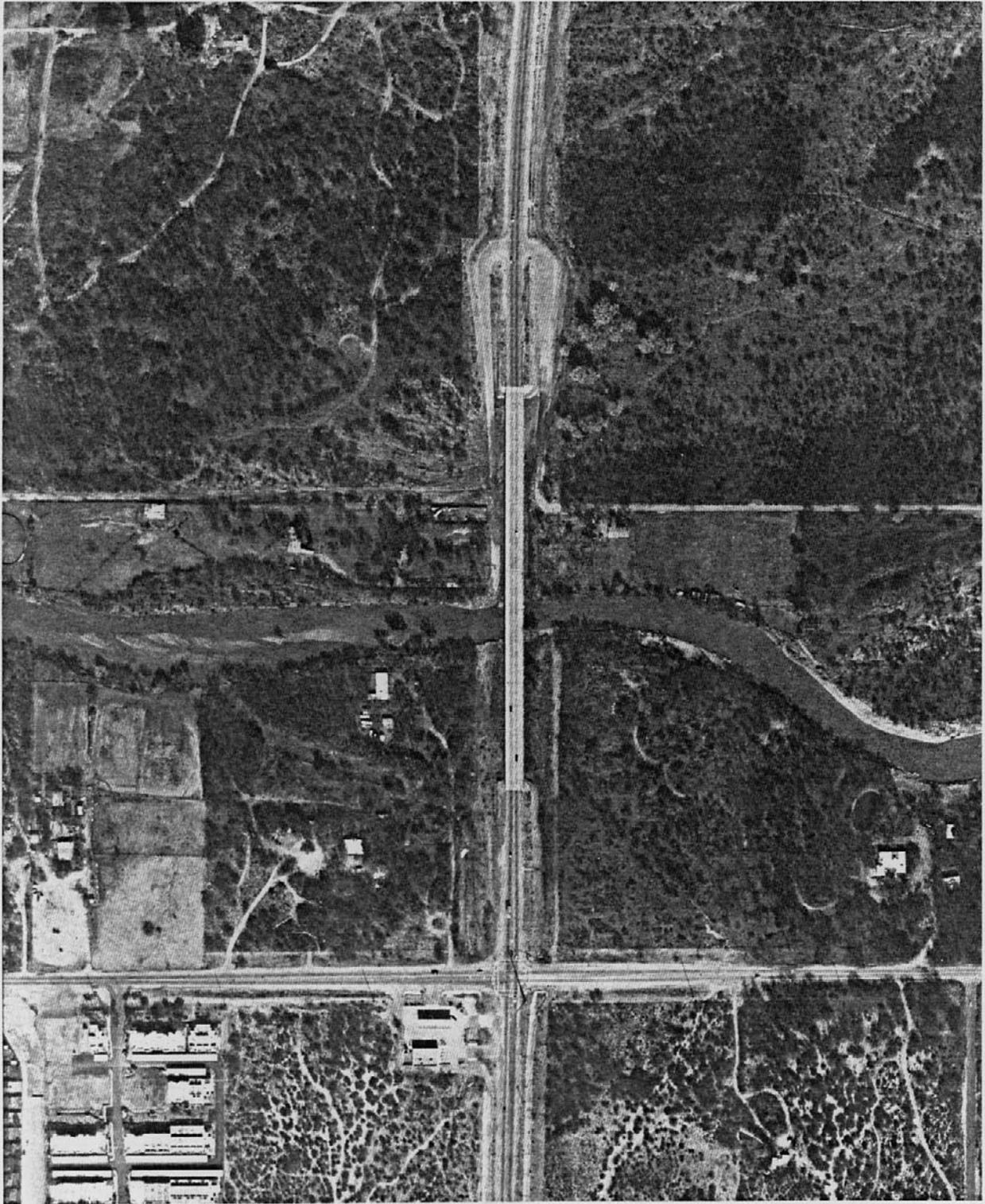


Tanque Verde Creek at Houghton Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.27



Tanque Verde Creek at Houghton Road
January 20, 1993

SCALE 1" = 400'



Much like the Santa Cruz River, bank stabilization which has been constructed since the October 1983 Flood along several vulnerable reaches of Rillito Creek reduced the flood and erosion loss during the January 1993 Floods. Additionally, acquisition of vulnerable areas near Camino de la Tierra as part of the District's Floodprone Land Acquisition Program reduced flood losses in January 1993.

Tanque Verde Creek - Damage to public infrastructure and private property, including structures and eroded acreage, was much greater in 1983 due primarily to the higher peak discharges (Figures 8.26 and 8.27). Also, the reach between Tanque Verde Road and the Ventana Canyon Wash has since been protected by soil-cement bank stabilization.

Greater Damage in January 1993 Floods

Agua Caliente Wash - Overbank flooding, and sediment and erosion damage along Agua Caliente Wash were much greater in the January 1993 Floods, due to the greater discharges and extended duration of high flows. Contribution of snowmelt runoff in 1993 exacerbated an already critical flood situation.

All roadway crossings were closed during peak flooding. Up to 2500 residents of the area located between the Agua Caliente Wash and Tanque Verde Creek were precluded from accessing their residences for several days.

Many private properties were inundated, and several accessory structures were damaged or destroyed. Although many residential yards were covered with water, only a couple of residents reported water inside their houses.

Amity, Incorporated, a private, non-profit social service agency located on the north and south sides of Tanque Verde Road east of Houghton Road, was extensively damaged. It should be noted many of the damaged areas at Amity on the south side of Tanque Verde Road are located within the 100-year floodway of Agua Caliente Wash.

Sabino Creek - Flood damage to public infrastructure and private property was much greater in the January 1993 Floods due to the higher discharges.

Finger Rock Wash - Flood and sediment damage to private property in the vicinity of Sutton Lane was much greater in the January 1993 Floods due to the higher discharges. Residents reported essentially no damage in the 1983 Flood (Figures 8.28 and 8.29). Additionally, ball playing fields at the Mehl-Foothills District Park, located near Pontatoc and River Roads, were damaged by erosion.

Rillito Creek - The January 1993 Floods resulted in greater localized damage at two locations: 1) the Craycroft Road bridge area, and 2) the Country Club Road "bend area". Much acreage was lost in both locations due to excessive bank erosion.

Comparison of Damage at Other Locations

Figures 8.30 - 8.33 show flood photographs from the October 1983 Flood and the January 1993 Floods at selected locations, for comparison purposes.

FIGURE 8.28



Finger Rock Wash at Sutton Lane
October 3, 1983

SCALE 1" = 400'



FIGURE 8.29



Finger Rock Wash at Sutton Lane
January 20, 1993

SCALE 1" = 400'



FIGURE 8.30



Canada del Oro at First Avenue
October 3, 1983

SCALE 1" = 800'



FIGURE 8.31



Canada del Oro at First Avenue
January 20, 1993

SCALE 1" = 800'



FIGURE 8.32

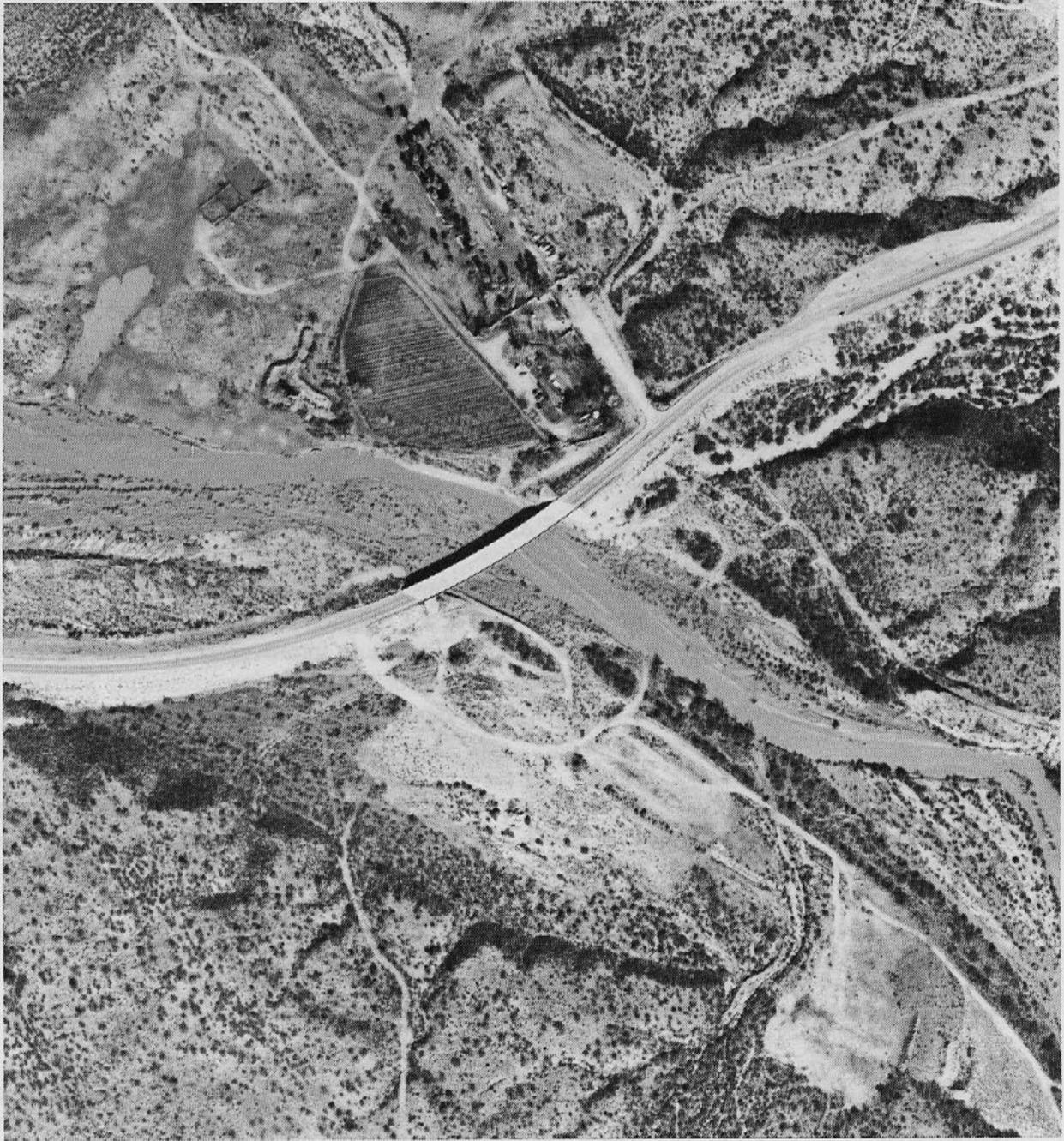


Pantano Wash at Colossal Cave Road
October 3, 1983

SCALE 1" = 400'



FIGURE 8.33



Pantano Wash at Colossal Cave Road
January 20, 1993

SCALE 1" = 400'



8.4 Costs

Following the **October 1983 Flood**, PCDOT & FCD developed a Flood Repair and Flood Hazard Mitigation Program to repair infrastructure damaged; to acquire flood storage areas, including relocating residents of flood-damaged property; and to improve access to areas isolated during the flood. The total cost of the repair program was estimated at **\$ 105.7 million in 1984 dollars**. This included repairs to infrastructure along major watercourses within the City of Tucson and the Town of Marana.

As of the writing of this report, **emergency repair cost estimates** for damage to public transportation and flood control facilities during the **January 1993 Floods** are as follows:

Pima County	\$ 2,764,000
Marana	\$ 17,000
City of Tucson	\$ 659,646

TOTAL **\$ 3,440,646**

In addition, permanent repairs which will prevent further flood damage are planned to be constructed in several locations at an estimated cost of \$ 8,650,400 for long-term improvements in Pima County (see Chapter 7.0), and \$ 1,824,500 for long-term improvements within the Town of Marana. For the three jurisdictions, the cost estimate for long-term improvements is **\$ 10,474,900**. The total cost estimate for emergency repairs and long-term improvements is **\$ 13,915,546**.

Note: information regarding cost estimates for emergency repairs and long-term improvements within the Town of Marana provided by Bob Kern, Town of Marana; and Morgan Johnson and Mick Matthews, GLHN Architects and Engineers, Incorporated.

No information is available regarding cost estimates of damage to private property for the October 1983 or January 1993 floods.

Based on estimates of damage incurred, the October 1983 Flood caused much greater damage than the January 1993 Floods, as would be expected based on the much higher peak discharges on the Santa Cruz River in October 1983. Monies expended since 1983 to repair and provide a higher level of protection to damaged infrastructure, as well as to protect vulnerable areas, contributed to the lower amount of damage incurred during the January 1993 Flood, although this amount is difficult to quantify.

9.0 PERFORMANCE OF BRIDGES AND FLOOD CONTROL STRUCTURES

Because Pima County in modern times had never experienced a flood like that in October 1983, much was learned about protecting bridges and channel banks based on the damage incurred. The following standards for constructing new and replacing existing bridges and bank stabilization were adopted by the Board in May 1984, as part of the design and repair philosophy to be used on PCDOT & FCD projects:

Bridge standards

- Bridges will be constructed to convey the 100-year peak discharge;
- Bank stabilization or channelization will be placed as required to prevent lateral migration of the channel and destruction of the approaches.

Bank Stabilization standards

- Soil-cement bank stabilization will be provided on major watercourses, and will be designed to withstand the 100-year peak discharge;
- Bank stabilization will be constructed to a minimum thickness of eight feet;
- Upstream and downstream ends of bank stabilization shall be properly keyed-in to the natural banks to prevent erosion behind the bank protection should lateral migration of the channel occur.

For a more complete listing of the standards adopted, the reader is referred to the Flood Repair and Flood Hazard Mitigation Implementation Plan, April 1984; and the Flood Repair and Flood Hazard Mitigation Program report, Pima County, Arizona, May 1984.

Based on the referenced standards, PCDOT & FCD bridge and bank stabilization projects designed and constructed since May 1984 would be expected to withstand large floods with less damage than was incurred in 1983. Such was the case in January 1993, as is discussed in subsections 10.2 and 10.3 below. Only major repair or construction projects on watercourses which had large flows during the January 1993 Floods are discussed; projects constructed since the 1983 Flood on the Cañada del Oro Wash and Pantano Wash are not mentioned. Most figures referred to are located in Chapter 6.0.

9.1 Bridges Constructed or Repaired Since the 1983 Flood

Santa Cruz River

Three bridges have been constructed (Elephant Head Road, Continental Road and Cortaro Road) and one underwent major repairs (Ina Road) after the 1983 Flood. The Continental Road bridge was undamaged during the January 1993 Floods. As discussed below, the Elephant Head Road and Ina Road bridge abutments and approaches were significantly damaged, and the east abutment at the Cortaro Road bridge sustained damage.

The Elephant Head Road bridge replaced an at-grade crossing and was constructed in 1986 to provide access for residents on the east side of the Santa Cruz River and south of Green Valley. The floodplain in this area is wide, averaging about 1000 feet; the length of the bridge is about 500 feet. The benefits to be gained by constructing a bridge at this location were such that a shorter bridge was determined to be more appropriate. Therefore, in larger floods it can be expected that major repairs will be required. During the January 1993 Floods, a meander to the west caused severe erosion at the west side of the bridge; the approach and abutment were also damaged (Figures 6.1 and 6.2).

Upstream of Ina Road, the natural river channel is unprotected and the main flowpath has a tendency to shift alignment during large flow events. After both the east and west approaches were severely damaged during the 1983 Flood, the bridge was lengthened to the west to accommodate a shift in alignment. Although the bridge structure was unharmed during the January 1993 Floods, the west approach was washed out, and the west bank soil-cement abutment was damaged. Damage was significant, but less than that in 1983 (Figures 6.7 and 6.8).

At Cortaro Road, although the upstream soil-cement bank stabilization key-in was damaged by erosion during the January 1993 Floods, the bridge structure and approaches were undamaged, and the bridge remained open. Compared to the damage incurred in 1983, when the entire bridge was destroyed, damage incurred during the January 1993 floods was much less (Figures 6.9 and 6.10).

Because the floodplain becomes very wide and the main channel less defined downstream of Continental Ranch, the Avra Valley, Sanders Road, Trico-Marana, and Trico Road bridges typically require much maintenance after large flows, such as the October 1983 and January 1993 Floods. Refer to Figures 6.12 - 6.22. The Sahuarita and Pima Mine Road bridges usually incur some flood damage also, as they are older bridges constructed to standards less stringent than the current ones (Figures 6.3 and 6.4). Of the remaining bridges, almost all within the urbanized area required maintenance or repair to approaches and/or abutments after the 1983 Flood; none, however, was damaged during the January 1993 Floods.

Rillito Creek

During the 1983 Flood, bridge abutments and/or approach roads damaged included Swan Road, Dodge Road, Campbell Avenue, and First Avenue; the bridge structure was also damaged at Dodge Road. All were subsequently repaired, and a new bridge was constructed at the Swan Road crossing in 1985. The Craycroft Road bridge, completed in February 1983, was undamaged, but erosion threatened the north approach.

During the January 1993 Floods, channel bank erosion occurred in the vicinity of the Swan Road and Campbell Avenue bridges, however no damage to the bridge structure, abutments, or approaches occurred. The First Avenue bridge also was undamaged, and minimal damage occurred at the Dodge Road bridge. In summary, repairs completed after the 1983 Flood held up well during the January 1993 Floods, even though peak flows on Rillito Creek were very similar in October 1983 and January 1993.

Although most of the bridges on Rillito Creek fared well during the January 1993 Floods, one did not: the north approach to the Craycroft Road bridge was severely eroded on the upstream side, under the bridge, and on the downstream side, as previously discussed in Chapter 5.0. This bridge was constructed in 1982, prior to the adoption of the 1984 standards currently used, and the embankment near the abutment consisted of unprotected fill, making it vulnerable to erosion. However, as mentioned previously, the bridge structure sustained no damage during the January 1993 Floods.

Tanque Verde Creek, which drains into the north side of the confluence area at Craycroft Road, had a much higher peak discharge in the October 1983 Flood than in the January 1993 Floods, and was flowing at a higher stage in 1983, yet the bridge and abutment were undamaged. It is unclear at this time why and where the north bank erosion started. However once it began, adjacent unprotected north bank areas were vulnerable. Further study is needed to better understand why the dramatic erosion under the north abutment and downstream of the bridge occurred.

Tanque Verde Creek

After the 1983 Flood, the old bridges at Sabino Canyon Road and Tanque Verde Road were replaced with new bridges, and a new bridge was constructed to replace an at-grade crossing at Houghton Road. Although flows in Sabino Creek and Tanque Verde Creek were substantial during the January 1993 Floods, none of the three was damaged.

9.2 Soil-Cement Bank Stabilization Constructed Since the 1983 Flood

Most of the bank stabilization along the major watercourses has been constructed since the October 1983 Flood, after much land was eroded and residential and commercial buildings were washed away. After the flood, voters in 1984 and 1986 authorized \$43.0 million for bridge replacement/repair and bank stabilization, and \$4.9 million for structural improvements on the Santa Cruz River, respectively. PCDOT & FCD implemented an ambitious program to protect the banks of major watercourses in the urbanized areas, to minimize future flood losses.

During the January 1993 Floods, where bank stabilization has been constructed to contain the 100-year peak discharge, flows were entirely contained within the stabilized banks and no overbank flow occurred. Within the Continental Ranch subdivision, located along the Santa Cruz River downstream of Ina Road, flows were generally contained within the low-flow bank stabilization (10-year peak discharge design), although some overbank flooding occurred; flows were, however, well-contained within the 100-year design bank stabilization.

Based on field investigations conducted during and after the January 1993 storms, remarkably little damage to soil-cement bank stabilization occurred. Of the damage observed, most was where the bank stabilization is adjacent to unprotected banks, and was typically associated with bridge abutments; locations where this occurred were discussed in Section 9.2 above. This section focuses on damage to bank stabilization not associated with transportation infrastructure. Because no formal inspection of all bank stabilization has been conducted at the time of writing of this report, additional damage, if observed, will be documented in a subsequent report. Limited damage to soil-cement bank stabilization was observed at the following locations:

Santa Cruz River

Damage was observed at the beginning of the Continental Ranch low-flow bank stabilization.

Rillito Creek

A short section of soil-cement bank stabilization collapsed on the south bank immediately downstream of where Alvernon Wash flows into Rillito Creek (Figure 9.1). On the south bank west of the First Avenue bridge, a small lens of soil-cement bank stabilization located immediately downstream of a storm drain outlet into the Rillito had cracked and eroded.

Sabino Creek

Soil-cement bank stabilization extends about 2000 feet upstream of the Tanque Verde Creek confluence, along both banks of Sabino Creek. Floodwaters flowed around the back side of the upstream key-in on the west side, and the uppermost 50-foot section of bank stabilization broke off and fell into the creek (Figure 6.35).

9.3 Regional Detention/Retention Basins

Of the eight regional detention/retention basins in Pima County, the three located in the northwest metropolitan area (Massingale, Meadowbrook, and Countryside) and the Mission West basin located in the southwest metropolitan area received significant inflow. Of these four, the Massingale retention basin received the greatest inflow. It was not overtopped, however, and the maximum water surface elevation was at least five feet below the top of the basin, hence there were no outflows. The basin functioned as designed and provided flood control to downstream areas. Lesser flows were received in the other three basins; none was overtopped and each provided flood control to downstream areas.

The four regional southeast detention/retention basins (Ajo Basin at Sam Lena Park; Rita Ranch, Julian Wash, and Rodeo Wash Basins) received only minor inflow as relatively little rain fell in this area and in the upstream watershed (see Figure 2.3). Little flooding and associated damage was observed, and no drainage complaints were recorded for this area.

10.0 PROPOSED ACTION

Although major floods cause damage, sometimes irreplaceable, to public and private property, are costly, and are inconvenient for the community, they provide an opportunity to examine and revise floodplain management procedures and practices to improve the level-of-service provided by PCDOT & FCD to the community. Based on a summary review of the January 1993 Floods, six categories where changes are or may be appropriate include 1) PCDOT & FCD's Five-Year Capital Improvement Program (CIP); 2) floodplain management policies; 3) acquisition priorities for the District's Floodprone Land Acquisition Program (FLAP); 4) maintenance of flood control facilities; 5) studies needed; and 6) the District's overall response to the flooding.

10.1 Five-Year Capital Improvement Program

Although cost estimates and funding sources have been identified for most emergency and temporary repairs needed, the same has not been completed for all of the larger and more costly long-term repairs and improvements required, mostly to bridges and other public infrastructure. Most are eligible and have been accepted for federal and/or state assistance, however, no decision has been made regarding assistance for some large-scale flood and erosion control projects. It is likely that both the Transportation and Flood Control elements of the CIP will need to be revised to include Pima County's local share of project improvements. At the time of writing of this report, however, it is too early to suggest revisions.

The importance of one project component of the Flood Control element of the CIP, Emergency Repairs/Improvement Districts, cannot be overemphasized. This fund was recently established as part of the CIP in fiscal year 1992/93, to provide money to repair emergency flood damages caused by storms and to assist in the formation of improvement districts. An annual funding level of \$250,000 is dedicated for these purposes, with an accumulation or "rollover" of unused funds from year to year. The District believes such a contingency fund is needed because the timing and frequency of flood damage is unpredictable, and the need for improvement district funding is also difficult to anticipate. In January 1993, before the flooding occurred, \$408,000 was available for use from this fund.

A long-term outlook for financing flood control capital improvements, primarily along the major watercourses, should also be addressed. A recently-compiled needs assessment identifies approximately \$246 million in unfunded structural and non-structural flood control improvements. Approximately one-half of this amount is for continuation of bank stabilization efforts. The bank stabilization program has proved to be greatly beneficial in reducing flood and erosion damage, as described in this report's comparison of the October 1983 and January 1993 flood events.

10.2 Floodplain Management/Flood Control Policies

As mentioned in Chapter 9.0, the design and repair philosophy adopted after the 1983 Flood contributed significantly to lowering the overall flood damage incurred during the January 1993 Floods. Two new policies are suggested for adoption by the Board, and Board clarification of one policy has been accomplished.

Policies Recommended for Board Adoption:

a) Bank Stabilization on One Side of a Major Watercourse

Soil-cement bank stabilization shall be constructed simultaneously along both banks of a major watercourse. A waiver may be granted if the applicant dedicates to the Pima County Flood Control District along the unprotected bank an erosion buffer having a width of 500 feet (or the width of the erosion hazard area, whichever is greater) and extending the full length of the project and 50 feet beyond in the upstream and downstream directions.

Otherwise, a surety bond is to be paid by the applicant, which will be used by the Pima County Flood Control District to pay for the cost of any future damages to adjacent properties arising out of improvements to only one side of a channel. The surety bond will be held until such time as bank stabilization is constructed on the opposite bank of the channel.

Alternatively, the applicant may obtain a release of liability from the owner(s) of the property on the opposite side of the channel in the vicinity of the improvements if the property might be affected by the project when soil-cement bank stabilization is to be constructed on only one side of the channel. The release of liability must also include Pima County and the Pima County Flood Control District.

b) Reclamation Policy

Riverine systems within the jurisdiction of the Pima County Flood Control District must be regulated using existing conditions at the time of application for use or activity (i.e., reclamation or channel bank restoration) within a regulatory floodplain or erosion hazard area. All requests for such proposed activity within the regulatory floodplain or erosion hazard area shall be evaluated with respect to current conditions while considering the existing hazards to public and private improvements and the overall riverine environment.

Requests to reclaim land or restore previous channel bank and/or floodplain conditions shall be evaluated similar to other requests for activity within a regulatory floodplain/erosion hazard area and shall be subject to the same criteria and evaluation as any other use. Such evaluation would include all pertinent permitting requirements as allowed for within the Ordinance.

c) Tanque Verde Creek and Tributaries

Background:

Regarding structural versus non-structural floodplain management on Tanque Verde Creek, Agua Caliente Wash, and Sabino Creek, the District has been guided by recommendations in a report titled River Management Plan for the Rillito River and Major Tributaries, adopted by the Board in 1984. The report recommended that these watercourses should be left in their mostly natural states because reducing the existing natural flood storage by channelization would increase the

downstream flood peak discharges on Rillito Creek by over 40%, placing downstream public infrastructure and riverside development at increased risk of flood and erosion damage. Infrastructure and riverside development on the Santa Cruz River downstream of the confluence with Rillito Creek could also be endangered.

A second study, the Survey and Environmental Assessment, Rillito River & Associated Streams, Tucson, Arizona, completed by the U.S. Army Corps of Engineers (Corps) in May 1986, and revised in February 1987, concluded that, "...no justified plans of improvement could be formulated," i.e., the costs of constructing structural improvements outweighed the benefits to be gained, for the Tanque Verde Creek and Agua Caliente Washes, except for two locations along Tanque Verde Creek: 1) Fortyniners Country Club Estates, and 2) Del Rio. A flood control project is being developed at the former; and a project providing 100-year flood protection has already been constructed at the latter. Consequently, the Corps declared the Agua Caliente Wash and the remaining reaches of Tanque Verde Creek ineligible for federal assistance for construction of bank stabilization.

Recent:

After the January 1993 Floods, several residents along Tanque Verde Creek and Agua Caliente Wash expressed an interest in constructing bank stabilization with District assistance along these watercourses. PCDOT & FCD staff visited several sites with Soil Conservation Service (SCS) personnel to assess whether they would be eligible for SCS assistance in providing bank stabilization. SCS subsequently informed us that the sites would not be eligible for SCS funding.

Clarification Received:

At a May 11th, 1993 Board meeting, the District suggested that the feasibility of constructing low-flow bank stabilization be evaluated with the intent of protecting some of the most vulnerable locations along Agua Caliente Wash and Tanque Verde Creek. The District noted that this would be consistent with recommendations in the River Management Plan for Rillito River and Major Tributaries, as overbank floodwater storage would be preserved. The Board agreed and approved the District's request to evaluate the feasibility of constructing low-flow bank stabilization in selected areas, but did not commit any District funds for construction.

10.3 Floodprone Land Acquisition Program (FLAP)

As mentioned in Section 8.3, acquisition of floodprone land and relocation of residents after the October 1983 Flood helped reduce the overall losses incurred in the January 1993 Floods. It is recommended that a request for additional funding to acquire floodprone areas be placed before the electorate in the next bond election.

When the electorate is asked to approve additional funding for the FLAP, specific areas to be acquired are typically listed. For those acquisitions not specifically governed by bond issues but financed by the District tax levy, the District has generally been implementing the FLAP via the guidelines and priorities set forth in the 1985 memorandum prepared for the Board, justifying the establishment of the program. The two priority systems used are 1) watercourse reach priorities, for those reaches where non-structural floodplain management is planned; and 2) land use priorities, essentially a parcel-based assessment of flood and/or erosion risk, based on damage previously incurred, location relative to the floodway and floodplain, and amount of improvements on the property.

Recommendation:

No revisions to the priority list are recommended at this time. Although it has long been recognized that some existing development along Tanque Verde Creek, Agua Caliente Wash, and Sabino Creek is at-risk, acquisition of floodprone land along the Cañada del Oro and Black Washes has been assigned a higher watercourse priority in terms of fulfilling stated community goals, based on studies which have been completed and approved by the Board. At-risk properties located along watercourses which have not been assigned the highest watercourse reach priority can still be acquired if the risk is deemed high, based on the land use priority ranking.

10.4 Maintenance of Flood Control Facilities

It is recommended that a comprehensive database listing of District-owned and maintained flood control facilities continue to be developed. Design characteristics, including the year of construction, design details, and design discharge, should be included in the database, as well as current estimates of regulatory discharge.

Achieving a balance of the fiscal resources available, demand for maintenance needs, a prioritization of needs, and infrastructure data should form the basis of a maintenance plan. Performance standards will be the mechanism to evaluate the quality and quantity of delivered maintenance service.

10.5 Recommended Studies

a) Federal Emergency Management Agency (FEMA) Flood Insurance Studies (FIS)

- The significance of channel cross-section and adjacent topography changes resulting from the January 1993 Floods along the Agua Caliente Wash should be evaluated, to assess whether a new FIS is needed. As part of an ongoing FIS, mapping is proceeding along the entire Tanque Verde Creek.
- As part of an FIS underway on the upper Santa Cruz River and the upper Cañada del Oro Wash, topography was obtained in 1992, to be used in revising the FEMA flood limits. Changes in the channel cross-section topography and that of adjacent areas should be quantified and the data for the ongoing FIS should be revised as necessary.

b) Drainage Studies

- This office is proceeding to determine the most appropriate method to alleviate flooding at the terminus of Finger Rock Wash, in the residential area north of River Road near Sutton Lane, including requesting assistance from the U.S. Army Corps of Engineers.

10.6 Examination of PCDOT & FCD's Response to the Flooding

- A comprehensive study should be conducted to analyze how the Department responded to the flood emergency. Actions taken by all Divisions should be analyzed, and recommendations for improvement are sought. Suggestions for expanding the flood warning system should be included.

11.0 SUMMARY

Based on damage to public transportation and flood control facilities, currently estimated at about \$13.9 million for emergency repairs and long-term improvements in Pima County, the City of Tucson, and Town of Marana; damage to private property; and the inconvenience caused by loss of access for up to 2500 residents of areas near Agua Caliente Wash and Tanque Verde Creek, the January 1993 Floods were the most significant to impact Pima County in ten years, since the October 1983 Flood.

In the flood of January 7th - 8th 1993, major watercourses located in the northeast and north-central metropolitan areas, including Agua Caliente Wash, Tanque Verde Creek, Sabino Creek, and Finger Rock Wash, were most heavily impacted. Peak flows on Rillito Creek were high as well, as the above-referenced watercourses drain to the Rillito. Damage was greatest along these watercourses, especially along Rillito Creek, during the beginning of the two-week period of excessive rain and high floodwater stages.

The second major peak flow event, which occurred on January 18th -19th, impacted most heavily on the upper Santa Cruz River watershed. Damages occurred primarily along the Santa Cruz River, to bridge abutments and access roads of those bridges located upstream and downstream of the metropolitan Tucson area. Little damage to transportation and flood control infrastructure occurred within the City of Tucson.

When compared to the October 1983 Flood, the peak discharge on Rillito Creek during the January 1993 Flood was almost the same (about 25,000 cfs for both); however that on the Santa Cruz river during the January 1993 Flood was significantly lower (60,000 cfs in October 1983 versus 38,000 cfs in January 1993, at Marana). Although discharge data are not available, other data indicate that the peak discharge on Tanque Verde Creek was higher in 1983; however the peak discharges on Agua Caliente Wash, Sabino Creek, and Finger Rock Wash were higher in 1993.

Cost estimates to repair and mitigate flood damage were estimated at \$ 105.7 million in 1984; this is considerably higher than the \$ 13.9 million estimate to repair damage resulting from the January 1993 Floods and to mitigate future flood damage. A strict comparison between the two cannot be made, however, as the January 1993 estimate does not include as extensive a mitigation program as the 1984 cost estimate.

Although less damage would be expected in the January 1993 Floods as the peak discharges were, except for Rillito Creek, generally lower than those in 1983, implementation of the Flood Repair and Flood Hazard Mitigation Program (the Program) also mitigated flood and related losses incurred during the January 1993 Floods. The Program's elements included a permanent repair philosophy for replacing existing or constructing new bridges and bank stabilization; a component which emphasized the benefits of overbank floodwater storage, floodprone land acquisition, and relocation of residents of damaged property; and an access improvement component.

Overall, actions taken by Pima County since the 1983 Flood have contributed to the reduced flood losses in January 1993. Accelerated implementation of the 1984 Flood Repair and Hazard Mitigation Program was made possible by voters' authorization of bond issues in 1984 and 1986 for those specific purposes. Most of the bond monies have been expended, primarily for improvements along the Santa Cruz River and Rillito Creek, and the District's Floodprone Land Acquisition Program.

In light of the January 1993 Floods, the Pima County Board of Supervisors on January 19th, 1993 voted to accelerate construction of a bridge across the Agua Caliente Wash at Tanque Verde Road. Plans to construct soil-cement bank stabilization along vulnerable reaches of Rillito Creek have also been accelerated, particularly at the Country Club bend area, and in the vicinity of Camino de la Tierra. Plans to improve the Pegler Wash conveyance to Rillito Creek have also been accelerated. While progress is being made toward reducing potential future flood damage and loss, there are many areas throughout Pima County which are still at risk, and where the flood mitigation needs remain unmet.

Through its progressive floodplain management program, funded by the District's tax levy on real property, bond monies, and assistance from the federal government during and after major flood emergencies, the Pima County Flood Control District strives to reduce flood and erosion hazard and loss in unincorporated Pima County while seeking a balance between structural and non-structural floodplain management practices.

REFERENCES

- Arizona Daily Star, Tucson, Arizona; February 17, 1993; March 10, 1993
- Corsette, Barbara; Arizona Division of Emergency Management; personal communication; April 1993
- Johnson, Morgan; and Matthews, Mick; GLHN Architects and Engineers, Incorporated; personal communication; May 1993
- Kern, Bob; Town of Marana; personal communication; May 1993
- MacDonald, Karen; Red Cross, Tucson, Arizona; personal communication; April 1993
- Pima County, Arizona; Disaster Control Plan - Standard Operating Procedures, March 1986
- Pima County Department of Transportation and Flood Control District, Tucson, Arizona; Flood Repair and Flood Hazard Mitigation Implementation Plan, April 1984
- Pima County Department of Transportation and Flood Control District, Tucson, Arizona; Flood Repair and Flood Hazard Mitigation Program Report, Pima County, Arizona, May 1984
- Pima County Department of Transportation and Flood Control District, Tucson, Arizona; Floodplain and Erosion Hazard Management Ordinance No. 1988-FC2; December 1988
- Pope, Greg; United States Geological Survey, Tucson, Arizona; personal communication; May 1993
- Simons, Li & Associates, Incorporated; River Management Plan for the Rillito River and Major Tributaries, prepared for Pima County Department of Transportation and Flood Control District; March 1984
- Simons, Li & Associates, Incorporated; Investigations of Two Sites Impacted by the January 1993 Floods in Pima County: (1) The Rillito Creek, from Dodge Boulevard to Country Club Road; and (2) The Agua Caliente Wash, from Fort Lowell Road to Houghton Road, March 1993
- Smith, Chris; United States Geological Survey, Tucson, Arizona; personal communication; April 1993

REFERENCES (continued)

United States Army Corps of Engineers, Survey and Environmental Assessment, Rillito River and Associated Streams, Tucson, Arizona, completed May 1986, revised February 1987

United States Department of Interior, Bureau of Indian Affairs; Safety of Dams Modification Report for Coolidge Dam, San Carlos Project; November 1988

United States Department of Interior, U.S. Geological Survey; Floods of October 1983 in Southeastern Arizona; USGS Water-Resources Investigations Report 85-4225-C

Walsh, Mike; Pima County Sheriff's Department; personal communication; March 1993

Zickus, Tom; United States Department of Commerce, National Weather Service; Phoenix, Arizona; personal communication; April 1993

APPENDIX A

EXCERPTS FROM

JANUARY 1993 FLOOD SUMMARY REPORT OF

PIMA COUNTY FLOOD WARNING SYSTEM

**JANUARY 1993 FLOOD SUMMARY REPORT OF
PIMA COUNTY FLOOD WARNING SYSTEM**



**Prepared by:
Pima County Department of Transportation
and Flood Control District
Flood Control Planning and Development Division**

**John M. Bernal
Director**

May 25, 1993

BACKGROUND:

This report has been prepared by Pima County Flood Control District (District) staff to provide the precipitation and stream flow hydrograph data, and an overview of the ALERT system's performance during the storm which occurred on January 5th - 19th, 1993.

The District manages a flood threat recognition system which provides real-time storm monitoring and early warning capabilities to Pima County. The system comprises three components: radar, weather channel, and ALERT. These data sources, as well as information obtained from field observations and National Weather Service (NWS) forecasts, enable the District to provide early warning of possible flooding to various emergency response agencies.

Since the formation of the District in 1978, Pima County has taken a very active and progressive approach toward flood warning. The resolve to provide the best possible flood warning is reflected by the Pima County Board of Supervisors' commitment to the program, the National Weather Services' strong support, a pro-active local Emergency Services Division, and the dedication of the people that work together to maintain and operate the flood warning program.

ALERT, Automated Local Evaluation in Real Time, is a telemetric electronic environmental sensing system. It automatically senses and collects precipitation, stream stage and meteorological data and transmits them, real time, via radio frequency signals, to two base stations where they are received, processed, and stored in computers. These base stations are maintained by the Tucson National Weather Service Office (NWSO), and Pima County Department of Transportation and Flood Control District. Data collected at the District are processed, edited, archived and backed up routinely.

A network of remotely-located sensor stations transmit data via UHF radio signals to a repeater site on Mt. Lemmon, where they are transformed into microwaves and transmitted to the County Communications Center on Ajo Way. At the Communications Center, the signal is rebroadcast via UHF radio transmission to computers at the Tucson NWSO, and at the District office located in the Public Works Building in downtown Tucson.

After a flood threat has been recognized, District personnel follow emergency response and flood warning procedures outlined in the District's Flood Response Plan. This Plan identifies personnel assignments and key agencies to be notified during a flood event.

Although the ALERT system provides advance notice of possible flooding, the District is not authorized to issue weather advisories or initiate evacuation notices to the general public. During severe weather and flooding, the District provides technical support to the NWSO and Emergency Services personnel, who are authorized to disseminate flood warnings to the general public. The District also provides flood warning information to the Pima County Operations Division's highway maintenance units located in the field.

Beside its flood warning capability, the ALERT system is generating an increasingly valuable database. ALERT data are well-suited for studies and research projects conducted by universities, private consultants and other governmental agencies; many data requests are processed each month. Both the National Park Service and the U.S. Geological Survey have direct telephone access to ALERT data.

The ALERT system presently includes 47 precipitation devices, 21 stream flow devices, two weather devices, and 4 repeaters. Sensor devices are strategically located along major watercourses and in the upper reaches of watersheds in Eastern Pima County. Precipitation gauges located in the upper parts of watersheds provide maximum warning time for possible floods moving towards the low-lying populated areas. To provide warning for floods originating in ungauged areas, the District installs stream gauges along the major watercourses. Stream gauges are a reliable means of quickly confirming the flow depth, and of determining if the water is rising or receding, and at what rate.

FLOOD WARNING SYSTEM PERFORMANCE:

Overall, the ALERT system's performance during the storm was excellent. Ninety-seven percent of the precipitation gauges and eighty-seven percent of the stream gauges were operating efficiently. Highlights of the system's performance included:

- (1) There was no loss of equipment during the storm.
- (2) By utilizing the ALERT computer, radar, and satellite imagery via the weather channel, the District provided timely and factual stream flow and meteorological information to the necessary emergency response groups as well as to numerous other agencies and individuals upon request.
- (3) ALERT system personnel monitored flows and storm movement during the storms. Based upon the quality of data received staff was able to assess and predict the potential and severity of site-specific flooding, as well as the time of peak flow. Staff was also able to respond in a timely manner to requests for information from the general public.
- (4) ALERT system personnel continuously updated neighboring counties of possible flood threats. Upon request, staff provided information about flood flow forecasting and precipitation data to local news agencies and the general public in a timely manner.
- (5) Two District computers were online during the storms, which proved very beneficial in providing ALERT personnel with the capability of analyzing and interpreting data from different locations simultaneously.
- (6) The District has located stream gauges such that some redundancy in measurement occurs along the major watercourses. If one gauge goes down, neighboring gauges can still provide data. This proved very beneficial in terms of public safety during the flood event.

Although the overall performance of the ALERT system was excellent, some aspects of the program can be improved to enhance the system's overall performance, as follows:

- (1) Due to loss of trained employees and the remaining staff's work load, insufficient maintenance resulted in improperly functioning gauges in some locations. This problem has been resolved, and maintenance and installation of ALERT devices is on schedule.
- (2) Pima County communication on Mount Lemmon was down for approximately 3 hours on January 13th, 1993; consequently the District's ALERT repeater was unable to forward incoming data to the base stations during this time period. The District is currently working on installing a "hot repeater" on Mount Lemmon, to function as a backup for transmitting field sensor data directly to the base stations for processing and interpretation.
- (3) Due to a damaged board within the Empire Peak repeater, as of December 28, 1992 the system was unable to forward continuous signals from the gauges at Rincon Creek, Vail, and Cienega Creek. ALERT system personnel received some data from the Pantano Wash watershed area by occasionally switching frequencies at the District office, however, staff was unable to receive data from gauges located in areas that were experiencing the more serious flooding problems. Repairs were completed on January 27th, 1993, and the repeater has been operating since.
- (4) The Pima County Flood Control District has established good communication with emergency agencies, and this communication rapport worked well. However, communication between other agencies could be improved.
 - The NWSO was unable to provide qualitative information which would allow the District to forecast more accurate flood flows during the last week of the storm.
 - Local jurisdictions need to establish more definitive protocols with Emergency Services. This would result in one message being transmitted to the public, helping to quell the spread of rumors, and reducing the number of calls to the Pima County Flood Control District.
- (5) Channel cross-sections should be resurveyed near all stream gage locations as warranted, and, if applicable, rating tables should be revised to reflect changes in channel topography caused by the January 1993 Floods.
- (6) Flow depth measurement indicators should be installed on the piers of bridges in selected locations, to allow county personnel to safely obtain readings. This would provide District staff with accurate flow depths on ungauged watercourses, as well as verification of ALERT stream gage data on gauged watercourses.

PEAK FLOW ESTIMATES:

Flood Control District staff has estimated the peak flows along major watercourses using water surface elevations observed by the staff or recorded in ALERT system. These peak flows are as follows:

WATERCOURSE	DATE	PEAK FLOW _{CFS}	FLOW DEPTH _{FT}
Santa Cruz River @ Trico Marana Bridge	01/08/93	38,000	12.7
Santa Cruz River @ Cortaro Road Bridge	01/08/93	39,000	5.4
	01/18/93	40,000	6.0
Santa Cruz River @ Valencia Bridge	01/18/93	22,000	8.0
Rillito River @ Dodge Blvd.	01/08/93	28,000	8.3
	01/18/93	13,500	5.6
Tanque Verde Creek @ Tanque Verde Guest Ranch	01/07/93	9,950	9.0
	01/18/93	9,206	8.7
Canada Del Oro @ Rancho Solano	01/08/93	1,590	6.5

CONCLUSION:

The Pima County Flood Warning System performed well during the January 1993 Floods. District ALERT personnel were able to analyze and assess data, and predict potential flooding, the severity of flooding, and the peak flow in site-specific areas. Real-time storm monitoring allowed staff to provide early warning of flooding to emergency response groups, Pima County Operations Division personnel, and neighboring jurisdictions, enabling them to take actions necessary to ensure public safety. ALERT system staff also provided precipitation data to local news agencies and the general public in a timely manner.

The District has established good communication with emergency response groups as well as with many other agencies, and was commended for their operation and communication during the storm by Emergency Services and other counties in the State of Arizona. Michael Walsh, the coordinator of Tucson/Pima County Emergency Services, indicated that the Emergency Services Center would have been lost without the District's ALERT Flood Warning System information.

In summary, the system's performance was very good, but, as with any system, the opportunity for improvement exists. District staff is working to rectify the identified problems as time and financial resources permit.

FLOOD EVENT SUMMARY OF PRECIPITATION DATA

**PIMA COUNTY FLOOD CONTROL DISTRICT
PRECIPITATION DATA
JANUARY 5, 1993 TO JANUARY 19, 1993**

Date: Gauge:	1/5	1/6	1/7	1/8	1/9	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	TOTAL
1010	0.54	0.91	0.79	0	0.55	0.31	0	0.67	0	0	0.28	0.08	1.06	0.31	0	5.50
1020	0.59	0.75	0.51	0	1.1	0.67	0	1.06	0.12	0	0.20	0.12	1.30	0.51	0	6.93
1030	1.02	1.02	0.87	0.04	0.47	0.28	0	0.98	0	0	0.35	0.12	1.22	0	0.31	6.68
1040	0.67	1.22	0.67	0	0.63	0.24	0	0.91	0	0	0.24	0.24	0.87	0.59	0	6.28
1050	0.79	1.22	0.63	0	0.63	0.24	0.12	0.24	0	0	0	0.04	0.67	0.51	0	5.09
1060	0.94	1.3	0.83	0.04	0.71	0.39	0	0.91	0	0	0.39	0.16	1.42	0.71	0	7.80
1070	0.75	1.14	0.55	0	0.24	0.16	0	0.67	0	0	0.24	0	1.06	0.55	0	5.36
1080	0.79	1.06	0.79	0.04	0.83	0.39	0	0.91	0	0	0.28	0.12	0.87	0	0	6.08
1090	1.34	2.28	0.83	0.16	0.51	0	0.35	0.12	0.08	0.2	1.34	0.87	0.67	0	0.08	8.83
1100	0.55	1.34	0.67	0	0.35	0.16	0	0.59	0	0	0	0	0.79	0.51	0	4.96
1200	0.71	1.3	0.79	0	0.51	0.04	0	1.14	0	0	0.12	0.04	0.63	0.39	0	5.67
2020	1.02	1.89	1.06	0.04	0.43	0.16	0.04	0.87	0.08	0	0.35	0.2	1.69	0.20	0	8.03
2030	0.91	1.65	0.87	0.04	0.51	0.08	0.04	0.63	0.04	0	0.28	0.12	1.38	0.31	0	6.86
2050	0.43	0	0.04	0	0.04	0	0.04	0.39	0	0	0.39	0.16	1.57	0.28	0	3.34
2060	0.04	0.04	0.12	0	0.04	0	0	0	0	0	0	0	0.08	0	0	0.32
2080	1.02	1.93	0.98	0.12	0.67	0.16	0	0.79	0.08	0	0.47	0.2	1.42	0.35	0	8.19
2090	0.91	1.54	0.51	0.04	0.55	0.12	0	0.87	0.04	0	0.35	0.08	1.14	0.20	0	6.35

PRECIPITATION SHOWN IN INCHES

DISCLAIMER: These measurements are the best information at this time. The Pima County Department of Transportation and Flood Control District makes no warranty, expressed nor implied, regarding the accuracy of data provided.

* INCOMPLETE RECORD

**PIMA COUNTY FLOOD CONTROL DISTRICT
PRECIPITATION DATA
JANUARY 5, 1993 TO JANUARY 19, 1993**

Date: Gauge:	1/5	1/6	1/7	1/8	1/9	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	TOTAL
2110	0.59	1.22	0.51	0.12	0.47	0.04	0	0.91	0 [*]	0	0.20	0	1.26	0.08	0	5.40
2120	0.71	1.34	0.63	0.12	0.51	0.08	0	1.02	0 [*]	0	0.16	0	1.54	0.08	0	6.19
2150	2.01	2.99	4.88	0.04	1.3	1.42	0.35	1.46	0.2	0.31	1.54	1.26	0.94	0.08	0.39	19.17
2160	0.79	1.54	1.06	0.08	0.67	0.2	0	0.87	0 [*]	0	0	0	1.54	0.28	0	7.03
2170	0.75	1.06	0.87	0.04	0.51	0.2	0	0.83	0 [*]	0	0.2	0	1.34	0.28	0	6.08
3050	0.39	0.94	0.51	0	0.28	0.04	0.04	0.14	0 [*]	0 [*]	0.08	0	0.75	0.12	0	3.29
3310	0.28	1.1	0.47	0.04	0.47	0.08	0.04	0.91	0	0 [*]	0.16	0	1.14	0	0	4.69
4100	0.08	0 [*]	0 [*]	0.12	0.31	0.08	0.28	0.08	0 [*]	--	--	--	--	--	--	0.95
4250	0.04	0.39	0.08	0	0	0	0	0	0 [*]	0 [*]	0	0	0	0	0	0.51
4280	0.08	1.02	0.12	0	0.51	0.04	0	0.16	0	0 [*]	0	--	0.55 [*]	0.12	0	2.60
4310	0.75	0.2	0	0	0.35	0.28	0	0.2	0 [*]	0 [*]	0	0.24	0.08	0	0.04	2.14
6020	0.51	1.06	0.55	0	0.2	0.08	0	1.02	0 [*]	0	0.08	0	0.59	0.35	0	4.44
6040	0.63	0.71	0.04	0.08	0.31	0	0	0.47	0 [*]	0 [*]	0.04	0.04	0.79	0.08	0	3.19
6050	0.35	0.75	0.04	0	0.63	0	0	0.12	0	0 [*]	0.31	0.04	0.55	0.08	0	2.87
6060	0.31	0.16	0.04	0	0.31	0.04	0	0.08	0 [*]	0 [*]	0.24	0.04	0.39	0.04	0.04	1.69
6070	0.43	0.16	0	0	0.51 [*]	0.08	0	0.16	0 [*]	0	0.12	0.35	1.22	0.35	0	3.38

PRECIPITATION SHOWN IN INCHES

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* INCOMPLETE RECORD

-- No signal was received for the indicated day.

**PIMA COUNTY FLOOD CONTROL DISTRICT
PRECIPITATION DATA
JANUARY 5, 1993 TO JANUARY 19, 1993**

Date: Gauge:	1/5	1/6	1/7	1/8	1/9	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	TOTAL
6110	0.51	0.79	0.35	0	0.31	0.08	0	0.98	0.08	0	0.2	0	0.2	0.28	0	3.78
6290	0.51	1.3	0	0	0.51	0	0	0.28	0	0	0.08	0.2	0.51	0.16	0	3.55
6310	0.47	0.43	0.2	0	0.59	0.04	0	0.31	0	0	0.55	0.12	0.59	0.12	0	3.42
6320	0.59	0.59	0.24	0	0.91	0.08	0	0.24	0.12	0	0.43	0.08	0.91	0.12	0	4.31
6330	0.51	0.28	0.12	0.04	0.04	0	0	0.04	0	0	0	0	0.04	0	0.04	1.11
6350	0.43	0.31	0.08	0	0.55	0.16	0	0.08	0.08	0	0.31	0.04	0.91	0.24	0	3.19
6410	0.39	0.75	0.43	0.08	0.51	0.04	0	0.28	0	0	0.12	0.04	0.94	0.16	0	3.74
6420	0.63	0.91	0.28	0.04	0.31	0	0	0.39	0	0	0.08	0.04	0.51	0.2	0	3.39
6430	0.59	0.59	0.24	0.04	0.2	0	0	0.51	0	0	0.04	0.04	0.67	0.12	0	3.04
6440	0.2	0.28	0.08	0.04	0	0.04	0	0.04	0	0	0.04	0	0	0	0	0.72

PRECIPITATION SHOWN IN INCHES

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• INCOMPLETE RECORD

**SENSOR DESCRIPTION AND COORDINATES
PIMA COUNTY ALERT DATA COLLECTION SYSTEM**

SENSOR#	SENSOR NAME	TYPE	COORDINATES	ELEV.
1010	Golder Ranch	Precip	32° 32'N 110° 52'W	3310
1020	Oracle Ranger Sta	Precip	32° 35'N 110° 47'W	4520
1030	Oracle Ridge	Precip	32° 31'N 110° 45'W	6560
1039	Dodge Tank	Stream	32° 31'N 110° 51'W	3240
1040	Dodge Tank	Precip	32° 30'N 110° 51'W	3240
1050	Cherry Spring	Precip	32° 30'N 110° 50'W	4080
1060	Pig Springs	Precip	32° 31'N 110° 47'W	4815
1070	Cargodera Canyon	Precip	32° 26'N 110° 52'W	3195
1079	Rancho Solano	Stream	32° 33'N 110° 51'W	3380
1080	Rancho Solano	Precip	32° 33'N 110° 51'W	3380
1087	Mount Lemmon	Wind	32° 26'N 110° 47'W	9000
1090	Mount Lemmon	Weather	32° 26'N 110° 47'W	9000
1091	Mount Lemmon	Humidity	32° 26'N 110° 47'W	9000
1092	Mount Lemmon	Temp	32° 26'N 110° 47'W	9000
1094	Mount Lemmon	Bar Pres	32° 26'N 110° 47'W	9000
1099	Golder Road Bridge	Stream	32° 28'N 110° 53'W	2960
1100	Golder Road Bridge	Precip	32° 28'N 110° 53'W	2960
1200	CDO at Ina	Precip	32° 20'N 110° 02'W	2245
1203	CDO at Ina	Stream	32° 20'N 110° 02'W	2245
2020	Park Tank	Precip	32° 15'N 110° 32'W	5100
2030	Italian Trap	Precip	32° 16'N 110° 33'W	4000
2040	White Tank	Precip	32° 18'N 110° 34'W	4400
2050	Bellota Ranch Rd	Precip	32° 18'N 110° 36'W	4300
2060	Mule Deer Tank	Precip	32° 14'N 110° 36'W	4610
2070	Chiva Falls	Precip	32° 16'N 110° 36'W	3770
2073	Chiva Falls	Stream	32° 16'N 110° 36'W	3770
2080	Alamo Tank	Precip	32° 17'N 110° 38'W	4100
2090	Tanque Verde Ranch	Precip	32° 14'N 110° 40'W	2720

SENSOR#	SENSOR NAME	TYPE	COORDINATES	ELEV.
2093	Tanque Verde Ranch	Stream	32° 14'N 110° 40'W	2720
2110	Tanque Verde Bridge	Precip	32° 15'N 110° 49'W	2510
2109	Tanque Verde Bridge	Stream	32° 15'N 110° 49'W	2510
2120	TV/Sabino Bridge	Precip	32° 15'N 110° 50'W	2475
2123	TV/Sabino Bridge	Stream	32° 15'N 110° 50'W	2475
2150	White Tail	Precip	32° 25'N 110° 44'W	8400
2159	Sabino Dam	Stream	32° 18'N 110° 48'W	2160
2160	Sabino Dam	Precip	32° 18'N 110° 48'W	2160
2170	Vantana/ Sunrise	Precip	32° 18'N 110° 50'W	2720
3050	Rillito/Dodge	Precip	32° 16'N 110° 54'W	2375
3049	Rillito/Dodge	Stream	32° 16'N 110° 54'W	2375
3310	Alamo Wash	Precip	32° 15'N 110° 52'W	2440
3309	Alamo Wash	Stream	32° 15'N 110° 52'W	2440
4097	Manning Camp	Wind	32° 12'N 110° 33'W	7930
4100	Manning Camp	Precip	32° 12'N 110° 33'W	7930
4101	Manning Camp	Humid	32° 12'N 110° 33'W	7930
4102	Manning Camp	Temp	32° 12'N 110° 33'W	7930
4103	Manning Camp	Fuel Msr	32° 12'N 110° 33'W	7930
4104	Manning Camp	Bar Pr	32° 12'N 110° 33'W	7930
4110	Rincon Creek	Precip	32° 07'N 110° 37'W	3137
4109	Rincon Creek	Stream	32° 07'N 110° 37'W	3137
4249	Vail	Precip	32° 02'N 110° 40'W	3210
4250	Vail	Stream	32° 02'N 110° 40'W	3210
4280	Cienega/I-10	Precip	31° 59'N 110° 34'W	3570
4283	Cienega/I-10	Stream	31° 59'N 110° 34'W	3570
4310	Davidson Canyon	Precip	31° 59'N 110° 38'W	3480
4313	Davidson Canyon	Stream	31° 59'N 110° 38'W	3480
4320	Empire Peak	Precip	31° 53'N 110° 38'W	5588

SENSOR#	SENSOR NAME	TYPE	COORDINATES	ELEV.
6019	Cortaro Road	Stream	32° 21'N 110° 05'W	2145
6020	Cortaro Road	Precip	32° 21'N 110° 05'W	2145
6039	SCR/Valencia	Stream	32° 08'N 110° 59'W	2400
6040	SCR/Valencia	Precip	32° 08'N 110° 59'W	2400
6049	SCR/Continental	Stream	31° 51'N 110° 58'W	2856
6050	SCR/Continental	Precip	31° 51'N 110° 58'W	2856
6060	SCR/Conoa	Precip	31° 44'N 110° 02'W	3008
6063	SCR/Conoa	Stream	31° 44'N 110° 02'W	3008
6069	SCR/Nogales	Stream	31° 20'N 110° 51'W	3825
6070	SCR/Nogales	Precip	31° 20'N 110° 51'W	3825
6110	Avra Valley Air Park	Precip	32° 24'N 110° 13'W	2021
6290	Corona	Precip	31° 58'N 110° 47'W	3147
6310	Keystone Peak	Precip	31° 52'N 111° 12'W	6206
6320	Tinajo Ranch	Precip	31° 50'N 111° 09'W	4165
6330	Anamax	Precip	31° 52'N 111° 03'W	3445
6350	Elephant Head Butte	Precip	31° 43'N 110° 58'W	3475
6410	Diamond Bell Ranch	Precip	31° 59'N 111° 50'W	3250
6420	Brawley/Three Points	Precip	32° 33'N 111° 20'W	2551
6423	Brawley/Three Points	Stream	32° 33'N 111° 20'W	2551
6430	Valhala	Precip	32° 06'N 111° 08'W	2585
6440	Brawley/Milewide	Stream	32° 14'N 111° 14'W	2211

APPENDIX B
SUMMARY OF FLOOD REPAIR COSTS AND
RELATED FINANCIAL DATA
TRANSPORTATION AND FLOOD CONTROL FACILITIES

**SUMMARY OF FLOOD REPAIR COSTS AND RELATED FINANCIAL DATA
TRANSPORTATION AND FLOOD CONTROL FACILITIES**

• **OVERVIEW**

As of May 20, 1993, cost estimates for emergency repairs and long-term improvements resulting from damages sustained during the January 1993 Floods are estimated at \$ 13,915,546 for unincorporated Pima County, the City of Tucson, and the Town of Marana. Please note that these data are continually being revised. The breakdown is as follows:

Jursidiction	Emergency Repairs	Long-Term Improvements	Sum
Unincorporated Pima County	\$2,764,000	\$8,650,400	\$11,414,400
Town of Marana	\$ 17,000	\$1,824,500	\$ 1,841,500
City of Tucson	\$ 659,646		\$ 659,646
TOTALS	\$3,440,646	\$10,474,900	\$13,915,546

• **PRE-FLOOD FUNDING STATUS FOR EMERGENCY REPAIRS**

Before the January 1993 Flood, approximately \$408,000 in PCDOT & FCD funding was available for use in emergency situations, including \$250,000 from the District's annual budget for Emergency Repairs/Improvement Districts, and \$158,000 in unused carryover from prior years. PCDOT & FCD's annual operation and maintenance budget is about \$ 1,700,000.

Because the local financial resources were inadequate to address repair and improvement needs without dramatically impacting existing and planned programs, and only after federal and state disasters had been declared, PCDOT & FCD sought federal and state financial assistance to repair and mitigate flood damage. Because the flood damage was widespread throughout the State of Arizona, Pima County's requests for federal and state funding assistance have been and will continue to be competitively evaluated with respect to requests from other jurisdictions.

• **EMERGENCY ACTIONS BY BOARD OF SUPERVISORS**

Due to severe damage to roads, bridges and drainageways, on January 8th, 1993 the Board unanimously declared Pima County to be a disaster area. On January 19th, 1993, the Board authorized the use of \$1,000,000 of General Contingency Fund monies for emergency flood repairs. They also voted to accelerate the construction of a bridge across Agua Caliente Wash at Tanque Verde Road, to be funded by Municipal Property Corporation Bonds.

- "ON THE SPOT" FEDERAL FUNDING FOR EMERGENCY REPAIRS

During the January 1993 Floods, federal assistance was provided immediately at three locations in Pima County where the impending losses would greatly impact the community. The federal government assumed the cost of emergency repair work on the Rillito Creek at the Craycroft Road bridge (COE), at the Luker residence downstream of the bridge (SCS), and at the Country Club Road "bend area" (COE), as discussed in Chapter 5.0.

- REIMBURSEMENT FOR EMERGENCY REPAIRS

For all remaining sites at which emergency repairs were completed and for which reimbursement is being sought from FEMA or FHWA as shown in Table 7.1 following, the District advances the cost of the repairs and is reimbursed at a later date. Adjustments to Capital Program scheduling and funding transfers have allowed the District to allocate the funding needed for emergency repairs so that the cash flow impact on other District programs has been minimal.

Table 7.1 indicates that the total estimated cost of emergency repairs is \$2,763,876, with \$2,395,632 contributed by various agencies, and a cost of \$436,203 to Pima County. The \$2,395,632 contributed by various agencies includes 10% of the total agency contribution which will be paid by Pima County for FEMA projects.

- LONG-TERM IMPROVEMENTS

In several locations, new improvements will be constructed to mitigate future flood damage. This includes sites where little or no flood and erosion protection exists as well as sites where the existing level of protection will be increased. These are referred to as long-term improvements, to differentiate them from emergency repairs which restored the damaged sites to existing conditions. Table 7.2 lists the cost estimates for long-term improvements as of June 1993. As shown at the end of Table 7.2, the total estimated cost for long-term improvements is \$8,650,400; with \$2,513,600 contributed from SCS, \$ 2,219,344 from FHWA, and \$3,917,456 from PCDOT & FCD. Please note that these data are continually being updated as additional information becomes available.

- EMERGENCY ASSISTANCE AND LONG-TERM REPAIRS, FUNDING BREAKDOWN UNINCORPORATED PIMA COUNTY (EXCLUDES CITY OF TUCSON AND TOWN OF MARANA)

SPONSOR AGENCY	FEDERAL \$	STATE \$	LOCAL \$	SUBTOTAL
PIMA COUNTY (locally-funded projects)	-	-	1,641,000	1,641,000
FEMA 75% FEMA / 15% State / 10% local funding	807,000	161,000	107,000	1,075,000
FHWA 93% FHWA / 7% local funding for long- term impr. 100% FHWA funding for emergency repairs see note #1	3,641,000	-	349,000	3,990,000
SCS 80% SCS / 20% local funding see note #2	2,514,000	-	2,180,000	4,694,000
TOTALS	6,962,000	161,000	4,277,000	11,400,000

note #1: The dollar amounts shown include one long-term improvement project which will be funded by FHWA, ADOT, and PIMA COUNTY, where the split is 71% FHWA and ADOT / 29% Pima County

note #2: SCS contributes 80% of the construction costs only

- COMPARISON TO OCTOBER 1983 FLOOD

The total cost of the Flood Repair and Flood Hazard Mitigation Program developed in response to the October 1983 Flood was estimated at \$ 105.7 million in 1984 dollars, for emergency repairs and long-term improvements, including acquiring flood storage property and relocating residents. This included repairs and improvements to infrastructure along major watercourses within the City of Tucson and Town of Marana. By comparison, the repair and improvement costs resulting from the January 1993 Flood are estimated at \$ 13.9 million for unincorporated Pima County, the City of Tucson and Town of Marana.

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93)

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
1	Old Spanish Tr.	at Rincon		1	4	17-15-16	FHWA		35,000.00	35,000.00		0.00	Shoulder Work	N	
2	Camino Loma Alta	N. of Spanish Tr.		1	4	26/27-15-16	FEMA	51102	49,056.33	40,605.00	36,544.50	12,511.83	Crossing Destroyed	N	
3	Wilmot Rd.	Sahuarita	I-10	1	2	12-17-14	Local		2,007.37	0		2,007.37	Cleanup	Y	LOCAL
4	Dodge Blvd.	at Rillito Cr.		2EA	4	28-13-14	FHWA*		4,549.98	4,549.98		0.00	Major Cleanup	Y	5/13/93
5	Houghton Rd.	Tanque Verde	Speedway	2EB	1	35/36-13-15	FHWA		60,000.00	60,000.00		0.00	Bank Protection, Toe Exposed.	N	
6	Tanque Verde	East of Houghton		2EB	4	35/36-13-15	FHWA		45,371.00	45,371.00		0.00	Road and Shoulder wash out	Y	4/27/93
8	Wentworth	Tanque Verde Crk.		2EB	4	4/5-14-16	FEMA	50987	4,056.88	2,333.00	2,099.70	1,957.18	Crossing Washout	Y	4/13/93
9	Tanque Verde Loop	Tanque Verde Crk.		2EB	4	5/6-14-16	FHWA*		23,500.00	23,500.00		0.00	Crossing Washout	N	
10	Soldier Jr.	Agua Caliente		2EB	4	19/20-13-16	FHWA*		42,500.00	42,500.00		0.00	Crossing Washout	N	
11	Limberlost	Agua Caliente Wash		2EB	4	19/20-13-16	FEMA	50982	7,362.50	3,598.00	3,238.20	4,124.30	Crossing Washout	Y	4/13/93
11	Limberlost	Agua Caliente		2EB	4	19/20-13-16	FEMA	50983	6,989.75	6,720.00	6,048.00	941.75		Y	
12	Ft. Lowell	Agua Caliente		2EB	4	23/29/30-13-15/16	FHWA*		30,000.00	30,000.00		0.00	Damage to Bank Protection	N	
14	La Cholla	at C.D.O		2W	3	21/22-12-13	LOCAL		487.85	0.00		487.85	Dip Cleaning	Y	LOCAL
15	Overton	at C.D.O		2W	3	21/22-12-13	FHWA*		6,693.00	6,693.00		0.00	Dip Reconstruction	Y	4/27/93
16	Cmo. De La Tierra	Pegler Wash		2EA	3	8-13-13	FEMA	51118	6,007.00	6,007.00	5,406.30	600.70		Y	4/25/93
16	Cmo. De La Tierra	N. of Rillito River		2EA	3	8-13-13	FEMA	51120	18,308.00	9,768.00	8,791.20	9,516.80		Y	
16	Cmo. De La Tierra	at Rillito River		2EA	3	8-13-13	FEMA	51121	124,689.00	124,689.00	112,220.10	12,468.90		Y	
16	Cmo. De La Tierra	N. bank Pegler Wash	E. CDL Tierra	2EA	3	8-13-13	FEMA	51122	31,616.00	24,693.00	22,223.70	9,392.30		HOLD	
16	Cmo. De La Tierra	Pegler Wash		2EA	3	8-13-13	FEMA	51123	18,420.24	15,347.00	13,812.30	4,607.94		Y	4/25/93
19	Snyder Hill	San Joaquin	Sandario	3	3	34/35/36-14-11/12	FEMA	51115	6,282.30	6,282.00	5,653.80	628.50	Erosion/Cleaning	Y	

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
19	Snyder Hill	San Joaquin	Sandario	3	3	34/35/36-14-11/12	FEMA	51116	535.00	535.00	481.50	53.50		N	
20	Mt. Lemmon Hwy.	Catalina Hwy.			4	30/31-11-16	FHWA*		160,000.00	160,000.00		0.00	Various Location	N	
22	River Road	Hacienda del Sol	Swan	2EA	1	20-13-14	LOCAL		10,541.00	10,541.00		0.00		Y	4/27/93
25	Aguirre Rd.	in Marana		3	3	5/8/9/16/17-11-10	FEMA	51109	43,350.00	7,068.00	6,361.20	36,988.80	Cleanup Erosion	N	
26	Trico	at Santa Cruz		3	3	24-11-10	FHWA*		250,000.00	250,000.00		0.00	Re-channel	N	
27	Sanders (Marana)	at Santa Cruz		3	3	32/33-11-11	FHWA		5,500.00	5,500.00		0.00	Soil Cement	?	
28	Campbell	at Rillito River		2EA	1	19/20-13-14	FEMA	51124	22,195.73	22,195.73	19,976.16	2,219.57	Temporary Bank Protection	Y	4/5/93
32	Ina (Bridge)	at Santa Cruz		3	5	1/2-13-12	FHWA		12,686.00	12,686.00		0.00	Temporary Protection	Y	4/27/93
33	Trico /Marana Bridge	at Santa Cruz		3	3	24-11-10	FHWA		35,444.61	35,444.61		0.00	Temporary Protection	Y	5/10/93
35	Sunrise	at Ambrose		2EB	4		FHWA		5,858.41	5,858.41		0.00	CMP Replaced, Shoulder re	Y	5/10/93
36	Craycroft Bridge	at Rillito		2EA	4	25/26-13-14	FHWA		360,000.00	360,000.00		0.00	Engineering Review	N	4/27/93
37	Country Club(TRC)	Rillito	Adjacent to T.R.C.	2EA	1	20/21-13-14	local		1,295.03	0.00		1,295.03	Erosion	Y	LOCAL
38	Summer Haven	General Repairs			4	25/26/30/31-11-16	FEMA	56956	8,070.57	8,070.57	7,263.51	807.06		Y	
38	Summer Haven	Phoenix Avenue			4	25/26/30/31-11-16	FEMA	57692	365.00	365.00	328.50	36.50		N	
38	Summer Haven	Carter Canyon Rd.			4	25/26/30/31-11-16	FEMA	57693	3,521.00	3,521.00	3,168.90	352.10		N	
38	Summer Haven	E. Goat Hill Rd.			4	25/26/30/31-11-16	FEMA	57694	1,646.00	1,646.00	1,481.40	164.60		N	
38	Summer Haven	Retreat Rd.			4	25/26/30/31-11-16	FEMA	57695	6,897.00	6,897.00	6,207.30	689.70		N	
38	Summer Haven	Sabino Canyon Pkwy.			4	25/26/30/31-11-16	FEMA	57696	10,011.00	10,011.00	9,009.90	1,001.10		N	
38	Summer Haven	Florence & Tempe			4	25/26/30/31-11-16	FEMA	57697	398.00	398.00	358.20	39.80		N	

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
39	GENERAL PAVEMENT						LOCAL		37,190.63	0.00		37,190.63		Y	
40	Santa Cruz River	@ Mission Street					FEMA	507690	27,500.00	27,500.00	24,750.00	2,750.00		N	
41	DIRT ROAD REPAIRS						LOCAL		7,869.86	0.00		7,869.86		Y	
45	Reddington Rd	Edgar Wash		2EB	4	2/3-14-16	FEMA	51136	2,083.75	2,083.75	1,875.38	208.38	Dips Washout/Rail-Basket	Y	
45	Reddington Rd	1/2 m. SW Six Bar Ranch Road		2EB	4	2/3-14-16	FEMA	51137	1,247.00	1,247.00	1,122.30	124.70		Y	
45	Reddington Rd	Buehman Wash		2EB	4	2/3-14-16	FEMA	51138	1,141.13	1,141.13	1,027.02	114.11		N	
45	Reddington Rd	Bellota Ranch Road		2EB	4	2/3-14-16	FEMA	51139	555.00	555.00	499.50	55.50		Y	
45	Reddington Rd	Youtey Wash		2EB	4	2/3-14-16	FEMA	51140	312.40	313.00	281.70	30.70		Y	
45	Reddington Rd	1/4 m. E. of Forest Boundry		2EB	4	2/3-14-16	FEMA	51141	277.50	278.00	250.20	27.30		Y	
45	Reddington Rd	2 m. E. Bellota Road		2EB	4	2/3-14-16	FEMA	51142	833.75	350.00	315.00	518.75		Y	
46	Redfield Canyon Rd	E. of Benson Mammoth Hwy.		2EB	4		FEMA	51134	3,560.00	3,452.30	3,107.07	452.93	Roadway Washout	N	
46	Redfield Canyon Rd	at San Pedro River		2EB	4		FEMA	51135	2,000.00	760.40	684.36	1,315.64		Y	
46	Redfield Canyon Rd	Bridge Approach	Benson Highway	2EB	4		FEMA	51133	1,680.00	1,680.00	1,512.00	168.00		N	
48	San Pedro River Rd.	Pinal Co.	Reddington Rd	2EB	4		FEMA	51131	477.60	477.60	429.84	47.76	Dip Repair	Y	4/5/93
50	San Pedro River Rd. *	At Bridge		2EB	4		FEMA	51132	25,000.00	15,050.00	13,545.00	11,455.00	Rechannel River	N	
51	Tanque Verde	500' W. Wentworth		2EB	4	4/5-14-16	FEMA	50985	2,947.03	2,947.03	2,652.33	294.70	Shoulder Washout	Y	
52	Snyder Rd.	All	Harrison	2EB	4	15/22-13-15	FHWA*		7,500.00	7,500.00		0.00	Minor Repair/ Cleanup	N	
53	Sabino Cr.	at Webster		2EB	4	16-13-15	FEMA	50979	113,000.00	113,000.00	101,700.00	11,300.00	Bank Protection/Soil Cement	N	HOLD
54	SUBDIVISION ROADS						LOCAL		5,546.13	0.00		5,546.13		Y	LOCAL
55	Wolford	S. of Snyder		2EB	4	14/23-13-15	Local		140.50	0.00		140.50	Dips Washout	Y	LOCAL

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
56	Harrison	at Prospect/Snyder		2EB	4	22/23-13-15	FHWA		6,500.00	6,500.00		0.00	Rip-Rap Exp./ Toe repair	Y	
59	Calle Primula/Tabosa	Ocotillo	Snyder	2EB	4	15-13-15	Local		4,142.63	0.00		4,142.63	Shoulder Erosion	Y	LOCAL
60	Colina	N. of Snyder		2EB	4	13/24-13-15	Local		643.25	0.00		643.25	Dip Washout	Y	LOCAL
62	Thunderbird	W. of Soldier Tr.		2EB	4	19/20-13-16	FEMA	50996	411.40	411.40	370.26	41.14	Dirt Road Washout	Y	4/5/93
63	Summer Tr.	W. of Soldier Tr.		2EB	4	19/20-13-16	FEMA	50997	326.40	282.00	253.80	72.60	Dirt Road Washout	Y	4/5/93
64	Calle de Samuel	W. of Soldeir Tr.		2EB	4	19/20-13-16	FEMA	50998	1,417.50	1,233.00	1,109.70	307.80	2 Dips Washout	Y	
64	Calle de Samuel	W. of Soldeir Tr.		2EB	4		FEMA	50999	1,806.88	1,421.00	1,278.90	527.98		Y	
65	Sneller Vist Dr.	S. of Samuel		2EB	4	19-13-16	FEMA	51000	1,741.50	1,188.45	1,069.61	671.90	Dip Washout	Y	
68	Mona Lisa'	Carmac Wash		2W	1	33-12-13	FEMA	50974	6,000.00	948.00	853.20	5,146.80	Bank Protection	N	
69	Tangerine Rd.	E. of Tortila		2W	3	(31-36)-11-12	Local		6,187.43	0.00		6,187.43	Road Washout	Y	LOCAL
71	Sahuarita Rd.	at Santa Cruz		4	3	12/13-17-13	FHWA*		21,620.00	21,620.00		0.00	Temporary Repairs	N	4/27/93
72	Tres Bellotas	Arivaca Cr.	Ruby Rd.	4	3	28/29-21-10	FEMA	51144	8,022.60	8,022.60	7,220.34	802.26	Road Washout	Y	4/5/93
73	Elephant Head Rd.	at Santa Cruz		4	4	29-19-13	FHWA*		18,131.86	18,131.86		0.00	Temp. Bank Protection	Y	4/27/93
74	Arivaca Sasbee Rd.	Mile post 4.3,4.5		4	3	18/19/20/28-21-10	FHWA		42,000.00	42,000.00		0.00	Box Culvert	N	
75	Sutton Lane	Finger Rock Wash		2EA	1	21/28-13-14	FEMA	51125	4,733.73	3,664.00	3,297.60	1,436.13	Dip Sections Damage	Y	
75	Roger Rd.	Finger Rock Wash		2EA	1		FEMA	51126	651.00	651.00	585.90	65.10	Shoulder Work	Y	4/25/93
76	Alvernon Wash	N of Kleindlale		2EA	1	27-13-14	FEMA	50978	45,892.00	45,892.00	41,302.80	4,589.20	Bank Erosion/Soil Cement	N	HOLD
78	St. Gregory	at Rillito		2EA	1	26-13-14	Local		88,372.53	0.00		88,372.53	Bank protection	Y	LOCAL
79	4020 Alvernon			2EA	1	33-14-14	FEMA	51127	8,343.24	1,143.00	1,028.70	7,314.54	Dip Washout	Y	4/13/93
80	Cmo. De la Bajada	E. of Alvernon		2EA	1	22-13-14	FEMA	51128	10,292.75	10,292.75	9,263.48	1,029.28	Roadway Repair	Y	4/5/93

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
81	Alvermon Way	N. of Llanosa		2EA	1	22-13-14	FEMA	51129	4,940.88	1,142.00	1,027.80	3,913.08	Roadway Repair	Y	4/5/93
82	Happy Valley Rd.	Cochise Co	End	1	4	QM-QQ 257	FEMA	51101	74,153.00	74,153.00	66,737.70	7,415.30	Road Washout	N	
84	Neal Ave	North of Bopp	Claude	3	3	30-14-12	FEMA	51114	4,084.00	2,327.00	2,094.30	1,989.70	Road and Shoulder Erosion	N	
88	Pump Station	Silverbell	Avra Valley	3	3		FEMA	51146	14,250.00	2,800.00	2,520.00	11,730.00	Road and Shoulder Erosion	N	
88	Pump Station	Silverbell	Avra Valley	3	3		FEMA	51147	3,846.15	3,846.00	3,461.40	384.75		Y	
89	Twin Peak			3	3	16/17/19/20-12-11/12	FEMA	51148	2,473.68	2,473.68	2,226.31	247.37	Roadway Damage	Y	4/5/93
91	Avra Valley	E of Bridge	Frontage	3	3	8-12-12	FHWA		281,000.00	281,000.00		0.00	Erosion	N	4/27/93
92	Cortaro Bridge	at Santa Cruz		3	3	26-12-12	FHWA(M ARANA)		41,090.19	41,090.19		0.00	Bank Protection	Y	5/10/93
93	TRUCKING						LOCAL		98,868.33	0.00		98,868.33		Y	
94	Ironwood Hill	West of Silverbell		3	5	33-13-13	FHWA*		10,558.95	10,558.95		0.00	Crossing Damage	N	
102	DEBRIS REMOVAL						LOCAL		200,000.00	200,000.00		0.00		N	
105	Flagstaff	Vantana Wash		2EB	4		FEMA	51143	3,000.00	753.00	677.70	2,322.30	Bank Erosion	N	
106	Homestead	1500' s. of Snyder		2EB	4		FEMA	50992	3,000.00	2,160.00	1,944.00	1,056.00	Rip-Rap Washout	N	
107	Como Dr.	N. of Moore		2W	3	28-11-13	FEMA	51105	1,092.00	1,092.00	982.80	109.20	Dip Sections Washout	Y	
108	Alley Fill	Red Wolfe		2W	3	24-12-12	FEMA	51107	2,912.25	2,810.00	2,529.00	383.25	Erosion	Y	4/5/93
110	Cole Road, Ajo			5	3		FEMA	57301	23,551.99	23,551.99	21,196.79	2,355.20		N	
111	Mead Road, Ajo			5	3		FEMA	57302	15,744.33	15,744.33	14,169.90	1,574.43		N	
							TOTAL		2,763,876.28	2,395,631.71	611,628.04	436,203.24			

TABLE 7.1 - JANUARY 1993 FLOOD, EMERGENCY REPAIR SITES (5/20/93) - CONTINUED

SITE NO (1)	ROAD (2)	FROM (3)	TO (4)	MAINT DIST (5)	BOS DIST (6)	LOCATION (S-T-R) (7)	FUNDING SOURCE (8)	FEMA DSR # (9)	ESTIMATED COST (10)	AGENCY CONTRIBUTION (11)	FEMA @ 90 % CONTRIBUTION (12)	PIMA COUNTY COST (13)	DAMAGE DESCRIPTION (14)	WORK COMPLETED ? (15)	DATE SUBMITTED (16)
NOTES:															
1	THE NUMBERS FOR THE LOCATIONS ARE CONTROL NUMBERS. THEREFORE SOME NUMBERS DO NOT HAVE LOCATIONS ASSIGNED.														
2	ESTIMATED COST (COLUMN 10) IS THE TOTAL ESTIMATE FOR COMPLETION OF REPAIRS AT EACH SITE. THIS ESTIMATE COMES FROM ENGINEERING, FIELD SUPERVISORS AND FEMA INSPECTORS. WHEN COMPLETED, COLUMN REFLECTS ACTUAL COST.														
3	AGENCY CONTRIBUTION (COLUMN 11) IS THE TOTAL EXPECTED REIMBURSEMENT OF COSTS FROM ANY SOURCE INCLUDING FEMA, FHWA, SCS, COE AND OTHER AGENCIES. THE FEMA AMOUNT IS THE TOTAL DSR ESTIMATE.														
4	FEMA CONTRIBUTION @ 90 % (COLUMN 12) IS THE EXPECTED REIMBURSEMENT FROM FEMA BASED ON 90 % OF THE DSR ESTIMATE. THE FUNDS ARE PAID AT 75 % BY FEMA UPON COMPLETION OF REPAIRS AND 15% PAID BY THE STATE UPON INSPECTION AND AUDIT OF RECORDS.														
5	PIMA COUNTY COST (COLUMN 13) IS THE ESTIMATED EXPENSE TO PIMA COUNTY FOR EACH LOCATION, BASED ON ESTIMATED COST AND THE EXPECTED REIMBURSEMENT FROM OUTSIDE AGENCIES. THIS COST INCLUDES THE COUNTY'S 10% SHARE OF THE DSR REPAIRS.														
6	SITES WITH FHWA* IN THE AGENCY COLUMN ARE SITES THAT ARE BEING SUBMITTED TO FHWA BUT ALSO HAVE BEEN ASSIGNED DSR NUMBERS.														
7	AMOUNT BILLED/REIMBURSEMENT COLUMN IS THE AMOUNT BILLED FOR REIMBURSEMENT TO FEMA AND FHWA. THE FEMA AMOUNT IS FIGURED AT 90 % OF THE DSR ESTIMATE, REGARDLESS OF THE ACTUAL COST OF REPAIRS. SOME OF THE FHWA SITES ARE ONLY PARTIAL BILLINGS AT THIS TIME. SITE LABELED NA ARE PIMA COUNTY PROJECTS, NOT SUBJECT TO REIMBURSEMENT.														

TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Elephant Head Road at Santa Cruz River Repair bank prot.					Received project approval from FHWA for long-term solution, including soil cement bank protection along the west bank; emergency repairs were also approved for reimbursement.
Design	60,000		55,620	4,380	
Right-of-Way					
Construction	745,000		690,615	54,385	
Field Inspection	75,000		69,525	5475	
TOTAL	880,000	FHWA	815,760	64,240	
Ina Road at Santa Cruz River Bank protection					Approval to proceed with the engineering design for a long-term solution has been received from FHWA. Plans are completed, however additional information is required prior to receiving ADOT/FHWA approval for the plans.
(west bank)					
Design	30,000		27,810	2,190	
Right-of-Way					
Construction	320,000	FHWA	296,640	23,360	
Field Inspection	50,000		46,350	3,650	
TOTAL	400,000		370,800	29,200	
(drop structure)					
Design	36,500		26,043	10,457	
Right-of-Way	40,000	FHWA	28,540	11,460	
Construction	580,000	&	413,830	166,170	
Field Inspection	98,500	ADOT	70,280	28,220	
TOTAL	755,000		538,693	216,307	

TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Trico-Marana Road at Santa Cruz River					Emergency repairs completed. Long-term solution awaiting approval by FHWA.
Bank protection, SW abutment					
Design	50,000		46,350	3,650	
Right-of-Way	10,000		9,270	730	
Construction	393,000		364,311	28,689	
Field Inspection	80,000		74,160	5,840	
TOTAL	533,000	FHWA	494,091	38,909	
Trico Road at Santa Cruz River					Emergency repairs completed. Long-term repairs were not approved by FHWA.
channel clean-up					
Design	111,080			111,080	
Right-of-Way					
Construction	1,110,800			1,110,900	
Field Inspection	166,620			166,620	
TOTAL	1,388,500			1,388,500	

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TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Rillito Creek at St. Gregory's bank protection					This location has been approved by SCS as a non-exigency project. Local sponsor funding source is yet to be identified. Design concept submitted to SCS for approval.
Design	70,000			70,000	
Right-of-Way	20,000			20,000	
Construction	432,000		345,600	86,400	
Field Inspection	65,000			65,000	
TOTAL	587,000	SCS	345,600	241,400	
Rillito Creek at Country Club Road bend bank protection					This project was added to Granite's contract for the Rillito, from Campbell Avenue to Country Club Road (with SCS concurrence).
Design	60,000			60,000	
Right-of-Way	20,000			20,000	
Construction	580,000			180,000	
Field Inspection	75,000			75,000	
TOTAL	735,000	SCS	400,000	335,000	

TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Rillito Creek at U of A Cooperative Ext. Bldg. bank protection					Project awarded to Granite, with SCS concurrence. Construction has started.
Design	50,000			50,000	
Right-of-Way					
Construction	603,900		488,000*	115,900	* \$520,000 available if all work eligible
Field Inspection	108,000			108,000	
TOTAL	761,900	SCS	488,000	273,900	
Rillito Creek at Pegler Wash					Project awarded to Ashton, with SCS concurrence. Construction to begin at end of June or early July.
Design	100,000			100,000	
Right-of-Way					
Construction	1,800,000		960,000	840,000	
Field Inspection	180,000			180,000	
TOTAL	2,080,000	SCS	960,000	1,120,000	

TABLE 7.2 - LONG-TERM IMPROVEMENT COST ESTIMATES

June 1993

Project Name	Estimated Cost	Funding Source	Agency Contribution	PC Cost	Comments
Tanque Verde Creek at Tucson Country Club Estates					Board approved agreement with SCS. RS Engineering has submitted a proposal to design the project. Contract must be awarded by 8-30-93.
Design	50,000			50,000	
Right-of-Way	20,000			20,000	
Construction	400,000		320,000	80,000	
Field Inspection	60,000			60,000	
TOTAL	530,000	SCS	320,000	210,000	

TOTALS

SCS	\$ 2,513,600
FHWA	\$ 2,219,344
PCDOT & FCD	\$ 3,917,456
SUM TOTAL	\$ 8,650,400