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STORM DRAINAGE AND FLOOD CONTROL STUDY SOUTHEASTERN MARICOPA COUNTY STATE OF ARIZONA

PREPARED FOR
MARICOPA COUNTY

BY
BOYLE ENGINEERING CORPORATION
AND
L. H. BELL AND ASSOCIATES
A JOINT VENTURE

BOYLE ENGINEERING CORPORATION AND L. H. BELL AND ASSOCIATES

A JOINT VENTURE

June 1973

Maricopa County
Board of Supervisors
111 S. Third Avenue
Phoenix, AZ

Gentlemen:

Presented herewith is the report on Storm Drainage and Flood Control Study for Southeast Maricopa County, which we have prepared in accordance with your authorization.

The report sets forth a general plan of flood protection improvements that will provide for the orderly urban development within the area. The proposed plan of improvements is based on anticipated development to the year 2000 and includes preliminary estimates of project costs for facilities to contain the estimated 100-year return period flood flows in accordance with standard requirements for projects designed and installed with federal assistance.

Existing and planned federally assisted projects for the area have been incorporated into the plan and a hydrologic analysis of the unprotected area was made in accordance with Soil Conservation Service criteria for Public Law 566 watershed projects for the area.

Planning and recommendations for installation of interim structural measures with smaller capacities is presented that would provide a more expedient alternative of protection against the more frequently occurring floods.

We have been pleased to perform this service for you and trust that it will provide the impetus necessary to effect the coordinated installation of facilities to protect this area.

Respectfully submitted,

Dennis Hustead

Registered Professional Engineer (Civil) CERTIFICATE NO. 8566 DENNIS HUSTEAD Date Signed 6/26/73 ARIZONA, U.S.A.

Dennis Hustead P. E.
Boyle Engineering Corp.

L. H. Bell P. E.
L. H. Bell and Associates

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STORM DRAINAGE AND FLOOD CONTROL STUDY
SOUTHEASTERN MARICOPA COUNTY

INTRODUCTION

This storm drainage and flood control study of southeastern Maricopa County has been prepared to bring into focus the problems related to storm runoff and the needs for measures to control this runoff under conditions of present development and in anticipation of projected future development in this area.

There have been a number of previous studies and investigations related to the control of storm runoff in this area. The Flood Control District of Maricopa County has sponsored the development of projects by federal agencies and has made overall studies of the area's problems and recommended solutions.

There has been considerable progress toward the solution of the major problems in the area. Federally assisted projects have been installed and other projects have been approved for construction and could be installed within the next several years which would provide protection to the major developed areas from potentially disastrous floods.

It is the objective of the present study to evaluate previous studies, make additional investigations and recommend a program for the solution of the storm runoff problems in this area.

The development of concepts for additional projects within the study area is based generally upon available information. The intensity of planning has been limited to that required to determine the engineering feasibility of the concepts and to determine approximate dimensions of the costs for alternatives that would provide solutions to the storm runoff problems. A hydrologic analysis was made for the area west of the Roosevelt Water Conservation District Canal in accordance with procedures and criteria used by the Soil Conservation Service in formulating their Public Law 566 watershed projects in the area.

These additional projects have been formulated to include structural measures with capacities to contain the estimated 100-year return period peak flood flows. These capacities are intended to approximate those that would be provided in flood control projects designed and installed with federal agency assistance. Structural measures with smaller capacities may be installed to provide protection against the more frequently occurring floods as an interim measure or as a necessary expedient.

DESCRIPTION OF THE STUDY AREA

The study area generally includes the drainage area bounded on the east by the Superstition Mountains; on the north by the Salt River drainage area boundary; on the west by the extent of the area draining into the Gila Drain; and on the south by Queen Creek and the Gila River.

The major portion of the area is in agricultural use and even though urban development is rapidly expanding much of the area will remain in agriculture for the foreseeable future.

The principal cities and towns in the area are Mesa, Chandler and Gilbert with Tempe progressively expanding into the area.

Irrigation water supply for agriculture is provided by the Salt River Project, the Roosevelt Water Conservation District, the Queen Creek Irrigation District and the Chandler Heights Citrus Irrigation District. The Salt River Project provides the major source of irrigation water supply within the area, including all irrigated agricultural lands to the west and to Eastern canal on the east. Other major Salt River Project canals in the area are the Consolidated Canal located west of the Eastern Canal, Tempe Canal which is the dividing line between the cities of Tempe and Mesa, and Western Canal which runs in an east-west direction from the Consolidated Canal through the north edge of Gilbert to discharge into the Gila Drain.

The Roosevelt Water Conservation District Canal is located east of the Eastern Canal and provides irrigation water supply to an area east of that served by the Salt River Project.

The Queen Creek Irrigation District is comprised of lands located adjacent to Queen Creek above the Consolidated and Eastern Canals. The Chandler Heights Citrus Irrigation District provides irrigation water supply to the area in the vicinity of Chandler Heights. Both of these irrigation districts obtain their water supply from wells.

The total drainage area above the Roosevelt Water Conservation District Canal and the considered floodway through the Gila Indian Reservation, including the Queen Creek drainage area, is 759 square miles. The additonal drainage area below the Roosevelt Water Conservation District canal, which drains into the Gila Drain on the west side of the study area, is 244 square miles.

The estimated present population in southeastern Maricopa County, including the City of Tempe, is in excess of 200,000. It is projected that the population in this area will increase to about 600,000 by the year 1990. The cities of Tempe and Mesa have populations of 85,000 and 80,250, respectively, at the present time.

The storm drainage and flood problems in this area have become progressively more serious as urban development has expanded. This is due to the reduced infiltration rates that result from urban development as compared to agricultural use of the land and the concentrations of runoff into larger channelized flows, which increase the potential for damages. Such development as the Superstition Freeway which requires concentrations of storm runoff for freeway crossings typify this problem.

During the period 1910 through 1971 a total of 38 floods have been reported. Many of these storms, which caused relatively minor damages in the past under conditions of agricultural land use, would cause much greater damages under present conditions of urban development, because of the larger amounts of runoff that would occur and the greater damage potential. This condition will become progressively more serious as urban development continues to expand.

The runoff from the drainage areas above the irrigation water supply canals is intercepted by these canals. When the intercepted runoff exceeds the limited capacities of these canals, they are breached and the large flows cause damages to the lower lands and cause breaching of the lower canals. Surface runoff into the canals also causes large maintenance costs to remove debris accumulation.

The most vulnerable of these canals is the Roosevelt Water Conservation District Canal which has the largest drainage area above it. In order to protect the canal from damages caused by runoff, the District has constructed an interception floodway above the canal which they have enlarged progressively over the years. At the present time the floodway does not have adequate capacity to contain a major flood and there is no controlled outlet for the accumulated flows.

The Eastern and Consolidated canals have similar problems to those of the Roosevelt Water Conservation District canal, even though the drainage areas above them are smaller. They have some intercepting floodway capacities above them which are inadequate for major floods and there are no controlled outlets for this intercepted runoff. In the event that the Roosevelt Water Conservation District Canal was breached, the Eastern and Consolidated Canals would be severely damaged by the released flow.

PROJECTS PLANNED FOR INSTALLATION

The Soil Conservation Service has prepared three watershed work plans under provisions of Public Law 566, as amended, to control the flood flows from the east to the Roosevelt Water Conservation District Canal. These work plans include floodwater retarding structures, diversion structures and floodways to provide protection against the 100-year return period flood. All of these work plans have been approved for construction and are currently being amended to provide additional capacities in a floodway adjacent to and above the Roosevelt Water Conservation District Canal and to provide an outlet for the floodway through the Gila Indian Reservation to the Gila River.

The floodwater retarding and diversion structures are generally located immediately above the alignment for the Central Arizona Project Canal anticipated to be installed within the next 10 years. These measures will provide protection to this canal from flood and debris damages.

Some of the structural measures included in these work plans have been installed and the remaining measures may be installed when provisions are made to meet other costs than those that are funded under provisions of Public Law 566 and as Public Law 566 funds are available.

These structural measures are included in the following Public Law 566 watershed projects:

Buckhorn-Mesa Watershed Project. This project includes floodwater retarding structures, a diversion and floodways as tabulated on Table I. These measures will provide for the diversion and retarding of flood flows above the Central Arizona Project Canal alignment from ~~the~~ McDowell Road to Apache Trail. The present plan provides for the diversion of the controlled flows into the Salt River. It is anticipated that the plan will be revised to divert these flows into Orme Reservoir, which will be constructed as an element of the Central Arizona Project. The work plan may also include an extension of the Roosevelt Water Conservation District

TABLE I
ESTIMATED INSTALLATION COSTS
BUCKHORN - MESA P. L. 566 PROJECT

PROJECT MEASURES	PROJECT COSTS - (DOLLARS) TOTAL		MEASURES INSTALLED		REMAINING	
	P. L. 566	OTHER	P. L. 566	OTHER	P. L. 566	OTHER
Floodwater Retarding Structures:						
Spook Hill	974,400[1/]	1,759,500[2/]			974,400[1/]	1,759,500[2/]
Signal Butte	486,000[3/]	148,000[4/]			486,000[3/]	148,000[4/]
Apache Junction	474,200[3/]	156,800[5/]			474,200[3/]	156,800[5/]
Pass Mountain	245,000[3/]	0 [6/]			245,000[3/]	0 [6/]
Bulldog Diversion	124,800[3/]	36,800[7/]			124,800[3/]	36,800[7/]
Floodways:						
Spook Hill	723,200[1/]	168,300[8/]			723,200[1/]	168,300[8]
Signal Butte	513,600[3/]	142,500[9/]			513,600[3/]	142,500[9]
Apache Junction	326,000[3/]	3,500[10/]			326,000[3/]	3,500[10/]
Pass Mountain	148,200[3/]	9,600[11/]			148,200[3/]	9,600[11/]
RWCD-Hwy. to Brown Rd. [13/]	150,000	750,000[12/]			150,000	750,000[12/]
	4,165,400	3,175,000			4,165,400	3,175,000

1/ 1963 Prices x 1.2 (inf. factor)

2/ 1963 Prices x 1.5 (inf. factor): 3 bridges - $45,000 (total); relocate transmission line - $7,500; serverance - $15,000; 449 ac. land @ $3,750 - $1,683,000; and admin. contracts - $9,000.

3/ 1963 Prices x 1.2 (inf. factor) - Revised plan and costs.

4/ 185 acres state land @$800 per acre (assumed); no road crossings or utility relocations.

5/ 196 acres state land @ $800 per acre (assumed); no road crossings or utility relocations.

6/ 70 acres land in Usury Park required; no road crossings or utility relocations.

7/ 46 acres state land @$800 per acre (assumed); no road crossings or utility relocations.

8/ 1963 prices x 1.5 (inf. factor): 1 bridge - $21,000; 41 ac. land @ $3,400 - $139,500; R/W for debris basin 7.9 ac. - $600 (total) and admin. of contracts - $7,200.

9/ 1963 prices x 1.5 (inf. factor): 2 bridges - $33,750; 29 acres land @ $3,750 - $108,750.

10/ Wilson road crossing - $2,100; 3 ac. state land @ $2,400 (assumed).

11/ Road crossing - $2,100; 2 ac. state land @ $800 - $1,600; and 2 ac. private land - @ $2,950 - $5,900.

12/ Land for R/W - $150,000; and two bridges - $600,000.

13/ It is anticipated that a supplemental work plan will be prepared which will extend the RWCD Floodway from Hwy. 80 to Brown Road and to relocate three of the floodwater retarding structures onto State and Federal lands. The Bureau of Reclamation has made a tentative commitment to participate in the purchase of rights-of-way to the extent that the project benefits the Central Arizona Project.

floodway from Apache Trail to Brown Road. The estimated installation costs as shown on Table I include the costs for extending the floodway. None of these measures have been installed.

Apache Junction-Gilbert Watershed Project. This project provides for the control of flood flows above the Central Arizona Project Canal alignment from Baseline Road to Ray Road. It includes a floodwater retarding structure and a floodway to discharge the controlled flows from this structure and the floodwater retarding structures included in the Williams-Chandler Watershed Project to the Roosevelt Water Conservation District floodway. It also includes the enlargement of the existing Roosevelt Water Conservation District floodway to provide capacities for the estimated 100-year return period flood from Apache Trail to Ray Road.

The floodwater retarding structure and the floodway from this structure to the Roosevelt Water Conservation District floodway have been installed. The enlargement of the Roosevelt Water Conservation District floodway remains to be done. Table 2 shows the costs of the structural measures that have been installed and the estimated costs to enlarge the Roosevelt Water Conservation District floodway.

Williams-Chandler Watershed Project. This project provides for the control of flood flows above the Central Arizona Project Canal alignment from Ray Road to the boundary of the drainage area into Queen Creek. It includes two floodwater retarding structures which discharge their controlled flood flows through the floodway included in the Apache Junction-Gilbert Watershed Project to the Roosevelt Water Conservation District floodway. It also includes the enlargement of the existing Roosevelt Water Conservation District floodway to contain the estimated 100-year

TABLE 2

ESTIMATED INSTALLATION COSTS
APACHE JUNCTION - GILBERT P. L. 566 PROJECT

	PROJECT COSTS - (DOLLARS)					
	TOTAL		MEASURES INSTALLED		REMAINING	
PROJECT MEASURES	P. L. 566	OTHER	P. L. 566	OTHER	P. L. 566	OTHER
Powerline FWR Structure	1,498,000	31,210	1,498,000	31,210 1/		
Diversion Structure & Floodway (Actual value of donated state land)				(798,000)		
Floodways:						
RWCD - Apache Trail to Ray Road	500,000	1,400,000 2/			500,000	1,400,000
	1,998,000	1,431,210	1,498,000	31,210	500,000	1,400,000

1/ Actual Costs Incurred

2/ 7 bridges @ $100,000 = $700,000; 233 acres land @ $3,000 = $700,000.

return period flood flows from Ray Road to the junction with Queen Creek. The work plan for this project is being amended to provide an outlet for the Roosevelt Water Conservation District floodway from the junction with Queen Creek through the Gila Indian Reservation to the Gila River.

The floodwater retarding reservoirs have been installed. The enlargement of the Roosevelt Water Conservation District floodway remains to be done. Table 3 shows the costs of the structural measures that have been installed and the estimated cost to enlarge the Roosevelt Water Conservation District floodway and provide an outlet to the Gila River.

The corps of Engineers has planned and installed Whitlow Dam and Reservoir on Queen Creek above its junction with Whitlow Canyon. This reservoir controls the flood flows from the major portion of the Queen Creek watershed.

An application for assistance under provisions of Public Law 566 was made to the Soil Conservation Service for a watershed project to provide additional control of floods from the Queen Creek watershed and the drainage area west of the Roosevelt Water Conservation District Canal that flows into the Gila Drain, and passes through the Gila Indian Reservation to the Gila River on the southwest side of the study area. The application was approved in November 1970 for planning to include the Queen Creek watershed only. Planning of the area for which the runoff discharges through the Gila Drain has been delayed because some projections of the land use for a major portion of this area indicate a change from agricultural use to urban use in the relatively near future. This would require a higher degree of protection than normally provided for agricultural land use and a major portion of the benefits would be based on this projected urban development. Public Law 566

TABLE 3

ESTIMATED INSTALLATION COSTS
WILLIAMS - CHANDLER P. L. 566 PROJECT

PROJECT COSTS - (DOLLARS)

PROJECT MEASURES	TOTAL		MEASURES INSTALLED		REMAINING	
	P. L. 566	OTHER	P. L. 566	OTHER	P. L. 566	OTHER
Floodwater Retarding Structures:						
Rittenhouse - Vineyard Road	1,130,000	522,330 1/	1,130,000	62,330 1/		460,000 1/
Floodway:						
Roosevelt WCD 3/	3,000,000	2,860,000 2/			3,000,000	2,860,000 2/
	4,130,000	3,382,330	1,130,000	62,330	3,000,000	3,320,000

1/ Actual costs to obtain government land - $62,330; Hwy. Bridge - $460,000 (budgeted but not spent.) Actual value of land estimated at $2,040,000 (also shown at a reduced value of $1,040,000).

2/ 300 acres private lands @ $3,000 - $900,000; 2 bridges in Indian Reservation - $460,000; and 6 bridges outside Indian Reservation @ $250,000 - $1,500,000. Value of donated right-of-way in Indian Reservation - $600,000 (not included in total).

3/ Includes extension of RWCD Floodway through Indian Reservation. A Supplemental Work Plan is now being prepared to include this extension.

projects normally provide primarily agricultural benefits. Protection for large urban areas are primarily the responsibility of the Corps of Engineers.

The Soil Conservation Service is currently preparing a watershed work plan for the Lower Queen Creek portion of this application. This project will include a floodwater retarding reservoir with outlet works. Table 4 shows the very preliminary estimated costs for these structural measures.

With the installation of all of the structural measures included in the three Public Law 566 projects approved for construction, as supplemented and amended, and the measures anticipated to be included in the Lower Queen Creek Project, major flooding will be controlled from the entire area east of the Roosevelt Water Conservation District Canal and these flows will be provided with an outlet into the Gila River.

The Soil Conservation Service has prepared a watershed work plan under provisions of Public Law 566 for the Guadalupe watershed on the west side of the study area and immediately west of the community of Guadalupe and Interstate Highway I-10. It has been approved for construction and procurement of rights-of-way is in process. This is a small watershed with a total drainage area of about 7.2 square miles. This project includes a floodwater retarding structure, a diversion structure and a pipeline to remove water from the floodwater retarding structure at a rate compatible with capacity limitations of the Western Canal. These measures will control the runoff from 1.87 square miles of watershed and their installation will provide flood protection to the community of Guadalupe and Interstate Highway I-10. Table 5 shows the estimated installation costs for these structural measures.

TABLE 4

ESTIMATED INSTALLATION COSTS (Reconnaissance only)
LOWER QUEEN CREEK P. L. 566 PROJECT (Application approved for planning)

PROJECT MEASURES	TOTAL P. L. 566	TOTAL OTHER	PROJECT COSTS - (DOLLARS)[1/] MEASURES INSTALLED P. L. 566	MEASURES INSTALLED OTHER	REMAINING P. L. 566	REMAINING OTHER
Lower Queen Creek Floodwater Retarding Reservoir	1,600,000	500,000[2/]			1,600,000	500,000[2/]
Reservoir Outlet	750,000	300,000[3/]			750,000	300,000[3/]
Total - Lower Queen Creek Project	2,350,000	800,000			2,350,000	800,000

1/ Very preliminary cost estimates.
2/ Land for right-of-way only.
3/ Land for right-of-way $250,000 (including land for groundwater recharge); and bridges - $50,000.

TABLE 5

ESTIMATED INSTALLATION COSTS
GUADALUPE P. L. 566 WATERSHED PROJECT

PROJECT MEASURES	TOTAL P. L. 566	TOTAL OTHER	MEASURES INSTALLED P. L. 566	MEASURES INSTALLED OTHER	REMAINING P. L. 566	REMAINING OTHER
	PROJECT COSTS - (DOLLARS)					
Floodwater Retarding Structure	186,940	266,160 [2]			186,940	266,160 [2]
Diversion Structure	20,390	58,010 [3]			20,390	58,010 [3]
Pipeline	94,390	15,260 [4]			94,390	15,260 [4]
Project Admin.	27,690	4,380 [5]			27,690	4,380 [5]
	329,410	343,810 [6]			329,410	343,810 [6]

1/ As shown in Watershed Work Plan 1970 prices.
2/ Lands for R/W - $181,500; relocation of two natural gas lines - $84,000; power pole relocation - $600; and clothes line relocation - $60.
3/ Lands for R/W - $26,650; Guadalupe Road tunnel conduit - $30,460; lower AT&T cable - $780; and utility company inspectors - $120.
4/ Lands for R/W - $14,780; utility company inspectors - $250; Baseline Road pavement repair - $230.
5/ Includes $1,610 for State of Arizona dam filing fees.
6/ Includes funds budgeted by Arizona Highway Department for right-of-way acquisition.

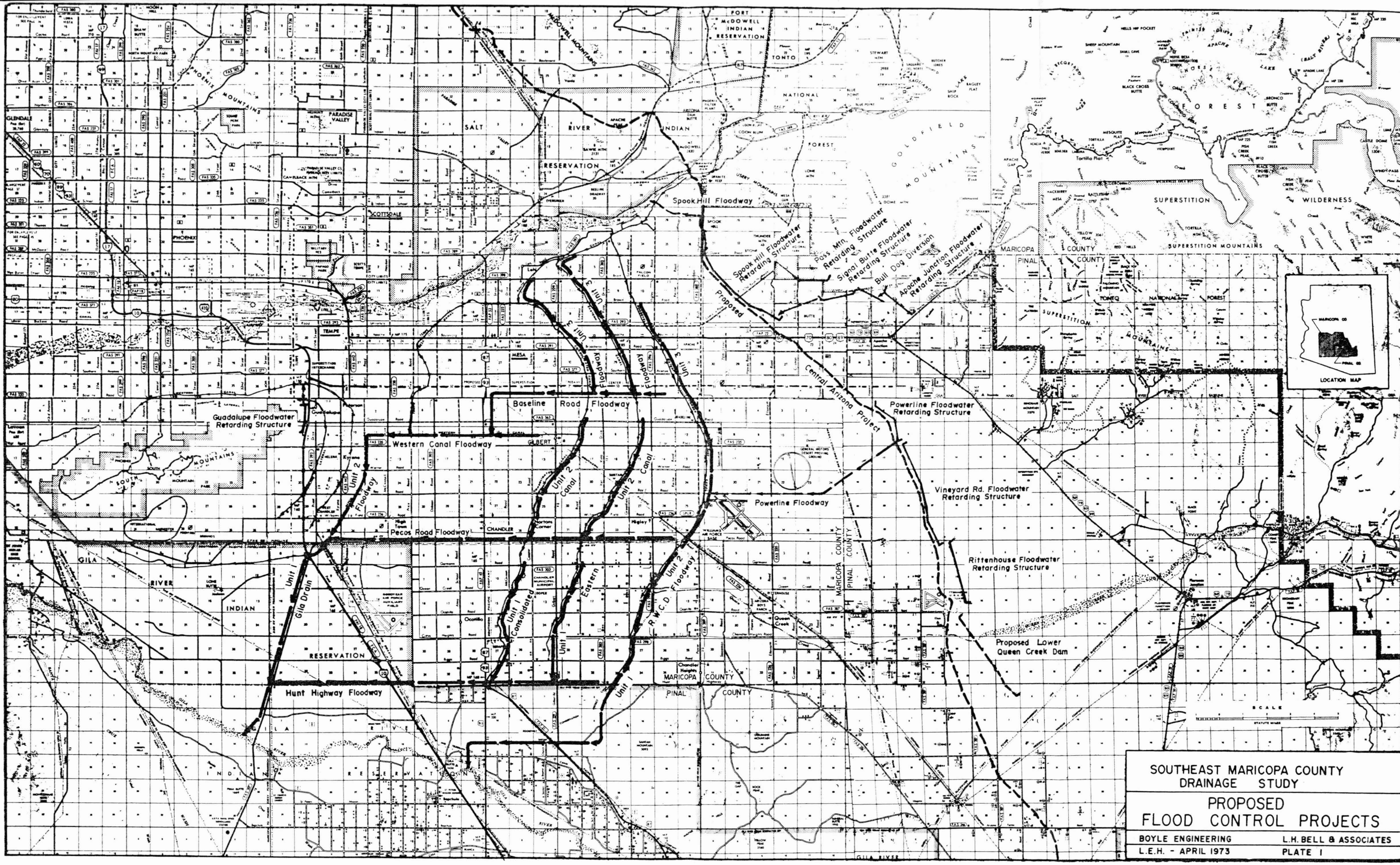
ADDITIONAL PROJECTS REQUIRED IN THE STUDY AREA

The installation of all of the Public Law 566 projects approved for construction, as amended and supplemented, and the measures anticipated for inclusion in the Lower Queen Creek Project will provide protection from the 100-year return period flood flows originating in the area east of the Roosevelt Water Conservation District Canal. The Guadalupe watershed project will provide protection to the community of Guadalupe and Interstate Highway I-10 but will have small effect on the remaining flood problems in the study area.

The area between the Roosevelt Water Conservation District Canal and the western boundary of the drainage area into the Gila Drain includes about 244 square miles. There is no coordinated collector system or outlet channels for the progressively increasing runoff from this area. As urban development expands further, flood problems will become acute without the provision of major outlet channels. The runoff from the areas above the Eastern and Consolidated Canals will exceed the limited capacities of the canals causing breaching of the canals and consequent damages from the released flows. The enlargement of floodways above the canals without an outlet to the Gila River will only transfer the flood problem to the lower areas where the larger accumulated flows are released.

Plate I illustrates a project concept of collector systems and major channels to control the flood flows generated in this area. It includes the development of an outlet channel to the Gila River into which the accumulated flows in floodways and other collector channels can be discharged.

This concept essentially divides the area into three units: the area north of Western Canal; the area between Western Canal and Pecos Road; and the area south of Pecos Road.



SOUTHEAST MARICOPA COUNTY DRAINAGE STUDY

PROPOSED FLOOD CONTROL PROJECTS

BOYLE ENGINEERING | L.H. BELL & ASSOCIATES
L.E.H. - APRIL 1973 | PLATE I

The runoff from the area north of Western Canal would be collected in a major floodway along the alignment of Western Canal from Gila Drain easterly to the Southern Pacific Railroad west of Center Street, thence northerly to Baseline Road, then continuing easterly along Baseline Road to a junction with Eastern Canal. Floodways above Eastern and Consolidated Canals would be provided which would discharge into this floodway. The development of the flood control plans for this area and for the other areas is contingent upon the completion of adequate capacity in the Gila Drain from the junction with Western Canal to the Gila River.

The major portion of the runoff from the area between Western Canal and Pecos Road would be collected in a floodway extending from the Gila Drain along Pecos Road to Eastern Canal. Floodways above Eastern and Consolidated Canals would discharge into this floodway along with collector laterals in the area west of Consolidated Canal which drains toward Pecos Road. Additional drains in the vicinities of Warner, Ray and Williams Field Roads would discharge directly into Gila Drain.

In the area south of Pecos Road collector systems would be developed to discharge into Gila Drain with a major outlet along Hunt Highway.

Federal assistance to provide major outlet channels for the area west of Roosevelt Water Conservation District Canal may be obtained through the Corps of Engineers or the Soil Conservation Service. There may be advantages to dividing the area into two parts: one that is anticipated to be primarily urban within the relatively near future and the other that is anticipated to remain in agriculture for the foreseeable future. The measures required for protection of the urban area, including a outlet to the Gila River through the Gila Drain, may appropriately be included in a Corps of Engineers flood control project. The measures required for protection of the area anticipated to remain primarily in agricultural use, including a portion of the Gila Drain, may be included in a Public Law 566 project with the advantage that Public Law 566 projects are more oriented to the needs of agriculture.

One of the objectives of this present study is to provide preliminary information which will assist in obtaining assistance in the development of these projects.

HYDROLOGIC ANALYSIS

The watersheds in the study area vary from steep mountains with slopes of 50 percent or greater in the eastern portion to the lands in the farmed areas with very gentle slopes. Soils in the area range from very shallow with sparse desert vegetation to the deep soils in the agricultural areas. In the steep upper watersheds the runoff accumulates in closely spaced channels which run generally in a southwesterly direction. The high velocities in these channels transport large amounts of sediment. As the slopes become less steep, sediment is deposited, the channels become less defined and the flood flows tend to spread over large areas.

There are not sufficient runoff data applicable to this area to serve as a basis for estimating peak flood flows for design purposes. Peak flood flows were estimated using the Soil Conservation Service computer program, TR-20, Hydrology for Project Formulation.

Estimated precipitation intensities for 24-hour durations were used in estimating runoff for the various return periods. These were obtained from precipitation maps prepared by the U. S. Weather Bureau for the Soil Conservation Service in 1967 and revised by the Arizona Highway Department in 1970.

Infiltration rates, indicated by curve numbers, were estimated using the hydrologic grouping of soils prepared by the Soil Conservation Service and the present or anticipated land use in the various area. Land use for the year 2000 was assumed in the hydrologic analyses as follows:

1. Area between the Roosevelt Water Conservation District Canal and the Central Arizona Project Canal alignment - saturated urban development between the Salt River and Guadalupe Road with the remainder of the area in its present use.

2. Area north of Baseline Road - Western Canal floodway alignment - 100 percent saturated urban development.

3. Area between Western Canal and Pecos Road floodway alignment.

   a. Gila Drain to Consolidated Canal - 50 percent saturated urban development.

   b. Area east of Consolidated Canal to Roosevelt Water Conservation District Canal - agricultural use.

4. Area south of Pecos Road to Maricopa County Line - 15 square miles urban development in close proximity to Interstate Highway I-10 with the remainder agricultural use.

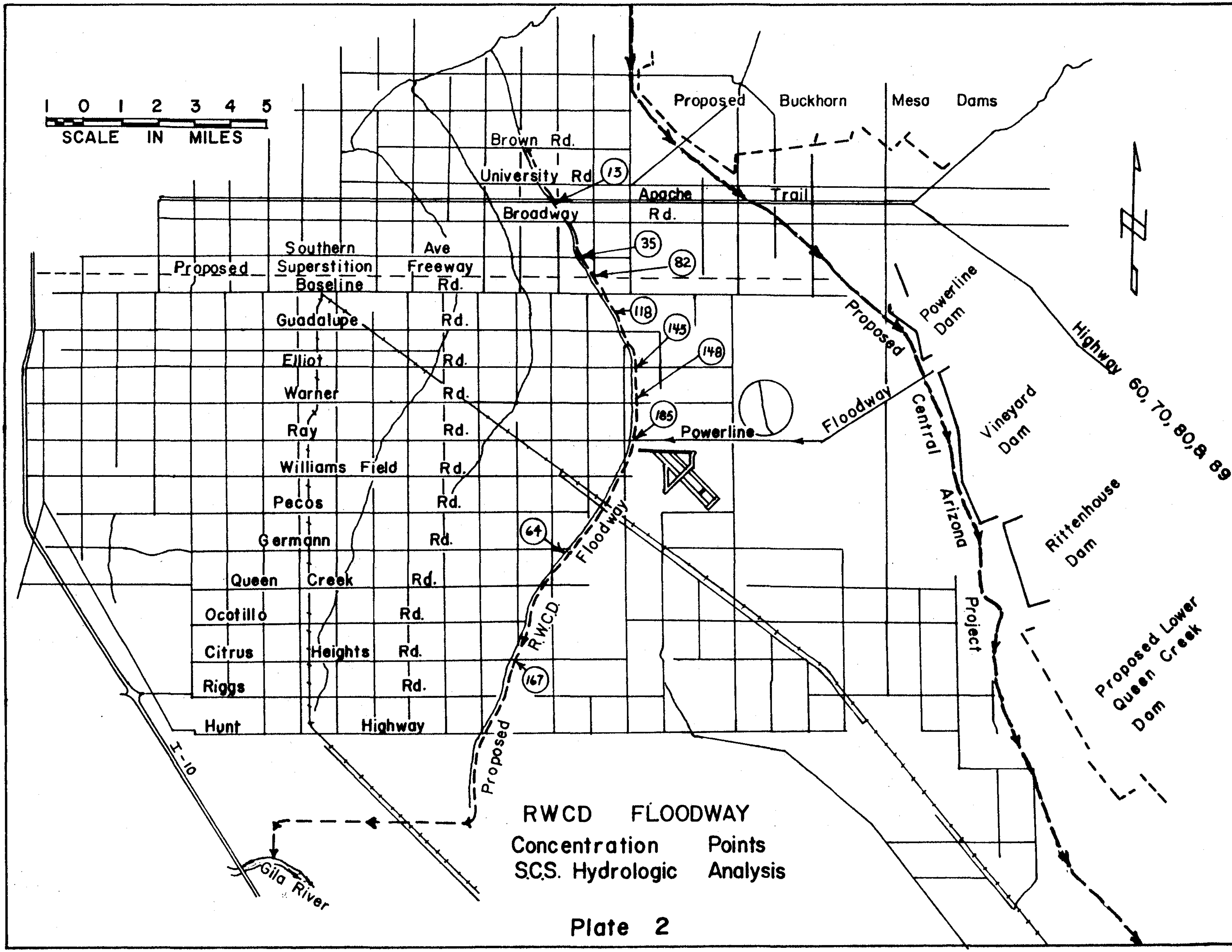
5. Area west of Gila Drain and Interstate Highway I-10 and north of Pecos Road - 5 square miles urban development with the remainder in its present use.

The Soil Conservation Service developed a mathematical hydrologic model for the area east of the Roosevelt Water Conservation District Canal in accordance with their computer program, TR-20, Hydrology for Project Formulation. This model provides for rapid analyses by computer to obtain estimates of peak flows at specified concentration points for various conditions of land use and floodwater retarding structures installed in the watershed.

This model was used by the Soil Conservation Service to estimate peak flood flows in the Roosevelt Water Conservation District floodway for various return periods under conditions with and without the Buckhorn-Mesa Project and the Lower Queen Creek Project structural measures installed under present and future conditions; and with these strucutral measures installed under future conditions. Table 6 summarizes the estimated peak flood flows for concentration points as shown on Plate 2.

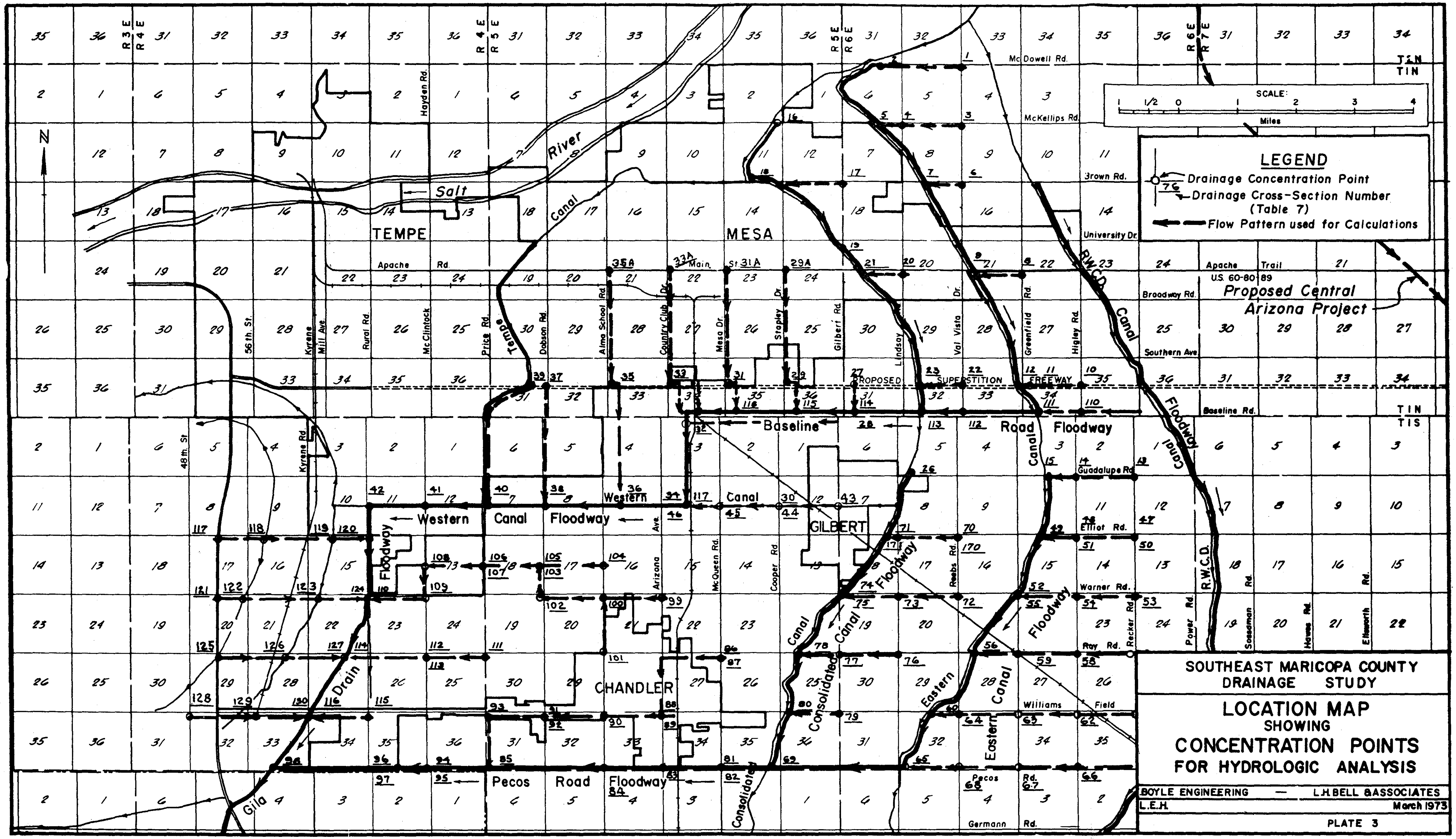
A similar hydrologic model was developed for the 244 square mile drainage area west of the Roosevelt Water Conservation District Canal for a project concept of floodways to discharge into the Gila Drain. Table 7 summarizes the estimated peak flood flows estimated for the 100-year return period flood for concentration points shown on Plate 3 and 4.

For the area north of the Superstition Freeway alignment and west of Consolidated Canal, computer runs were made for the estimated 2-, 5-, 10-, 25-, 50-, and 100-year return period floods. Table 8 summarizes the estimated peak flood flows and the volumes of runoff for these return periods at considered culvert crossings of the Superstition Freeway.



RWCD FLOODWAY
Concentration Points
S.C.S. Hydrologic Analysis

Plate 2



SOUTHEAST MARICOPA COUNTY DRAINAGE STUDY
LOCATION MAP SHOWING CONCENTRATION POINTS FOR HYDROLOGIC ANALYSIS
BOYLE ENGINEERING — L.H.BELL &ASSOCIATES
L.E.H.
March 1973
PLATE 3
LEGEND
Drainage Concentration Point
Drainage Cross-Section Number (Table 7)
Flow Pattern used for Calculations
SCALE:
Miles
TEMPE
MESA
GILBERT
CHANDLER
Salt River
Tempe Canal
Western Canal Floodway
Baseline Road Floodway
Pecos Road Floodway
Consolidated Canal
Eastern Canal
R.W.C.D. Canal
R.W.C.D. Floodway
Gila Drain
Proposed Central Arizona Project
PROPOSED SUPERSTITION FREEWAY
McDowell Rd.
McKellips Rd.
Brown Rd.
University Dr.
Apache Rd.
Apache Trail
U.S. 60-80-89
Main St.
Broadway Rd.
Southern Ave.
Baseline Rd.
Guadalupe Rd.
Elliot Rd.
Warner Rd.
Ray Rd.
Williams Field
Pecos Rd.
Germann Rd.
Hayden Rd.
56th St.
48th St.
Kyrene Rd.
Mill Ave.
Rural Rd.
McClintock
Price Rd.
Dobson Rd.
Alma School Rd.
Country Club Dr.
Mesa Dr.
Stapley Dr.
Gilbert Rd.
Lindsay
Val Vista Dr.
Greenfield Rd.
Higley Rd.
Arizona Ave.
McQueen Rd.
Cooper Rd.
Reebs Rd.
Recker Rd.
Power Rd.
Sossaman Rd.
Hawes Rd.
Ellsworth Rd.
R3E R4E
R4E R5E
R5E R6E
R6E R7E
T1N
T1S

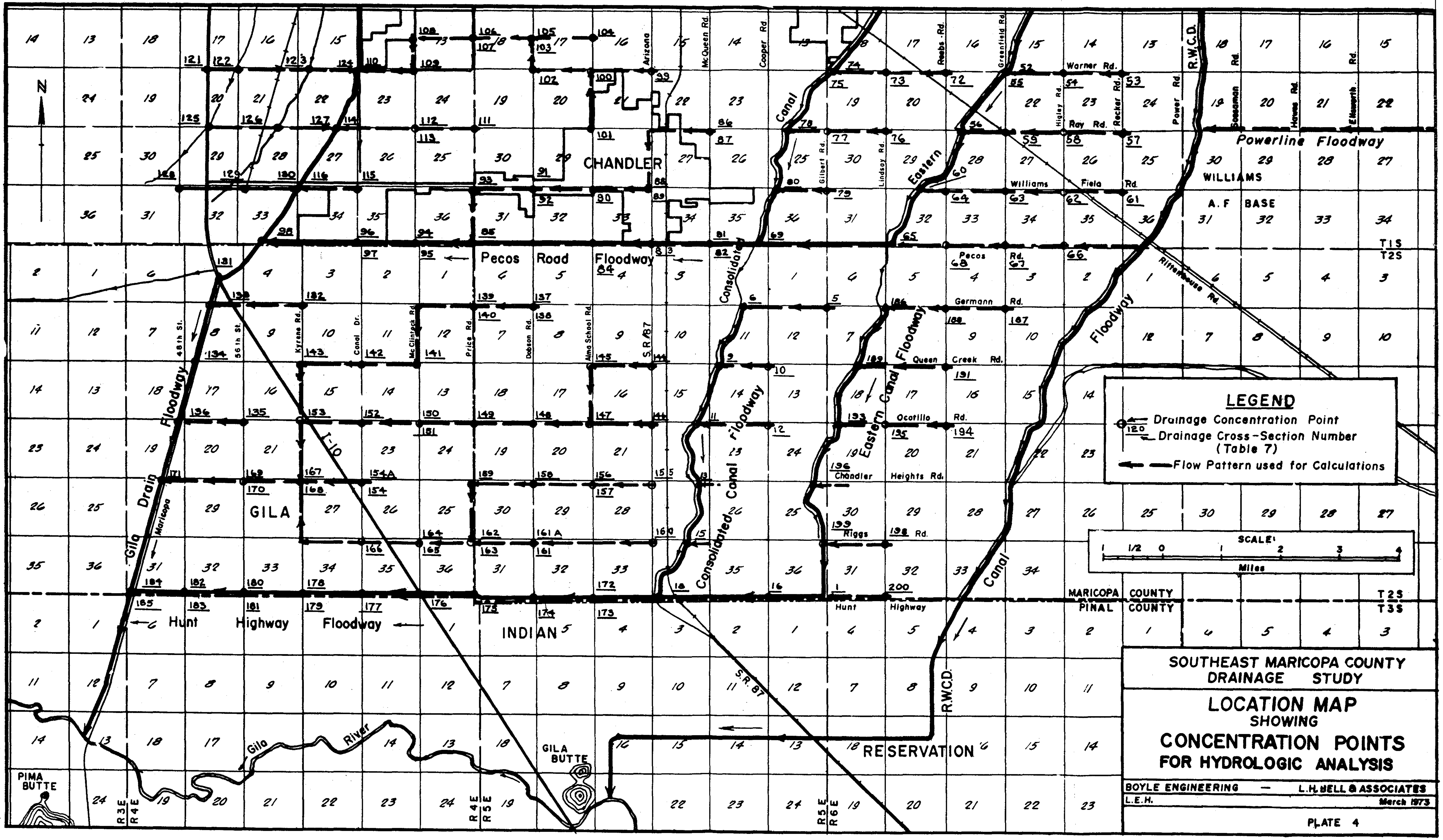

SOUTHEAST MARICOPA COUNTY
DRAINAGE STUDY
LOCATION MAP
SHOWING
CONCENTRATION POINTS
FOR HYDROLOGIC ANALYSIS
BOYLE ENGINEERING — L.H. BELL & ASSOCIATES
L.E.H.
March 1973
PLATE 4
LEGEND
Drainage Concentration Point
120 Drainage Cross-Section Number (Table 7)
Flow Pattern used for Calculations
SCALE
1/2 0 1 2 3 4
Miles
N
CHANDLER
GILA
INDIAN
RESERVATION
WILLIAMS
A. F BASE
Pecos Road Floodway
Powerline Floodway
Hunt Highway Floodway
Gila Drain Floodway
Maricopa
Consolidated Canal
Consolidated Canal Floodway
Eastern Canal
Eastern Canal Floodway
R.W.C.D. Floodway
R.W.C.D.
R.W.C.D. Canal
Gila River
GILA BUTTE
PIMA BUTTE
I-10
S.R. 87
MARICOPA COUNTY
PINAL COUNTY
T1S
T2S
T2S
T3S
R3E R4E
R4E R5E
R5E R6E
Warner Rd.
Ray Rd.
Williams Field Rd.
Pecos Rd.
Germann Rd.
Queen Creek Rd.
Ocotillo Rd.
Chandler Heights Rd.
Riggs Rd.
Hunt Highway
Rittenhouse Rd.
48th St.
56th St.
Kyrene Rd.
Canal Dr.
McClintock Rd.
Price Rd.
Dobson Rd.
Alma School Rd.
S.R. 87
Arizona
McQueen Rd.
Cooper Rd.
Gilbert Rd.
Lindsay Rd.
Reebs Rd.
Greenfield Rd.
Higley Rd.
Recker Rd.
Power Rd.
Sossaman Rd.
Hawes Rd.
Ellsworth Rd.

TABLE 6

ESTIMATED PEAK FLOOD FLOWS[1/]
ROOSEVELT WATER CONSERVATION DISTRICT FLOODWAY

Cross Section No.	Without Buckhorn-Mesa and Lower Queen Creek Project Structural Measures — Present Conditions Return Period - Years 100 cfs	25 cfs	10 cfs	Without Buckhorn-Mesa and Lower Queen Creek Project Structural Measures — Future Conditions Return Period - Years 100 cfs	25 cfs	10 cfs	With Buckhorn-Mesa and Lower Queen Creek Project Structural Measures — Future Conditions Return Period - Years 100 cfs	25 cfs	10 cfs
13	2,925	2,170	1,352	4,711	3,628	2,428	3,645	2,797	1,847
35	5,327	3,749	2,311	7,600	5,542	3,612	5,225	3,732	2,318
82	8,438	5,676	3,548	16,834	11,713	7,821	11,691	7,700	4,990
118	9,847	6,508	4,121	19,690	13,522	9,020	13,675	9,174	5,864
145	12,788	8,446	5,423	25,667	17,178	11,391	17,424	11,507	7,243
148	12,675	8,325	5,325	24,980	16,805	10,978	16,881	11,022	7,032
185	15,372	9,911	6,243	28,798	18,966	12,258	20,854	13,483	8,389
64	20,972	13,355	8,237	32,398	21,254	13,785	24,609	15,823	10,068
167	34,863	23,315	16,331	39,848	26,773	18,096	32,295	21,406	14,013

1/ Estimated by U. S. D. A. Soil Conservation Service

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain. Area. Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Western Canal - Baseline Road Floodway		
1	0.24	Eastern Canal Floodway - Rambo Rd.- Lateral	210	210
2	0.46	Eastern Canal Floodway - Rambo Rd.- Lateral	280	
2	0.70	Eastern Canal Floodway - Rambo Rd.- Lateral		440
3	0.61	Eastern Canal Floodway - So. of Rambo Rd.-Lateral	380	380
4	1.00	Eastern Canal Floodway - So. of Rambo Rd.-Lateral	590	900
5	0.84	Eastern Canal Floodway - So. of Rambo Rd.-Lateral	530	
5	2.45	Eastern Canal Floodway - So. of Rambo Rd.-Lateral		1300
5	3.15	Eastern Canal Floodway		1570
6	0.97	Eastern Canal Floodway - Brown Rd. - Lateral	670	670
7	1.07	Eastern Canal Floodway - Brown Rd. - Lateral	600	
7	2.04	Eastern Canal Floodway - Brown Rd. - Lateral		1200
7	5.19	Eastern Canal Floodway		2380
8	0.78	Eastern Canal Floodway - Apache Trail - Lateral	540	540
9	2.12	Eastern Canal Floodway - Apache Trail - Lateral	1420	
9	2.90	Eastern Canal Floodway - Apache Trail - Lateral		1910
9	8.09	Eastern Canal Floodway		3210
10	1.07	Eastern Canal Floodway - Lateral	650	650
11	1.97	Eastern Canal Floodway - Lateral	970	1570
12	0.71	Eastern Canal Floodway - Lateral	360	
12	3.75	Eastern Canal Floodway - Lateral		1910
12	11.84	Eastern Canal Floodway		3900
110	0.57	Eastern Canal Floodway - Baseline Rd. - Lateral	430	430
111	0.46	Eastern Canal Floodway - Baseline Rd. - Lateral	390	
111	1.03	Eastern Canal Floodway - Baseline Rd.- Lateral		670
111	12.87	Eastern Canal Floodway		4000

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Western Canal - Baseline Road Floodway (Continued)		
112	0.30	Baseline Road Floodway - Lateral	270	
112	13.17	Baseline Road Floodway		4010
113	0.38	Baseline Road Floodway - Lateral	370	
113	13.55	Baseline Road Floodway		4030
16	0.78	Consolidated Canal Floodway - Lateral	560	560
17	0.91	Consolidated Canal Floodway - Brown Rd. - Lateral	580	
18	1.49	Consolidated Canal Floodway - Brown Rd. - Lateral	730	
18	2.40	Consolidated Canal Floodway - Brown Rd. - Lateral		1050
18	3.18	Consolidated Canal Floodway		1500
19	0.67	Consolidated Canal Floodway - Lateral	440	
19	3.85	Consolidated Canal Floodway		1410
20	1.02	Consolidated Canal Floodway - Apache Trail - Lateral	860	860
21	1.45	Consolidated Canal Floodway - Apache Trail - Lateral	960	
21	2.47	Consolidated Canal Floodway - Apache Trail - Lateral		1720
21	6.32	Consolidated Canal Floodway		2250
22	1.20	Consolidated Canal Floodway - Superstition Freeway - Lat.	800	800
23	2.23	Consolidated Canal Floodway - Superstition Freeway - Lat.	1270	
23	3.43	Consolidated Canal Floodway - Superstition Freeway - Lat.		2000
23	9.75	Consolidated Canal Floodway		3010
113	23.30	Baseline Road Floodway		6920
27	1.77	Baseline Road Floodway- Gilbert Rd. - No. Lateral	1100	
114	0.61	Baseline Road Floodway - Gilbert Rd. - No. Lateral	400	
114	25.68	Baseline Road Floodway		7150

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Western Canal - Baseline Road Floodway (Continued)		
28	1.73	Baseline Road Floodway - So. Lateral	860	
28	27.41	Baseline Road Floodway		7510
29A	0.87	Baseline Road Floodway - Cooper Road - Lateral	510	
29	1.99	Baseline Road Floodway - Cooper Road - Lateral	920	
115	2.86	Baseline Road Floodway - Cooper Road - Lateral		1170
115	0.50	Baseline Road Floodway - Cooper Road - Lateral	330	
115	30.77	Baseline Road Floodway		7940
31A	1.48	Baseline Road Floodway - McQueen Road - No. Lateral	600	
31	2.02	Baseline Road Floodway - McQueen Road - No. Lateral	820	
116	3.50	Baseline Road Floodway - McQueen Road - No. Lateral		1070
116	0.36	Baseline Road Floodway - McQueen Road - No. Lateral	190	
32	1.64	Baseline Road Floodway - McQueen Road - So. Lateral	610	
116	36.27	Baseline Road Floodway		8610
117	0.64	Baseline Road Floodway - McQueen Road - Lateral	180	
117	36.91	Western Canal Floodway		8590
43	0.84	Western Canal Floodway - Gilbert Trib.	520	520
30	1.48	Western Canal Floodway- Gilbert Trib.	660	
44	2.09	Western Canal Floodway - Gilbert Trib.	1070	2210
45	1.51	Western Canal Floodway - Gilbert Trib.	780	
45	5.92	Western Canal Floodway - Gilbert Trib.		2890
117	42.83	Western Canal Floodway - Jct. w/ Gilbert Trib.		9290
33A	1.48	Western Canal Floodway - Arizona Ave. - No. Lateral	600	
33	1.98	Western Canal Floodway - Arizona Ave. - No. Lateral	800	1060
34	1.35	Western Canal Floodway - Arizona Ave. - No. Lateral	370	
34	4.81	Western Canal Floodway - Arizona Ave. - No. Lateral		1380
46	1.51	Western Canal Floodway - Arizona Ave. - So. Lateral	780	
34	49.15	Western Canal Floodway - Arizona Ave.		10,420
35A	0.82	Western Canal Floodway - Alma School Road - Lateral	420	
35	1.96	Western Canal Floodway - Alma School Road - Lateral	830	1020

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Western Canal - Baseline Road Floodway (Continued)		
36	1.98	Western Canal Floodway - Alma School Road	640	
36	4.76	Western Canal Floodway - Alma School Road		1550
36	53.91	Western Canal Floodway - Alma School Road		11, 250
37	2.02	Western Canal Floodway - Dobson Road - Lateral	860	
38	1.98	Western Canal Floodway - Dobson Road - Lateral	710	
38	4.00	Western Canal Floodway - Dobson Road - Lateral		1410
38	57.91	Western Canal Floodway - Dobson Road		11,840
39	1.05	Western Canal Floodway - Tempe Canal - Lateral	360	
40	1.90	Western Canal Floodway - Tempe Canal - Lateral	730	
40	2.95	Western Canal Floodway - Tempe Canal - Lateral		900
40	60.86	Western Canal Floodway - Tempe Canal		12,300
41	0.87	Western Canal Floodway - McClintock Road - Lateral	320	
41	61.73	Western Canal Floodway - McClintock Road		12,370
42	0.60	Western Canal Floodway - Rural Road - Lateral	170	
42	62.33	Western Canal Floodway - Rural Road - Jct. Gila Drain		12,430
117	1.61	Elliot Road Lateral to Gila Drain (West)	1000	1000
118	0.55	Elliot Road Lateral to Gila Drain (West)	430	1260
119	0.79	Elliot Road Lateral to Gila Drain (West)	30	1210
120	0.52	Elliot Road Lateral to Gila Drain (West)	30	
120	3.47	Elliot Road Lateral to Gila Drain (West)		1200
120	65.80	Gila Drain, Jct. w/ Elliot Road, Lateral (West)		12,550
121	2.77	Warner Road Lateral to Gila Drain (West)	880	880
122	0.65	Warner Road Lateral to Gila Drain (West)	450	1150
123	1.25	Warner Road Lateral to Gila Drain (West)	90	1200
124	0.74	Warner Road Lateral to Gila Drain (West)	30	
124	5.41	Warner Road Lateral to Gila Drain (West)		1200

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Warner Road Lateral (East)		
99	1.00	Warner Road	570	570
100	1.00	Alma School Road Jct.	620	
101	1.02	Alma School Road	540	
100	3.02	Warner Road		1620
102	1.00	Warner Road at Dobson Road	550	
102	4.02	Warner Road at Dobson Road		2080
103	0.50	Dobson Road	290	
103	4.52	Dobson Road		2270
104	1.51	East Lateral No. of Warner Road	720	720
105	1.01	East Lateral No. of Warner Road	520	1180
105	7.04	Jct. on Dobson Road		3440
106	1.00	North Lateral at Price Road	140	
107	0.48	South Lateral at Price Road	70	
107	8.52	At Price Road		3560
108	1.02	At McClintock Drive	60	3570
109	0.50	Warner Road and McClintock Drive	60	3590
110	1.53	Junction w/Gila Drain	40	
110	11.57	Junction w/Gila Drain		3580
110	82.78	Gila Drain - Jct. w/Warner Road Laterals		13,960
125	2.28	Ray Road Lateral (West)	270	270
126	1.50	Ray Road Lateral (West)	100	350
127	0.94	Ray Road Lateral (West)	60	
127	4.72	Ray Road Lateral (West)		390
111	0.99	Ray Road Lateral (East)	100	100
112	1.02	Ray Road Lateral (East)	100	
113	1.02	Ray Road Lateral (East)	50	240
114	1.13	Ray Road Lateral (East)	30	
114	4.16	Ray Road Lateral (East)		270
114	91.66	Gila Drain - Jct. w/ Ray Road Laterals		14,240
128	0.74	Williams Field Road Lateral (West)	30	30
129	0.90	Williams Field Road Lateral (West)	50	80
130	0.98	Williams Field Road Lateral (West)	140	
130	2.62	Williams Field Road Lateral (West)		210

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Warner Road Lateral (East) Continued		
115	0.99	Williams Field Road Lateral (East)	30	30
116	0.67	Williams Field Road Lateral (East)	20	
116	1.66	Williams Field Road Lateral (East)		50
116	95.94	Gila Drain - Jct. Williams Field Road Laterals		14,290
		Pecos Road Floodway		
13	0.71	Eastern Canal Floodway - Guadalupe Road - Lateral	30	30
14	0.98	Eastern Canal Floodway - Guadalupe Road - Lateral	30	60
15	0.59	Eastern Canal Floodway - Guadalupe Road - Lateral	50	
15	2.28	Eastern Canal Floodway - Guadalupe Road - Lateral		100
47	1.14	Eastern Canal Floodway - Elliot Road - Lateral	150	150
50	1.28	Eastern Canal Floodway - Elliot Road - Lateral	150	270
48	1.01	Eastern Canal Floodway - Elliot Road - Lateral	150	400
51	0.98	Eastern Canal Floodway - Elliot Road - Lateral	120	520
49	0.55	Eastern Canal Floodway - Elliot Road - Lateral	80	
49	4.96	Eastern Canal Floodway - Elliot Road		580
49	7.24	Eastern Canal Floodway - Elliot Road		670
53	1.21	Eastern Canal Floodway - Warner Road - Lateral	140	140
54	0.97	Eastern Canal Floodway - Warner Road - Lateral	150	250
52	0.85	Eastern Canal Floodway - Warner Road - Lateral	100	350
55	0.97	Eastern Canal Floodway - Warner Road - Lateral	150	
55	4.00	Eastern Canal Floodway - Warner Road - Lateral		470
55	11.24	Eastern Canal Floodway - Warner Road		1080
57	1.06	Eastern Canal Floodway - Ray Road - Lateral	130	130
58	0.99	Eastern Canal Floodway - Ray Road - Lateral	120	250
59	0.99	Eastern Canal Floodway - Ray Road - Lateral	120	350
56	0.46	Eastern Canal Floodway - Ray Road - Lateral	50	
56	3.50	Eastern Canal Floodway - Ray Road - Lateral		400
56	14.74	Eastern Canal Floodway - Ray Road		1430

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Pecos Road Floodway (Continued)		
61	0.58	Eastern Canal Floodway - Wms Field Road - Lateral	50	50
62	0.99	Eastern Canal Floodway - Wms. Field Road - Lateral	130	180
63	0.99	Eastern Canal Floodway - Wms. Field Road - Lateral	130	300
64	0.99	Eastern Canal Floodway - Wms. Field Road - Lateral	110	390
60	1.04	Eastern Canal Floodway - Wms. Field Road - Lateral	110	
60	4.59	Eastern Canal Floodway - Wms. Field Road - Lateral		500
60	19.33	Eastern Canal Floodway - Wms. Field Road		1750
66	0.83	Eastern Canal Floodway - Pecos Road No. Lateral	40	40
67	1.00	Eastern Canal Floodway - Pecos Road No. Lateral	40	70
68	1.00	Eastern Canal Floodway - Pecos Road No. Lateral	30	100
65	0.78	Eastern Canal Floodway - Pecos Road No. Lateral	80	
65	3.63	Eastern Canal Floodway - Pecos Road No. Lateral		180
65	22.96	Eastern Canal Floodway - Pecos Road		1830
69	1.10	Eastern Canal Floodway - Pecos Road, So. Lateral	140	
69	24.06	Eastern Canal Floodway - Pecos Road		1860
26	2.09	Consolidated Canal Floodway - Guadalupe Road - Lateral	230	
26	2.09	Consolidated Canal Floodway - Guadalupe Road - Lateral		230
70	1.33	Consolidated Canal Floodway - Elliot Road - Lateral	150	150
170	1.11	Consolidated Canal Floodway - Elliot Road - Lateral	170	290
171	0.99	Consolidated Canal Floodway - Elliot Road - Lateral	120	410
71	1.03	Consolidated Canal Floodway - Elliot Road - Lateral	130	
71	4.46	Consolidated Canal Floodway - Elliot Road - Lateral		530
71	6.55	Consolidated Canal Floodway - Elliot Road		720
72	0.52	Consolidated Canal Floodway - Warner Road - Lateral	100	100
73	1.00	Consolidated Canal Floodway - Warner Road - Lateral	130	220
74	0.54	Consolidated Canal Floodway - Warner Road - Lateral	210	420
75	0.99	Consolidated Canal Floodway - Warner Road - Lateral	150	
75	3.05	Consolidated Canal Floodway - Warner Road - Lateral		550
75	9.60	Consolidated Canal Floodway - Warner Road		1100

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Pecos Road Floodway (Continued)		
76	0.95	Consolidated Canal Floodway - Ray Road - Lateral	120	120
77	0.97	Consolidated Canal Floodway - Ray Road - Lateral	110	230
78	0.40	Consolidated Canal Floodway - Ray Road - Lateral	40	
78	2.32	Consolidated Canal Floodway - Ray Road - Lateral		270
78	11.92	Consolidated Canal Floodway - Ray Road		1270
79	1.19	Consolidated Canal Floodway - Wms. Field Road - Lateral	190	190
80	0.83	Consolidated Canal Floodway - Wms. Field Road - Lateral	100	
80	2.02	Consolidated Canal Floodway - Wms. Field Road - Lateral		280
80	13.94	Consolidated Canal Floodway - Wms. Field Road		1360
69	38.00	Pecos Road Floodway		3190
81	0.90	Pecos Road Floodway- McQueen Road	100	
82	0.57	Pecos Road Floodway - McQueen Road	20	3230
83	1.02	Pecos Road Floodway - Arizona Avenue	30	3230
84	1.03	Pecos Road Floodway- Alma School Road	70	3260
85	1.04	Pecos Road Floodway - Price Road	70	
85	42.56	Pecos Road Floodway - Price Road		3260
86	0.99	Tributary to Pecos Road Floodway - Ray Road	510	
87	1.15	Tributary to Pecos Road Floodway - Ray Road	130	620
88	1.00	Tributary to Pecos Road Floodway - Arizona Avenue	540	
89	0.99	Tributary to Pecos Road Floodway - Arizona Avenue	540	1510
90	1.00	Tributary to Pecos Road Floodway - Alma School Road	540	1940
91	1.01	Tributary to Pecos Road Floodway - Dobson Road	570	
92	1.00	Tributary to Pecos Road Floodway - Dobson Road	620	2710
93	1.00	Tributary to Pecos Road Floodway - Price Road	130	
93	8.14	Tributary to Pecos Road Floodway - Price Road		2810
85	40.70	Pecos Road Floodway - Jct. w/Price Road Trib.		3930
94	1.00	Pecos Road Floodway - McClintock Drive	30	
95	0.90	Pecos Road Floodway - McClintock Drive	20	3950
96	1.02	Pecos Road Floodway - Canal Drive	30	
97	0.94	Pecos Road Floodway - Canal Drive	30	3970

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Pecos Road Floodway (Continued)		
98	1.30	Pecos Road Floodway, Jct. W/Gila Drain	30	
98	55.86	Pecos Road Floodway, Jct. W/Gila Drain		3,960
98	151.80	Gila Drain, Jct. w/Pecos Rd. Floodway		18,040
131	1.72	Tributary to Gila Drain (West)	200	18,050
133	1.99	German Road Lateral	50	18,080
134	1.59	Queen Creek Road Lateral	590	18,130
136	1.99	Ocotillo Road Lateral	730	
136	159.09	Gila Drain, Jct. Ocotillo Rd. Lateral		18,200
		Chandler Heights Rd. Drain and Laterals		
138	2.07	Germann Rd. Lateral	70	70
139	1.05	Germann Rd. Lateral	30	
140	0.99	Germann Rd. Lateral	40	120
141	0.93	Jct. w/Queen Creek Rd. Lateral	20	140
142	0.99	Queen Creek Rd. Lateral	30	160
143	0.99	Queen Creek Rd. Lateral	30	
143	7.02	Queen Creek Rd. Lateral		180
144	1.27	Queen Creek Rd. Upper Lateral	30	30
145	0.99	Queen Creek Rd. Upper Lateral	20	50
147	1.96	Ocotillo Rd. Lateral	50	100
148	1.03	Ocotillo Rd. Lateral	30	120
149	0.99	Ocotillo Rd. Lateral	30	140
150	0.94	Ocotillo Rd. Lateral	20	
151	0.94	Ocotillo Rd. Lateral	30	180
152	1.00	Ocotillo Rd. Lateral	30	200
153	1.00	Ocotillo Rd. Lateral	440	
153	10.12	Ocotillo Rd. Lateral		450
153	17.14	Jct. Queen Creek Rd. and Ocotillo Rd. Lateral		470
154A	0.99	Lower Chandler Heights Rd. Lateral	400	
154	0.99	Lower Chandler Heights Rd. Lateral	370	760
167	1.00	Lower Chandler Heights Rd. Lateral	440	
168	1.00	Lower Chandler Heights Rd. Lateral	440	
168	3.98	Lower Chandler Heights Rd. Lateral		1,520
168	21.12	Lower Chandler Heights Rd. Lateral		1,970

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Chandler Heights Rd Drain and Laterals (Continued)		
157	3.24	Chandler Heights Road	80	80
158	1.00	Chandler Heights Road	30	105
159	1.01	Chandler Heights Road	30	
159	5.25	Chandler Heights Road		130
161	2.00	Riggs Road	50	50
162	1.01	Riggs Road	430	
163	1.00	Riggs Road	440	
163	4.01	Riggs Road		880
163	9.26	Jct. Riggs Road and Chandler Heights Road Tribs.		890
164	0.95	Riggs Road	410	
165	0.95	Riggs Road	400	1,640
166	0.99	Riggs Road	400	
166	12.15	Riggs Road		1,980
168	33.27	Jct. All Laterals		3,440
169	1.00	Chandler Heights Rd. Drain	370	
170	1.00	Chandler Heights Rd. Drain	30	3,700
171	1.14	Chandler Heights Rd. Drain	30	
171	36.41	Chandler Heights Rd. Drain		3,690
171	195.50	Gila Drain Jct. w/Chandler Hts. Rd. Drain		19,200
		Hunt Highway Drain - Eastern Canal Floodway		
187	1.02	Germann Rd. Lateral	40	40
188	1.02	Germann Rd. Lateral	30	70
186	1.08	Germann Rd. Lateral	30	
186	3.12	Germann Rd. Lateral		100
191	1.53	Queen Creek Rd. Lateral	40	40
189	1.30	Queen Creek Rd. Lateral	40	
189	2.83	Queen Creek Rd. Lateral		70
189	5.95	Eastern Canal Floodway		170

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Hunt Hwy. Drain - Eastern Canal Floodway (Cont.)		
194	1.20	Ocatillo Rd. Lateral	30	30
195	1.00	Ocatillo Rd. Lateral	30	60
193	1.78	Ocatillo Rd. Lateral	50	
193	3.98	Ocatillo Rd. Lateral		110
193	9.93	Eastern Canal Floodway		270
196	1.08	Chandler Heights Road Lateral	30	300
198	1.51	Riggs Road Lateral	40	
199	1.21	Riggs Road Lateral	40	
199	2.72	Riggs Road Lateral		80
199	13.73	Eastern Canal Floodway		350
200	1.50	Hunt Hwy. Lateral	40	
1	1.12	Hunt Hwy. Lateral	30	70
1	16.35	Eastern Canal Floodway at Hunt Hwy.		410
16	0.99	Hunt Hwy. Drain	30	430
18	1.78	Hunt Hwy. Drain	40	
18	19.12	Hunt Hwy. Drain		460
		Consolidated Canal Floodway		
5	0.91	Germann Road Lateral	20	
6	1.45	Germann Road Lateral	40	
6	2.36	Germann Road Lateral		60
10	1.20	Queen Creek Road Lateral	30	30
9	2.39	Queen Creek Road Lateral	60	
9	3.59	Queen Creek Road Lateral		90
9	5.95	Consolidated Canal Floodway		150

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain. Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Consolidated Canal Floodway (Continued)		
12	0.89	Ocotillo Road Lateral	20	
11	1.10	Ocotillo Road Lateral	30	
11	1.99	Ocotillo Road Lateral		50
11	7.94	Consolidated Canal Floodway		200
13	1.41	Chandler Heights Road Lateral	40	230
15	2.05	Riggs Road Lateral	60	270
18	30.52	Hunt Hwy. Drain, Jct. Conso. Canal Floodway		720
173	1.36	Hunt Hwy. Drain	30	750
174	1.66	Hunt Hwy. Drain	40	780
175	1.56	Hunt Hwy. Drain	40	800
176	1.56	Hunt Hwy. Drain	40	830
177	1.33	Hunt Hwy. Drain	40	850
178	0.99	Hunt Hwy. Drain	400	
179	1.25	Hunt Hwy. Drain	40	910
180	0.99	Hunt Hwy. Drain	20	
181	1.48	Hunt Hwy. Drain	40	940
182	0.99	Hunt Hwy. Drain	30	
183	1.40	Hunt Hwy. Drain	40	970
184	2.15	Hunt Hwy. Drain	50	
185	1.16	Hunt Hwy. Drain	30	
185	48.40	Hunt Hwy. Drain		1,020
185	243.90	Gila Drain, Jct. w/Hunt Hwy. Drain		20,130

TABLE 8

ESTIMATED PEAK FLOOD FLOW AND VOLUMES OF RUNOFF AREA NORTH OF SUPERSTITION FWY. ALIGNMENT AND WEST OF CONSOLIDATED CANAL FOR VARIOUS RETURN PERIODS

Return Period Years	Column Number 1/ D. A. Sq. Mi.	CONCENTRATION POINTS - NUMBER AND DRAINAGE AREA 1 1.77	2 2.86	3 3.50	4 1.73	5 1.73	6 2.78	7 3.07
2	Peak cfs	145	105	75	35	35	65	80
	Volume - Ac. Ft.	35	35	33	16	16	26	29
5	Peak cfs	305	265	210	100	100	190	230
	Volume - Ac. Ft.	67	77	77	38	38	61	68
10	Peak cfs	455	425	350	170	170	325	390
	Volume - Ac. Ft.	96	116	122	60	60	96	106
25	Peak cfs	685	700	600	295	295	560	675
	Volume - Ac. Ft.	142	183	197	98	98	156	173
50	Peak cfs	930	995	875	430	430	825	990
	Volume - Ac. Ft.	192	256	281	139	139	223	246
100	Peak cfs	1,100	1,200	1,070	530	530	1,010	1,220
	Volume - Ac. Ft.	225	307	341	168	168	270	298

1/ Culvert Crossing Concentration Points

1. 1.77 sq. mi - Gilbert Road Crossing
2. 2.86 sq. mi. - Stapley Drive Crossing
3. 3.50 sq. mi. - Mesa Drive Crossing
4. 1.73 sq. mi. - Center Street Crossing
5. 1.73 sq. mi. - Country Club Drive
6. 2.78 sq. mi. - Alma School Road
7. 3.07 sq. mi. - Tempe Canal

The peak flood flows for the 100-year return period floods were estimated using the output from the computer runs. Peak flood flows for the 50-, 25-, and 10-year return periods were estimated for specific drainage areas using factors representing the ratios of the more frequently occurring peak flows to the 100-year return period peak flows. These factors were estimated on the basis of the weighted curve numbers (indicating infiltration rates resulting from the combination of land use and hydrologic characteristics of the soils) for each drainage area considered. The factors are the ratios of the runoff which is estimated to occur with the 24-hour duration precipitation intensities for the 50-, 25-, and 10-year return periods to that which is estimated to occur for the 100-year return period intensity.

Table 9 shows the factors estimated for each of the drainage areas considered and the peak flood flows for various return periods estimated by the application of these factors. Drainage areas that are primarily in agricultural use have lower factors for the more frequently occurring floods. This is because of the higher infiltration rates which absorb a greater proportion of the lower precipitation intensities.

As these drainage areas were generally selected on the basis of consistency of land use within them the factor may be applied generally to all estimated 100-year return period peak flood flows in the areas. The factors developed for the total drainage areas with combinations of land uses and soils above major outlet channels are applicable to the outlet channels only. Table 9 indicates the extent to which there factors may be applied.

Standard project floods as developed by the Corps of Engineers are estimated or hypothetical floods that might be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably

TABLE 9

ESTIMATED PEAK FLOOD FLOWS 100-, 50-, 25-, AND 10-YEAR RETURN PERIODS FOR SELECTED DRAINAGE AREA WITH SIMILAR RUNOFF CHARACTERISTICS

		100-Year		50-Year		25-Year		10-Year		Factors Generally
	Sq. Mi.	cfs	F	cfs	F	cfs	F	cfs	F	Applicable to
Western Canal - Baseline Rd. Floodway										
Eastern Canal Floodway	13.55	4,030	1.00	3,380	0.84	2,340	0.58	1,730	0.43	
Consolidated C. Floodway	9.75	3,010	1.00	2,530	0.84	1,750	0.58	1,290	0.43	All Channels
Total drainage area	62.32	12,430	1.00	10,440	0.84	7,210	0.58	5,340	0.43	
Pecos Road Floodway										
Area above Jct. Price Rd. Tributary	42.55	3,260	1.00	2,380	0.73	1,300	0.40	680	0.21	All Channels
Price Road Tributary	8.14	2,810	1.00	2,360	0.84	1,660	0.59	1,260	0.45	All Channels
Total drainage area	55.85	3,960	1.00	2,970	0.75	1,700	0.43	1,030	0.26	Main channel below Jct. Price Rd. Trib.
Hunt Hwy Drain - Total Area	48.39	1,020	1.00	450	0.44	210	0.21	50	0.05	All Channels
Chandler Heights Road Floodway										
Riggs Road Trib.	12.15	1,970	1.00	1,440	0.73	790	0.40	410	0.21	All Channels
Germann Rd.-Queen Cr.Rd.-Ocotillo Rd. Trib.	17.14	470	1.00	260	0.55	120	0.26	40	0.09	All Channels
Total Drainage area	36.41	3,690	1.00	2,730	0.74	1,550	0.42	920	0.25	Outlet Channel
Gila Drain										
Jct. with Western C. F.W.	62.32	12,430	1.00	10,440	0.84	7,210	0.58	5,340	0.43	
Jct. with Wms. Field Rd. Dr.	95.94	14,290	1.00	11,720	0.82	8,000	0.56	5,860	0.41	Gila Drain at
Jct. with Pecos Rd. F.W.	151.79	18,040	1.00	14,430	0.80	9,380	0.52	6,490	0.36	Junction Points
Jct. with Chandler Hts. F.W.	195.49	19,200	1.00	15,170	0.79	9,600	0.50	6,530	0.34	Indicated
Jct. with Hunt Hwy Drain	243.89	20,130	1.00	15,500	0.77	9,300	0.46	6,100	0.30	

characteristic of the geographical region involved. Estimated flood frequencies estimated by the Corps of Engineers for Indian Bend Wash at Thomas Road are shown in Table 10 .

TABLE 10
ESTIMATED FLOOD FREQUENCIES
INDIAN BEND WASH AT THOMAS ROAD
CORPS OF ENGINEERS FLOOD SURVEY REPORT

Number of Times that Flood Would be Equaled or Exceeded in 100 Years	Uncontrolled Peak Discharges Cubic Feet Per Second	Ratios to 100 Years Return Period
0.23 (Standard Project Flood)	72,000	1.8000
1.0	40,000	1.0000
5.0	19,000	0.4750
10.0	12,500	0.3125
20.0	7,600	0.1900
50.0	2,900	0.0725
72.0	1,500	0.0375

These ratios to the 100-year return period flood flows are consistent with those obtained for the Gila Drain for the more frequently occurring floods. On this basis it may be estimated that the standard project floods for the Gila Drain and the major outlet channels may be about 80 percent higher than the estimates for the 100- year return period floods.

ESTIMATED COSTS TO INSTALL ADDITONAL PROJECTS REQUIRED IN THE STUDY AREA

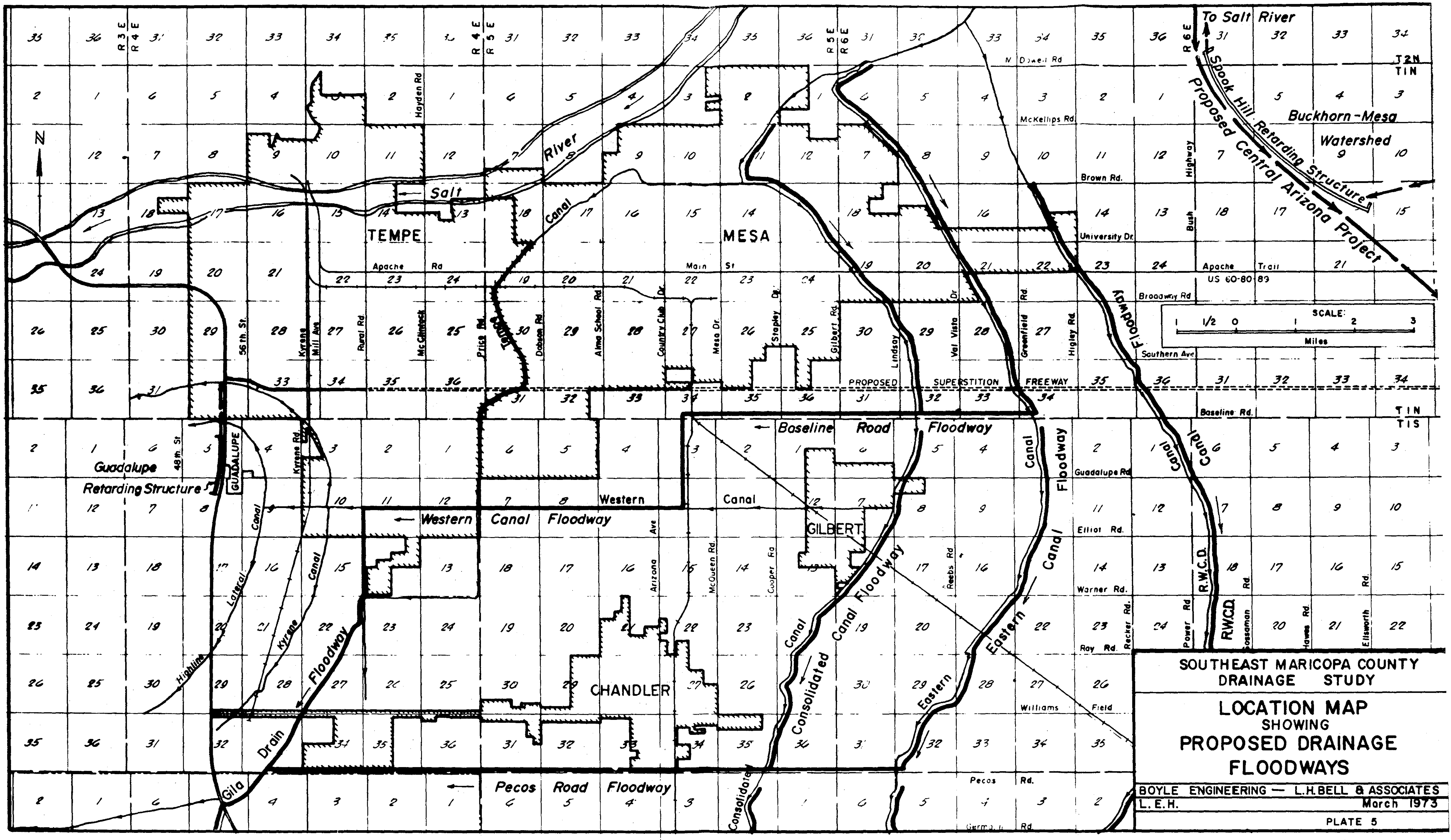
The costs to install the major channels and floodways as shown on Plates 5 and 6 were estimated for unlined earth sections and for concrete lined sections.

For unlined earth section channels a trapezoidal section with 2:1 (horizontal to vertical) side slopes was assumed and an "n" value of 0.035 was used except for the floodways above the Eastern and Consolidated Canals where a value of 0.025 was used. These floodways are on very gentle slopes and have relatively small capacity requirements. Vegetation in the channel sections can be controlled more conveniently that in the larger sections.

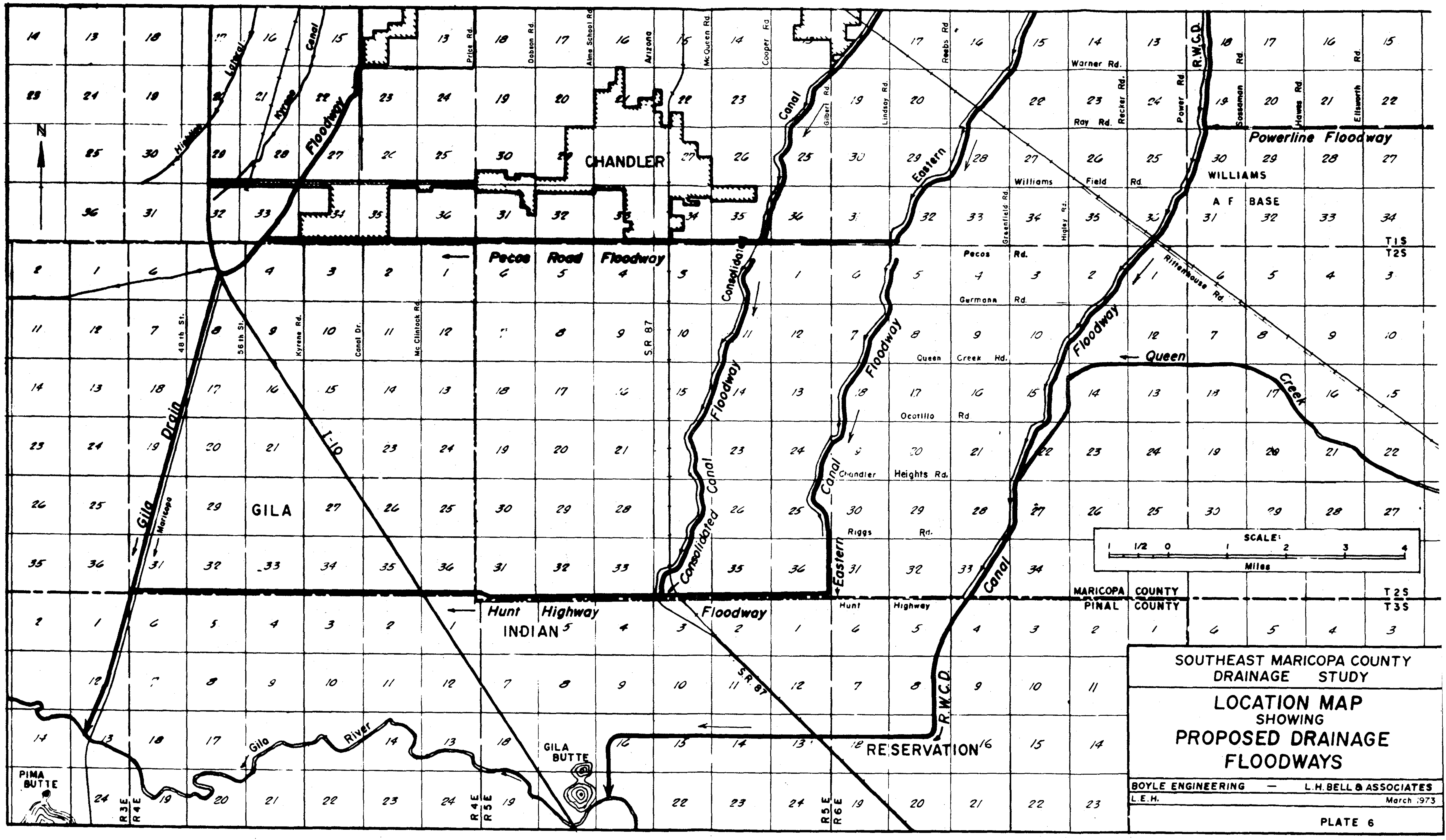
In all unlined earth section channels it was assumed that velocities under flow conditions with the 10-year return period floods (about 43 percent of the 100-year return period peak flood flows) would be maintained at less than 6 feet per second. With the probable amounts of vegetation that would become established in these channel sections they would generally remain stable under these flow conditions. Channel slope and toe stabilization would be provided in accordance with Soil Conservation Service requirements where needed. The 100-year return period flood flows would cause velocity increases of about 30 percent. However, these flow conditions would occur so infrequently and for such relatively short durations that major damages to the channel sections do not seem probable.

In area of intensive urban development unlined earth section channels have the disadvantage of requiring relatively large areas of costly lands for right-of-way and the bridge costs for the longer spans and frequent crossings become very much larger than with a concrete lined section. In such areas a rectangular concrete lined section requires the least land for right-of-way and reduces bridge costs to a minimum. A trapezoidal concrete line section requires more land for right-of-way and more costly bridges than a rectangular section, but considerably less than for an earth section channel.

For concrete lined channel sections an "n" value of 0.014 was used. Channel slopes were estimated from U.S.G.S. Quadrangle Sheets.



SOUTHEAST MARICOPA COUNTY
DRAINAGE STUDY
LOCATION MAP
SHOWING
PROPOSED DRAINAGE
FLOODWAYS
BOYLE ENGINEERING — L.H. BELL & ASSOCIATES
L. E. H.
March 1973
PLATE 5
To Salt River
Spook Hill Retarding Structure
Proposed Central Arizona Project
Buckhorn-Mesa
Watershed
Salt
River
Canal
TEMPE
MESA
GILBERT
CHANDLER
Guadalupe
Retarding Structure
GUADALUPE
Baseline Road Floodway
Western Canal Floodway
Western
Canal
Pecos Road Floodway
Consolidated Canal Floodway
Eastern Canal Floodway
Kyrene Canal Floodway
Highline Lateral
Kyrene
Gila Drain
Consolidated
Eastern
Floodway
R.W.C.D.
RWCD
PROPOSED SUPERSTITION FREEWAY
Apache Trail
US 60-80-89
SCALE:
Miles
R 3 E
R 4 E
R 5 E
R 6 E
T2N
T1N
T1S
N
McDowell Rd
McKellips Rd
Brown Rd.
University Dr.
Apache Rd
Main St
Broadway Rd
Southern Ave
Baseline Rd.
Guadalupe Rd
Elliot Rd.
Warner Rd.
Ray Rd.
Williams Field
Pecos Rd.
Germann Rd.
Hayden Rd
56th St.
48th St
Kyrene Rd
Mill Ave
Rural Rd
McClintock
Price Rd
Dobson Rd
Alma School Rd
Country Club Dr.
Arizona Ave
Mesa Dr.
McQueen Rd.
Cooper Rd
Stapley Dr.
Gilbert Rd.
Lindsay
Val Vista Dr.
Greenfield Rd.
Higley Rd.
Recker Rd.
Reebs Rd
Power Rd
Bush Highway
Sossaman Rd.
Hawes Rd.
Ellsworth Rd.

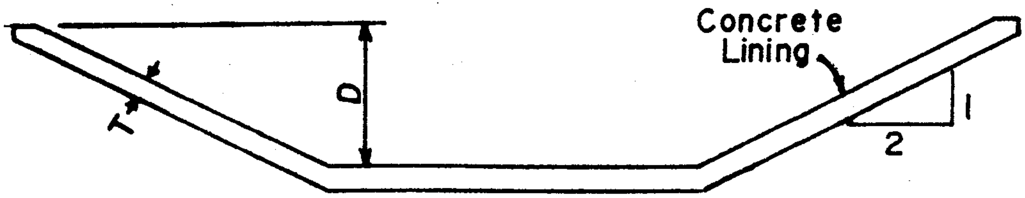


SOUTHEAST MARICOPA COUNTY
DRAINAGE STUDY

LOCATION MAP
SHOWING
PROPOSED DRAINAGE FLOODWAYS

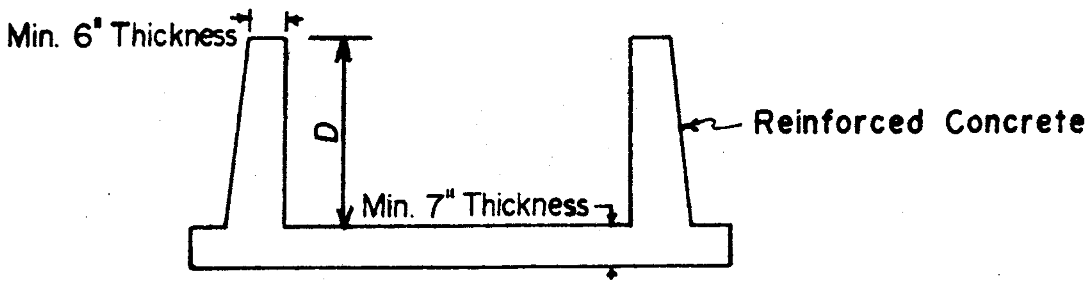
BOYLE ENGINEERING — L.H. BELL & ASSOCIATES
L.E.H. March 1973

PLATE 6



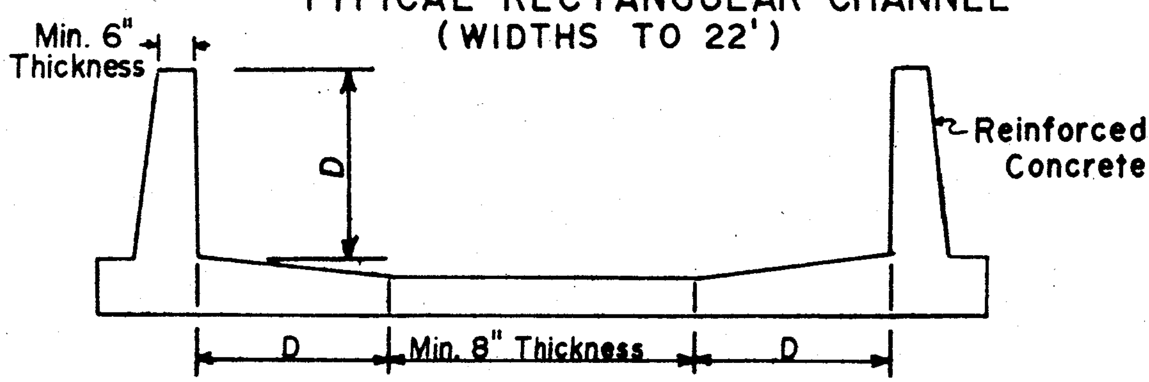
T Varies with Velocity & Whether Steel-Reinforced
(Earth Section is Identical Except for Omission of Lining)

TYPICAL TRAPEZOIDAL CHANNEL



Note: Use Non-Tapered Wall for D less than 8.5 feet.
Dimensions Vary with the Depth.

TYPICAL RECTANGULAR CHANNEL
(WIDTHS TO 22')



Dimensions Vary with Width and Depth

TYPICAL RECTANGULAR CHANNEL
(WIDTHS OVER 22')

Southeast Maricopa County
Drainage Study

TYPICAL CHANNEL SECTION

Boyle Engineering L.H. Bell & Assoc.
April 1973

PLATE 7

The total costs for excavating earth section channels were estimated on the basis of 60 cents per cubic yard except for the reach of Gila Drain below the junction with Pecos Road Floodway for which 50 cents per cubic yard was used. These costs are assumed to include the costs for installation services. All costs are based on 1973 prices.

The estimated costs of lands for rights-of-way range from $2,000 per acre for agricultural lands south of Pecos Road to $11,000 per acre for land adjacent to Baseline Road.

Costs were estimated separately for the five units which compose the total system of floodways and the outlet to the Gila River:

1. Baseline Road - Western Canal Floodway, including tributary floodways above the Eastern and Consolidated Canals.

2. Pecos Road Floodway, including tributary floodways above the Eastern and Consolidated Canals.

3. Hunt Highway Drain, including tributary floodways above the Eastern and Consolidated Canals.

4. Gila Drain - Unit 1 - from its outlet into the Gila River to the boundary of the Gila Indian Reservation near its junction with the Pecos Road Floodway.

5. Gila Drain - Unit 2 - from the boundary of the Gila Indian Reservation to its upper end at the junction with Baseline Road - Western Canal Floodway near Elliot Road.

<u>Baseline Road - Western Canal Floodway, Including Tributary Floodways</u>

The Baseline Road - Western Canal Floodway includes 15.43 miles of channel ranging in width from 38 feet to 300 feet for unlined earth channels and in depth from 9.5 feet to 13.5 feet. Allowing an average of 30 feet additional width for maintenance roads about 416 acres of land would be required for rights-of-way.

The tributary floodways above the Eastern and Consolidated Canals include 13 miles of channel ranging in width for an unlined earth section from 30 feet to 85 feet and in depth from 6.0 feet to 13 feet. Allowing additional width for maintenance roads about 189 acres of land would be required for rights-of-way.

The total construction costs including installation services costs for unlined earth section channels are estimated to be $4,816,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $8,075,000 for a total cost of $12,891,000.

The unlined earth sections on the Baseline Road - Western Canal Floodway requires extremely wide rights-of-way through a rapidly urbanizing area.

A rectangular section concrete lined channel on the Baseline Road - Western Canal Floodway would have a range of channel widths from 10 feet to 85 feet with depths ranging from 6 feet to 13 feet. About 169 acres of land would be required for right-of-way. The total construction costs for this project unit with rectangular section concrete lined channel on the Baseline Road - Western Canal Floodway and earth section on the tributary floodways are estimated to be $27,298,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $3,885,000 for a total cost of $31,183,000.

A trapezoidal section concrete lined channel on the Baseline Road - Western Canal Floodway would have a range of channel widths from 22 feet to 110 feet with depths ranging from 6.5 feet to 14 feet. About 238 acres of land would be required for right-of-way. The total construction costs for this project unit with trapezoidal section concrete lined channel on the Baseline Road - Western Canal Floodway and earth section on the tributary floodways are estimated to be $9,171,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $5,000,000 for a total cost of $14,171,000.

Pecos Road Floodway Including Tributary Floodways

The Pecos Road Floodway includes 10.66 miles of channel ranging in width for an unlined earth section from 58 feet to 98 feet and in depth from 8.5 feet to 12 feet. Allowing an average of 30 feet additional width for maintenance roads about 160 acres of land would be required for right-of-way.

The tributary floodways above the Eastern and Consolidated Canals include 11 miles of channel ranging in width for an unlined earth section from 25 feet to 66 feet and in depth from 5 feet to 9 feet. Allowing additional width for maintenance roads about 146 acres of land would be required for rights-of-way.

The total construction costs including installation services costs for unlined earth section channels are estimated to be $1,724,000, and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $2,026,000 for a total cost of $3,750,000.

A rectangular section concrete lined channel on the Pecos Road Floodway would have a range of channel widths from 14 feet to 24 feet with depths ranging from 11.5 feet to 14 feet. About 44 acres of land would be required for rights-of-way. The total construction costs for this project unit with rectangular section concrete lined channel on the Pecos Road Floodway and earth section on the tributary floodways are estimated to be $13,038,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,542,000 for a total cost of $14,580,000 .

A trapezoidal section concrete lined channel on the Pecos Road Floodway would have a range of channel widths from 43 feet to 73 feet with depths ranging from 8.5 feet to 12 feet. About 101 acres of land would be required for right-of-way. The total construction costs for this project unit with trapezoidal section concrete lined channel on the Pecos Road Floodway and earth section on the tributary floodways are estimated to be $4,607,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,714,000 for a total cost of $6,321,000 .

Hunt Highway Drain Including Tributary Floodways

The Hunt Highway Drain includes 11.52 miles of channel ranging in width for an unlined earth section from 35 feet to 49 feet and in depth from 5.25 feet to 6 feet. About 111 acres of land would be required for right-of-way.

The tributary floodways above the Eastern and Consolidated Canals include 10 miles of channel ranging in width for an unlined earth section from 20 feet to 38 feet and in depth from 4 feet to 6 feet. About 123 acres would be required for right-of-way.

The total construction costs including installation services costs for unlined earth section channels are estimated to be $1,042,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,020,000 for a total cost of $2,062,000.

It seems improbable that concrete lined section channels would be considered for the intensity of development assumed in the hydrologic analysis.

Gila Drain - Unit I - Gila River to Boundary of Gila Indian Reservation

This unit of the Gila Drain includes about 9 miles of channel ranging in width for an unlined earth section from 255 feet to 358 feet and in depth from 10 feet to 14.5 feet. About 402 acres of land would be required for right-of-way.

The total construction costs including installation services costs for an unlined earth section channel are estimated to be $3,843,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,424,000 for a total cost of $5,267,000.

It seems improbable that concrete lined channel sections would be considered for this unit of the Gila Drain.

Gila Drain - Unit 2 - Boundary of Gila Indian Reservation to Junction With Western Canal Floodway

This unit of the Gila Drain includes about 5 miles of channel ranging in width for an unlined earth section from 200 feet to 205 feet and in depth from 12.5 feet to 13.5 feet. About 149 acres of land would be required for right-of-way.

The total construction costs including installation services costs for an unlined earth section channel are estimated to be $1,633,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,832,000 for a total cost of $3,465,000 .

This unlined earth section channel requires extremely wide rights-of-way through this rapidly urbanizing area.

A rectangular section concrete lined channel would have a channel width of 70 feet with depths ranging from 14 feet to 15.5 feet. About 68 acres of land would be required for rights-of-way. Construction costs for this project unit with rectangular section concrete lined channel are estimated to be $12,448,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $807,000 for a total cost of $13,255,000.

A trapezoidal section concrete lined channel would have a range of channel widths from 104 feet to 116 feet with depths ranging from 14.5feet to 15 feet. About 95 acres of land would be required for right-of-way. Construction costs for this project unit with trapezoidal section concrete lined channel are estimated to be $3,737,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,144,000 for a total cost of $ 4,881,000 .

Estimated Costs for Channel Improvements to Contain the More Frequently Occurring Floods

Providing channel improvements with smaller capacities to contain the more frequently occurring peak flood flows would cost less, but the reduction in cost would be considerably less than the proportionate reduction in capacities.

Table 11 summarizes the estimated cubic yards of concrete required per linear foot of channel improvement for capacities representing the relative peak flows for the 100-, 50-, 25- and 10-year return periods. These estimates of concrete required are based on Soil Conservation Service design standards for open rectangular section concrete lined channels. These estimates were based on 100-year return period floods of 12,000 cfs and 4,000 cfs which represents the range within the Western Canal-Baseline Road Floodway.

The concrete requirements per linear foot of channel will vary with the constraints that may be applied to depths of flow because of maximum depths desired or for other reasons. In this analysis the most efficient sections in the use of concrete were used.

For the larger flows (100-year return period - 12,000 cfs) this analysis indicates that concrete requirements per linear foot of channel increase at about half the percent rate of increase of design capacities provided. For the smaller flows (100-year return period - 4,000 cfs) it is indicated that the concrete requirements increase at about one-third the rate of increase of design capacities.

There is less right-of-way requirement for the smaller channels and probably a higher unit cost for the smaller sections. However, this analysis indicates that project costs will increase at about 50 percent of the increase in design capacities provided in channel systems. This is summarized as follows in relation to the 10-year return period flood flows:

Return Period Years	Capacity Requirements Ratio to 10-Year R.P.	Estimated Project Costs Ratio to 10-Year R.P.
10	1.00	1.00
25	1.35	1.18
50	1.94	1.47
100	2.31	1.65

These relationships apply similarly to unlined earth section channel improvements.

TABLE 11

CUBIC YARDS CONCRETE REQUIRED PER LINEAR FOOT OPEN RECTANGULAR CONCRETE LINED CHANNEL TO PROVIDE CAPACITIES FOR FLOODS OF VARIOUS RETURN PERIODS

DEPTHS OF FLOW - FEET

Return Period Years	Q cfs	Ratio to 10-Year	d = 11.0 D[1/]/b	d = 11.0 Cu. Yds. Per L.F.	d = 10.0 D/b	d = 10.0 Cu. Yds. Per L.F.	d = 9.0 D/b	d = 9.0 Cu. Yds. Per L.F.	d = 8.0 D/b	d = 8.0 Cu. Yds. Per L.F.	Most Efficient Sections D/b	Most Efficient Sections Cu. Yds. Per L.F.	Most Efficient Sections Ratio to 10-Year
100	12,000	2.31	12.6/60	2.799							12.6/60	2.799	1.59
50	10,100	1.94	12.6/53	2.628	11.5/60	2.459					11.5/60	2.459	1.40
25	7,000	1.35	12.5/39	2.275	11.4/44	2.059	10.3/50	2.064	9.2/58	2.100	11.4/44	2.059	1.17
10	5,200	1.00	12.5/31	2.079	11.4/34	1.814	10.2/39	1.759	9.1/45	1.875	10.2/39	1.759	1.00

DEPTHS OF FLOW - FEET

Years	Q cfs	Ratio to 10-Year	d = 9.0 D/b	d = 9.0 Cu. Yds. Per L.F.	d = 8.0 D/b	d = 8.0 Cu. Yds. Per L.F.	d = 7.0 D/b	d = 7.0 Cu. Yds. Per L.F.	d = 6.0 D/b	d = 6.0 Cu. Yds. Per L.F.	Most Efficient Sections D/b	Most Efficient Sections Cu. Yds. Per L.F.	Most Efficient Sections Ratio to 10-Year
100	4,000	2.31	10.2/31	1.563	9.1/36	1.554	8.0/43	1.539	6.9/52	1.691	8.0/43	1.539	1.49
50	3,400	1.94	10.2/28	1.489	9.1/32	1.456	8.0/37	1.392	6.9/45	1.531	8.0/37	1.392	1.34
25	2,300	1.35	10.1/20	1.256	9.0/23	1.230	8.0/27	1.147	6.8/32	1.206	8.0/27	1.147	1.11
10	1,700	1.00	10.1/16	1.232	9.0/18	1.201	7.9/21	1.038	6.8/25	1.035	6.8/25	1.035	1.00

1/ D = depth of channel section, including freeboard, in feet.
Channel slope = 0.002 ft/ft. All velocities less than critical.
b = width of channel, feet.

PROJECT INSTALLATION PRIORITIES

The preferred sequence for project installation to control floods in the study area is:

1. Buckhorn-Mesa P.L. 566 Project Structural Measures (Spook Hill floodwater retarding reservoir and appurtenant diversions and outlets).
2. Roosevelt Water Conservation District Floodway - progressive installation from the Gila River to Brown Road.
3. Lower Queen Creek floodwater retarding structure and floodway.
4. Gila Drain progressive installation from the Gila River to Western Canal Floodway.
5. Baseline Road - Western Canal Floodway from its junction with Gila Drain to junction with Eastern Canal Floodway.
6. Eastern Canal Floodway to Baseline Road.
7. Consolidated Canal Floodway to Baseline Road.
8. Laterals into Western Canal Floodway from the area below the Consolidated Canal Floodway.
9. Local drains along Warner, Ray and Williams Field Roads which discharge directly into Gila Drain.
10. Pecos Road Floodway from its junction with Gila Drain to junction with Eastern Canal Floodway.
11. Eastern Canal Floodway from Baseline Road to Pecos Road Floodway.
12. Consolidated Canal Floodway from Baseline Road to Pecos Road Floodway.
13. Local drains between Pecos Road Floodway and Hunt Highway Drain which discharge directly into Gila Drain.
14. Hunt Highway Drain.

This sequence for project installation is preferred on the basis that the installation of each project element will not cause damages because of unnatural concentrations of flood flows without continued control to a safe outlet. Variations from this sequence can be made to meet the requirements for immediate needs if temporary provisions are made to assure that safe outlets are provided.

INTERIM FLOOD CONTROL MEASURES

It will be some time in the future before all of the project structural measures for flood control considered in this study can be installed practically.

The Public Law 566 projects that are approved for construction can be installed as rapidly as provisions are made to meet other costs than those that are federally funded under provisions of Public Law 566, and as Public Law 566 funds become available. The completion of the work plan for a Public Law 566 project on Lower Queen Creek and obtaining approval for construction will further delay the installation of the anticipated structural measures for this project. The installation of all structural measures included in these Public Law 566 projects will provide control of major floods from the eastern part of the area to the Roosevelt Water Conservation District Canal and flood protection for the community of Guadalupe and freeway I-10 in the western part.

The major immediate need for flood control measures in the area west of the Roosevelt Water Conservation District Canal is an outlet to the Gila River for concentrations of runoff from this area. Expanding urban development is causing greatly increased amounts of runoff because of reduced infiltration rates. Other developments that are needed because of the increased population, such as the Superstition Freeway, cause concentrations of this runoff which greatly increase the damage potential if stable outlet channels with adequate capacities are not provided.

Federal assistance in providing an outlet to the Gila River and the major collector channels and floodways in the area west of the Roosevelt Water Conservation District Canal will probably be delayed for the longest period of time because of the time required for project planning, review and approval. In the interim between the present time and the completion of these structural measures temporary measures will be required to permit continued urban development and associated improvements.

The cities of Tempe and Mesa are beginning to require that any new subdivision development provide for the control and non-damaging disposal of runoff from their development. The planning of these subdivisions provides for the storage and infiltration of runoff from each residential lot on the lot and for runoff from the subdivision streets to be collected in holding reservoirs from which the water is to be pumped into available outlet channels, such as the irrigation water supply canals, at rates that can be accommodated in these outlets.

The capacity requirements on the lots and in the holding reservoirs is based on the runoff that is estimated to occur from the 50-year return period flood. The 50-year return period, 24-hour duration, precipitation intensity estimated for this area is 3.4 inches. The estimated runoff from a 7,000 square foot residential lot for this 24-hour precipitation intensity is about 1,000 cubic feet and this volume of temporary storage capacity would be required. The infiltration rates in this area range from about 0.15 inch to 0.40 inch per hour which provides the basis for estimating the area required for the storage basins.

For a one half square mile urban development temporary storage capacity of about 10 acre-feet would be required in a holding reservoir to contain the runoff from subdivision streets.

The application of this requirement to new subdivision developments would limit the uncontrolled runoff to that from the major roads at one mile and half mile intervals. This will maintain the amounts of runoff with urban development to about that which occurs with agricultural use of the land. The application of this requirement to lands under the jurisdiction of Maricopa County would help to alleviate the flood problems caused by urban development on these lands.

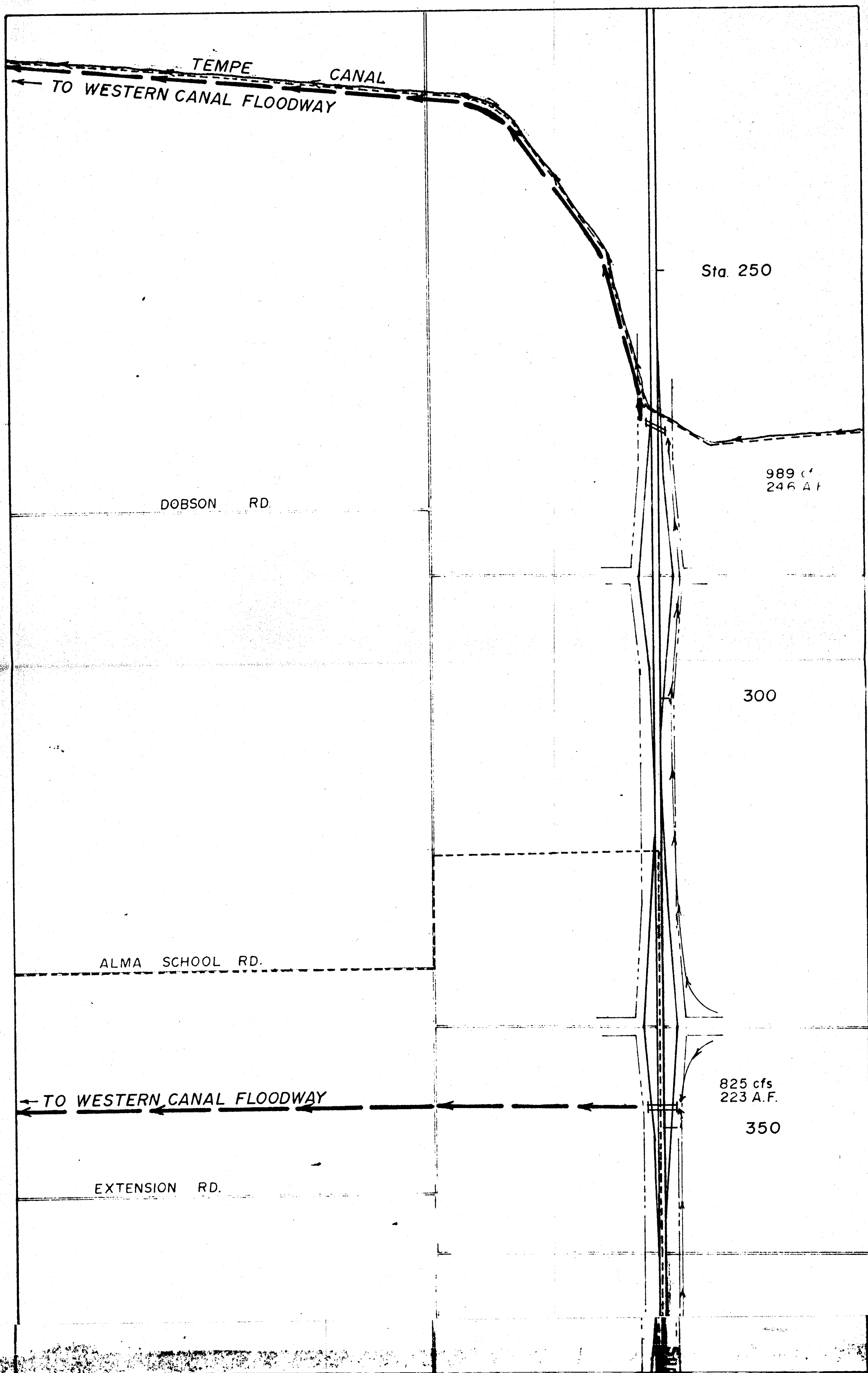
The most immediately urgent runoff problem is to provide for disposition of concentrations of runoff from the City of Mesa north of the Superstition Freeway alignment at freeway culvert crossings. With the rigid application of the requirement that new subdivision developments contain their runoff, the probability of runoff from the areas east of the Consolidated Canal breaching the

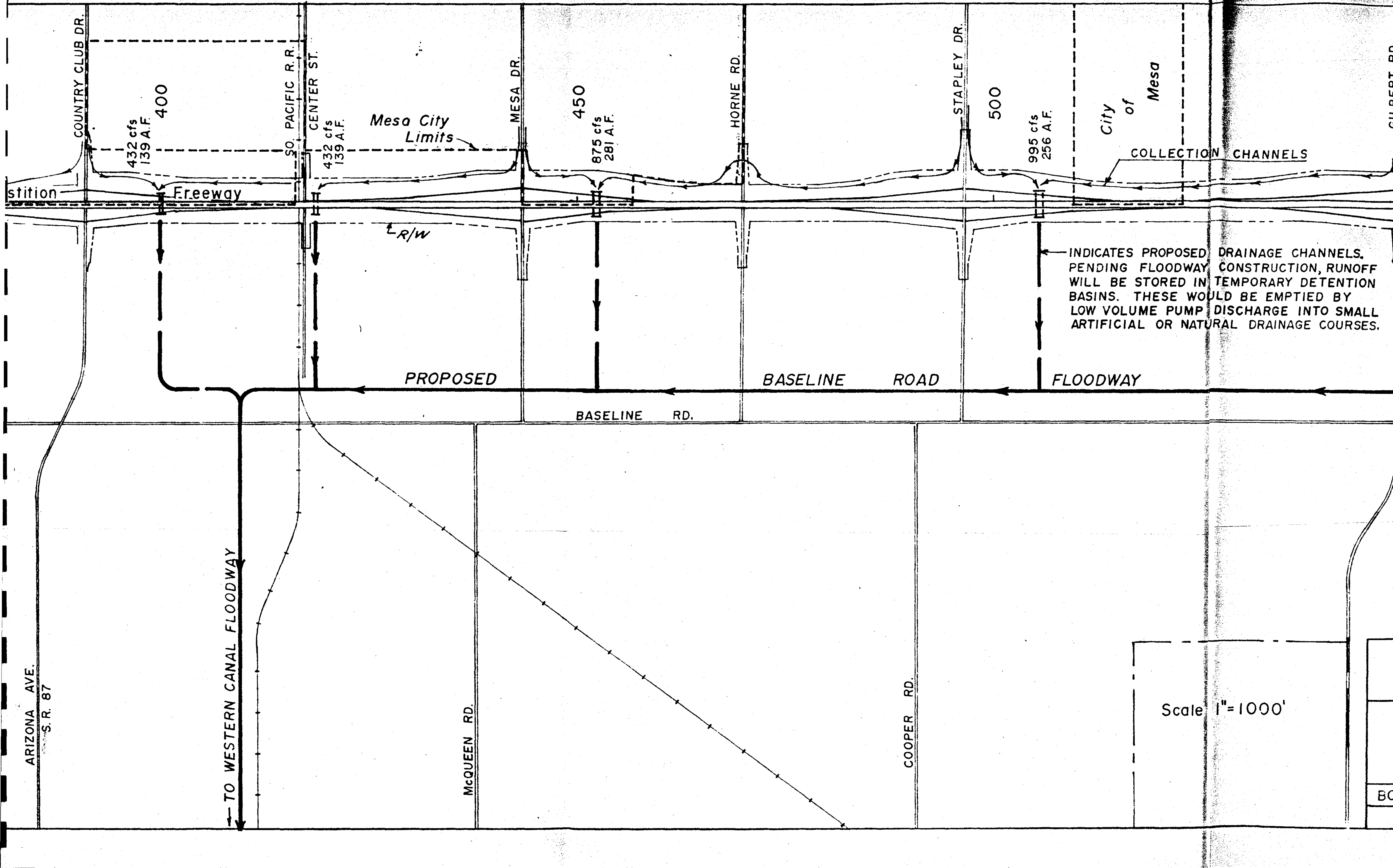
Eastern and Consolidated Canals and entering this area will not be greater than it is under existing conditions. These canals with their small protecting floodways have capacities to divert the more frequently occurring runoff without breaching.

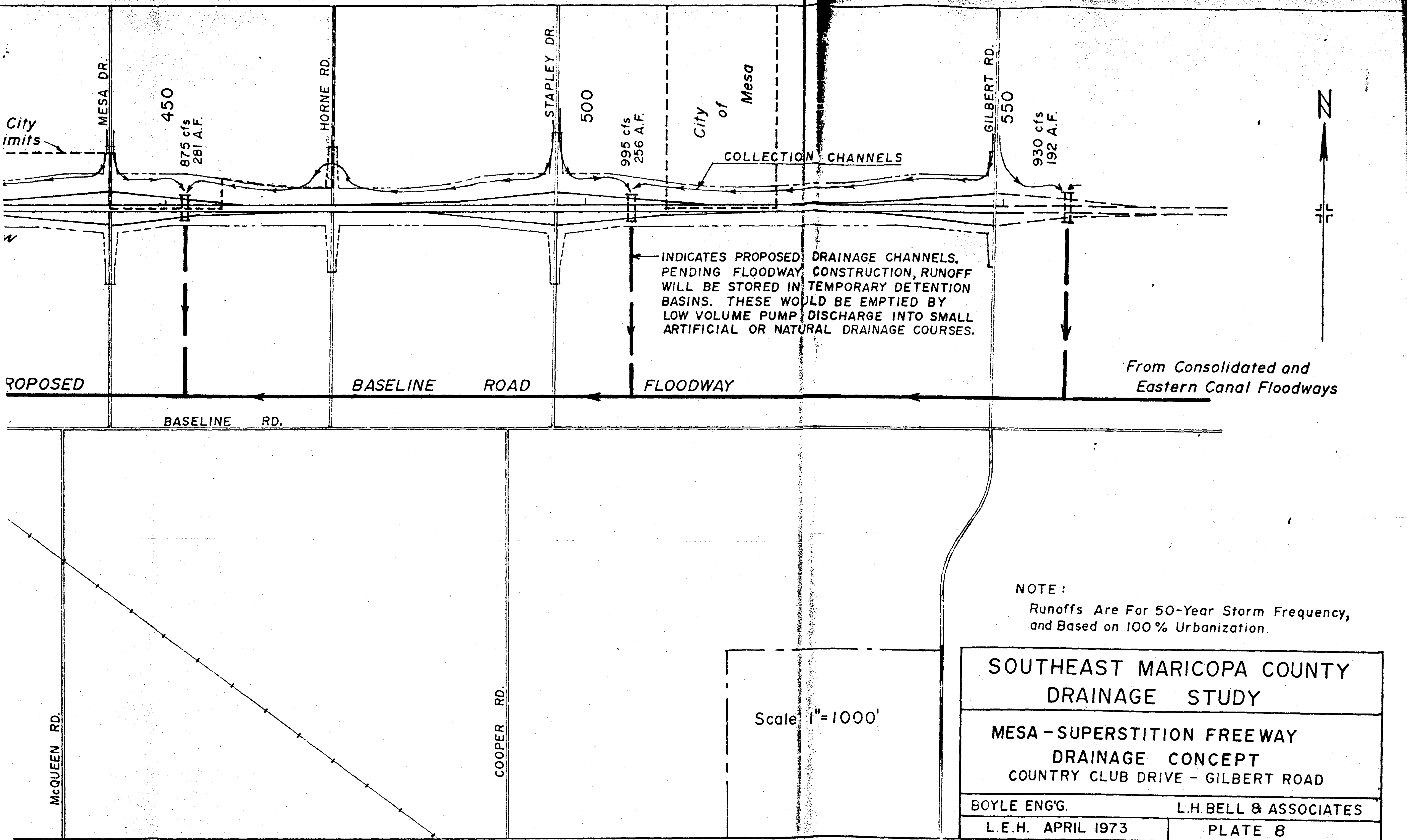
The plan for the control of runoff after the Gila Drain and the major floodways have been installed is for the storm drainage collector system in the City of Mesa to discharge at culvert crossings through the Superstition Freeway. Superstition Freeway crossings can be provided at points where the freeway profile permits these crossings, which is generally at intervals of about one mile. Channels from these culvert crossings would connect with the Western Canal Floodway.

In the interim prior to the provision of outlet capacities in the Western Canal Floodway and the Gila Drain, the concentrations of flood flows through the freeway culverts create a disposal problem. It is proposed that an interim solution would be to collect the storm runoff on the north side of the Superstition Freeway with collector systems as they become installed or by dikes to direct the accumulated flows to the culvert crossings. The culvert outlets would discharge into channels which would terminate at temporary storage ponds. The accumulated storm runoff would be pumped from these ponds at rates which could be accommodated in the Western Canal and the Gila Drain.

Plate 8 illustrates the concept for accumulating storm runoff from the north side of the freeway at the freeway culvert crossings. Table 8 summarizes the estimated peak flood flows and volumes of runoff for concentration points at these culvert crossings for various return periods. The temporary storage ponds would have capacities to contain the volumes of runoff estimated for the flood having the return period from which full protection is considered necessary. This may vary between ponds depending upon the damage potential in the event that the capacities of the ponds were exceeded. It is probable that pond capacities should not be less than the volumes of runoff estimated for the 10-year return period flood.


TEMPE CANAL
TO WESTERN CANAL FLOODWAY
Sta. 250
989 c
246 A
DOBSON RD.
300
ALMA SCHOOL RD.
825 cfs
223 A.F.
TO WESTERN CANAL FLOODWAY
350
EXTENSION RD.


COUNTRY CLUB DR.
SO. PACIFIC R.R.
CENTER ST.
MESA DR.
HORNE RD.
STAPLEY DR.
GILBERT RD.
400
450
500
432 cfs
139 A.F.
432 cfs
139 A.F.
875 cfs
281 A.F.
995 cfs
256 A.F.
Mesa City
Limits
City
of
Mesa
COLLECTION CHANNELS
stition
Freeway
R/W
INDICATES PROPOSED DRAINAGE CHANNELS. PENDING FLOODWAY CONSTRUCTION, RUNOFF WILL BE STORED IN TEMPORARY DETENTION BASINS. THESE WOULD BE EMPTIED BY LOW VOLUME PUMP DISCHARGE INTO SMALL ARTIFICIAL OR NATURAL DRAINAGE COURSES.
PROPOSED
BASELINE
ROAD
FLOODWAY
BASELINE RD.
ARIZONA AVE.
S.R. 87
TO WESTERN CANAL FLOODWAY
McQUEEN RD.
COOPER RD.
Scale 1"=1000'
BC



NOTE:
Runoffs Are For 50-Year Storm Frequency, and Based on 100 % Urbanization.

SOUTHEAST MARICOPA COUNTY DRAINAGE STUDY

MESA – SUPERSTITION FREEWAY DRAINAGE CONCEPT
COUNTRY CLUB DRIVE – GILBERT ROAD

BOYLE ENG'G.	L.H. BELL & ASSOCIATES
L.E.H. APRIL 1973	PLATE 8

This concept of controlling the runoff concentrations at freeway culvert crossings will permit control with temporary storage ponds to be accomplished incrementally as the freeway installation progresses.

The estimated peak flood flows and volumes summarized in Table 8 are based on urban development of the area West of Consolidated Canal and North of the Superstition Freeway similar to existing urban development in the area. Until such development occurs, the peak flood flows and volumes would be less than those estimated. To the extent that future urban development contains and controls runoff in accordance with the City of Mesa's present criteria, these lesser peak flows and volumes would be maintained as urban development expands. The City of Mesa is currently developing a plan for storm drainage in this area which will consider the effects of these considerations. Superstition Freeway culvert capacities whould probably be based on the peak flows summarized in Table 8, but the interim holding pond capacities could reasonable be less when the estimated effects of these controls on new development have been evaluated.

The Gila Drain has very limited capacities under existing conditions in some reaches from the outlet of Western Canal to the Gila River. An interim improvement of the Gila Drain to contain at least the capacity of Western Canal would provide better temporary outlet conditions for natural runoff and for pumped releases from temporary storage ponds. The capacity of Western Canal is estimated at 500 cubic feet per second. Some reaches of the Gila Drain have capacities of 55 cubic feet per second or less.

When the concept of the ultimate channel system has been firmly established and rights-of-way locations are determined, interim channel improvements to contain the more frequently occurring floods may be installed to alleviate the more immediate problems.

Priorities for these interim improvements should be considered as follows:

1. Reduce the runoff from new subdividison developments by on-lot retention and accumulation of street runoff in temporary retention ponds as currently practiced by the Cities of Mesa and Tempe; and expand the application of this requirement to lands under the jurisdiction of Maricopa County. This will assist in maximizing the effectiveness of existing outlet facilities and reduce the possibility of flood flows breaching the Eastern and Consolidated Canals and entering the City of Mesa.

2. Progressive installation of facilities to control the runoff from the City of Mesa at culvert crossings as the installation of the Superstition Freeway is extended to the east.

3. Increase capacities in the Gila Drain to accommodate flows from the Western Canal.

4. Make interim improvements to relieve local flood problems within the pattern of the channel system concept for ultimate improvements.

CONCLUSIONS AND RECOMMENDATIONS

The rapid change of land use in this area from agriculture to urban causes progressively larger amounts of runoff, and the urban development increases the potential for damages when floods occur. The need for an integrated system of flood control measures to provide protection for existing development and anticipated future development is urgent.

A major part of the flood problem would be solved with the installation of the remaining structural measures included in the three Public Law 566 projects in the eastern part of the area which have been approved for construction by the Congress of the United States. These completed projects will control the runoff from the entire area east of the Roosevelt Water Conservation District Canal and discharge it through a floodway constructed above the Roosevelt Water Conservation District Canal and extended through the Gila Indian Reservation to the Gila River.

Senate Bill 1104, recently approved by the Legislature of the State of Arizona provides for making allocations from the general fund for flood control projects to pay for one-half the cost of lands, easements, and rights-of-way necessary for the construction of flood control projects adopted and authorized by the Congress of the United States and recommended by the Arizona Water Commission and approved by the Legislature as Congress makes available funds for their construction. This bill appropriates $1,350,000 for the Roosevelt Water Conservation District Floodway project and $1,000,000 for the Buckhorn-Mesa project to the Arizona Water Commission to carry out the provisions of this act. These funds in combination with local matching funds will provide a major part of costs other than those funded under provisions of Public Law 566 for the completion of these projects.

It is recommended that the procurement of rights-of-way for these projects be expedited so that their installation can be completed as rapidly as Public Law 566 funds are made available.

The Soil Conservation Service is presently developing a work plan for the lower Queen Creek project to provide a floodwater retarding reservoir to control the runoff from the drainage area of Queen Creek below Whitlow Dam. The installation of measures considered for inclusion in this project would complete the control of runoff from the entire area east of the Roosevelt Water Conservation District Canal between the Salt River and the Gila River.

It is recommended that the Soil Conservation Service be urged to expedite the completion of the lower Queen Creek watershed work plan.

The Guadalupe Public Law 566 Project has been approved for construction by the Congress of the United States and rights-of-way are presently being procured.

It is recommended that completion of rights-of-way procurement be expedited and that the Soil Conservation Service be urged to proceed with installation of the project measures.

This study has indicated the engineering feasibility of controlling the runoff from the area west of the Roosevelt Water Conservation District Canal with a combination of collector systems and floodways discharging into an outlet to the Gila River. The major elements of this system include a floodway along Baseline Road and Western Canal alignment; a floodway along Pecos Road; and a floodway along Hunt Highway; all discharging into a common outlet designated as the Gila Drain to the Gila River. These projects are of such magnitude that federal assistance may be obtained through the flood control assistance programs of the Corps of Engineers and the Soil Conservation Service.

It is recommended that these potential projects be discussed with representatives of the Corps of Engineers and the Soil Conservation Service. On the basis of these discussions it should be determined from which agency assistance should be requested for all or parts of the needed improvements. It may be that assistance from both agencies may be requested based upon an appropriate division of the area.

The right-of-way requirement for the GilaDrain through the Gila Indian Reservation should be discussed with the Tribe in the near future. Arragements should be made for obtaining the lands for right-of-way so that they may be used in the development of interim improvements.

The project elements were formulated on the basis of providing capacities to contain the runoff estimated of occur with the 100-year return period floods under conditions of anticipated urban development. Estimates of installation cost were made for unlined earth section channels and for concrete lined channels with rectangular and trapezoidal sections. The least capital cost for improvements is required for unlined earth section channels. However, operation and maintenance costs are much higher for earth-section channels than for concrete lined channels, greater widths of land for right-of-way are required and bridge costs are much larger because of the longer spans required.

It is recommended in project development that all of these factors be considered especially for presently or anticipated intensively urbanized areas where frequent bridge crossings are required and the relatively wide earth section channels may have an adverse environmental impact.

In the hydrologic analysis for this study runoff was estimated for the 100-year return period flood and other return periods for some areas under specified conditions of anticipated urban development. This was accomplished using the Soil Conservation Service computer program, TR-20, Hydrology for Project Formulation. In the interim between the present and the time that the ultimate projects are installed interim improvements may be required to control the more frequently occurring floods under conditions of urban development varying from those used in this study.

It is recommended that the Flood Control District of Maricopa County obtain the computer program, TR-20, Hydrology for Project Formulation for use with the County's IBM 1130 computer. With the parameters established in this study for hydrologic analysis adjustments can be made to obtain runoff estimates for other return periods and intensities of urban development.

Interim improvements will be required between the present and the time that the ultimate projects are installed to permit the continuing development of the area.

At present the cities of Mesa and Tempe are requiring that new developments require the containment of runoff from individual residential lots on the lots until it infiltrates or evaporates; and the runoff from subdivision streets in ponds to be disposed of at rates compatible with the capacities of existing outlet facilities. These requirements tend to neutralize the effects of urban development in increasing runoff to outlet channels.

It is recommended that Maricopa County establish similar requirements for urban development on county lands.

The development of the Superstition Freeway could continue without causing increased flood damages due to concentrations at culvert crossings if these flood volumes were temporarily stored in ponds and released at rates compatible with capacities of existing outlet channels.

It is recommended that the City of Mesa and the State Highway Department obtain agreement with regard to responsibilities for the disposal of these flood volumes as to permit the continued construction of the Superstition Freeway.

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