2

Charles Laird

SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT

COMPREHENSIVE STORM DRAIN PLAN
PROJECT 3-3
RIALTO CHANNEL DRAINAGE AREA

VOLUME I
STORM DRAIN SYSTEMS

JMM James M. Montgomery Consulting Engineers Inc. in association with Bill Mann & Associates

SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT

COMPREHENSIVE STORM DRAIN PLAN

PROJECT 3-3

RIALTO CHANNEL DRAINAGE AREA

VOLUME I

STORM DRAIN SYSTEMS

APRIL 1988

James M. Montgomery, Consulting Engineers, Inc.
in association with
Bill Mann & Associates

- Volume VI, Rialto Channel Hydrology Computer Printout Data (South of Randall Avenue), provides the computer printouts for the analyses of the Rialto Channel south of Randall Avenue.

The report also includes a study, performed in conjunction with the City of Rialto, to utilize the Cactus Basin area, in addition to its primary functions as a flood control retention facility, as a park and recreation and water conservation facility. The study concludes that a 15-acre parcel in the southwest portion of the basin area could be utilized for park and recreation activities and that the excavated portion of the retention basins could be utilized for football, soccer, baseball, etc. activities.

The total construction costs for all the components of Project 3-3, including 20 percent contingency, is $99,428,500. These cost estimates are based on an Engineering News Record (ENR) construction cost index for Los Angeles County of 5450 (January 1986).

The cooperation and assistance received during preparation of the report from the staffs of the County of San Bernardino and the Cities of Rialto, Fontana, and Colton have been greatly appreciated. We will be pleased to discuss any aspect of this comprehensive storm drainage plan at your convenience.

Respectfully submitted,

Miles E. Wollam

Miles E. Wollam, P.E.
Project Manager

/pbs

Enclosures

OFFICIALS OF THE COUNTY OF SAN BERNARDINO

BOARD OF SUPERVISORS

John Joyner, Chairman
Jon D. Mikels
Barbara Cram Riordan
Larry Walker
Robert L. Hammock

ADMINISTRATION

Ken A. Miller, P.E., Director of Environmental Public Works Agency
Charles L. Laird, P.E., Assistant Director for Planning
Lewis S. Neeb, P.E., Project Manager
Robert W. Corchero, P.E., Chief of Water Resources Division

COMMUNITY REPRESENTATIVES

Renato Ranoa, P.E., City of Rialto
Clayton Cabrinha, City of Rialto
Alexander "Sandy" McKinley, City of Rialto
Felipe Molinos, City of Fontana
Robert Schoenborn, P.E., City of Fontana
John Hutton, P.E., City of Colton
C. Glen Wilson, P.E., City of Colton

PROJECT STAFF

ENGINEERING

Miles E. Wollam, Project Manager
Douglas M. Hahn, Project Engineer
Bill C. Mann, Bill Mann & Associates
Win-Kai Liu, Engineer
Arsalan Dadkhah, Senior Engineer
Cathy Anderson, Engineer
Karen Murphy, Engineer
Bessie Lee, Engineer
Peter Sturtevant, Engineer
Kevin Reagan, Engineer

GRAPHIC ARTS

Mary Shick, Graphics Artist
Ann Mancilla, Graphics Artist
Linda Dickson, Graphics Artist

WORD PROCESSING

Donna Wiesbach

REPORT REPRODUCTION

Jack Bencomo

TABLE OF CONTENTS

Table of Contents

Table of Contents

CHAPTER 9 - PHASED CONSTRUCTION APPROACH

CHAPTER 10 - PLANS, PROFILES, AND COST ESTIMATES

APPENDICES

APPENDIX A - ABBREVIATIONS AND DEFINITIONS

APPENDIX B - LETTERS OF CONCURRENCE

APPENDIX C - CACTUS BASIN PARK ALTERNATIVES

APPENDIX D - RATIONAL METHOD SUMMARY TABLES VOLUME II

Table of Contents

ADDITIONAL VOLUMES

Table of Contents

LIST OF TABLES

Table of Contents

LIST OF FIGURES

[a] Full-page figures are on page following number shown on this list.

Table of Contents

LIST OF FIGURES (Continued)

[a] Full-page figures are on page following number shown on this list.

CHAPTER 1

CHAPTER 1

INTRODUCTION

This report presents a comprehensive storm drain plan for the areas draining to the Rialto Channel. A system of drainage control facilities including channels, detention basins and underground pipes and culverts is discussed along with cost estimates, assignments of priority and a phased construction approach for various components of the plan.

AUTHORIZATION

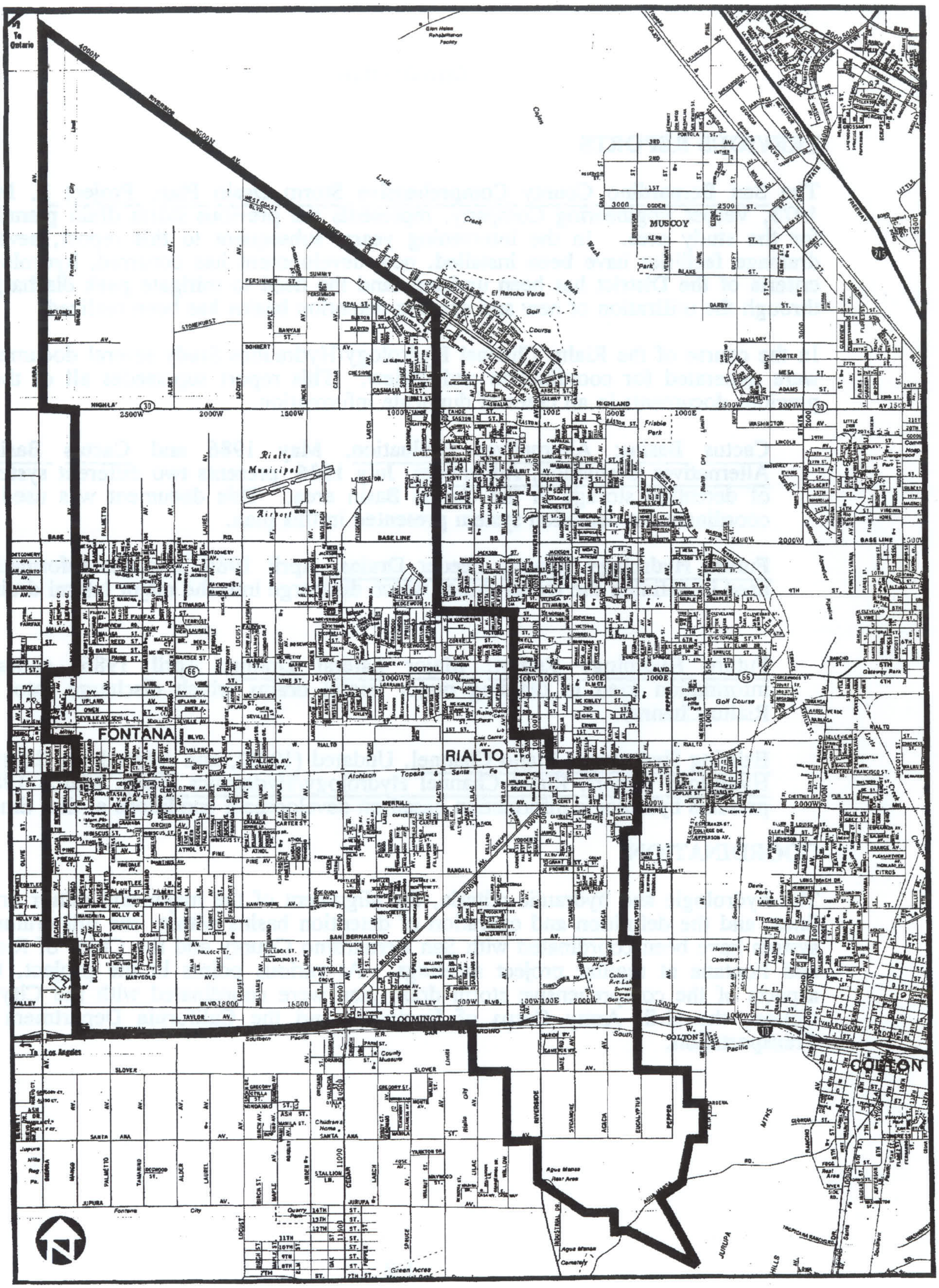
This comprehensive storm drainage plan was prepared in accordance with contract number 84-858-A1 between the County of San Bernardino Flood Control District (District) and James M. Montgomery, Consulting Engineers, Inc. (JMM) dated December 17, 1984.

LOCATION

The area covered in this storm drain plan is the approximately twenty-six square mile watershed drained by the Rialto Channel. It is located in the southwestern corner of San Bernardino County from the southern portion of the Lytle Creek alluvial fan down to the Santa Ana River (Figure 1-1). Most of the drainage area lies north of Interstate Highway 10 (I-10) and is approximately bounded by Sierra Avenue on the west and by Riverside Avenue on the east and the north. Lytle Creek Channel lies immediately to the north and effectively prevents any runoff from the nearby San Gabriel Mountains from entering the study area.

PURPOSE

The purpose of this hydrology/hydraulics study and comprehensive storm drain plan is to present a system of drainage facilities that 1) is efficient, 2) is coordinated between the various municipalities, 3) conforms to current hydrologic and hydraulic criteria established by the District, and 4) will accommodate the planned future development of the area. This study will be used by local communities in planning future drainage improvements and other improvements that will be impacted by the drainage system. The comprehensive storm drain plan defines drainage facilities to a level which will enable reasonable cost estimates to be made, but does not represent the detailed design of new facilities. This plan presents base information which will aid in the design of future drainage facilities.



VICINITY MAP
FIGURE 1-1

Introduction

PREVIOUS REPORTS

The San Bernardino County Comprehensive Storm Drain Plan, Project 3, May 1973, Verpet Engineering Company, represents the previous storm drain planning for the study area. In the intervening years, subsequent to this report, several drainage facilities have been installed, new development has occurred, hydrologic criteria of the District has been updated, and the need to mitigate peak discharges through the utilization of new and existing detention basins has been realized.

In the course of the Rialto Channel Hydrology/Hydraulics Study several documents were generated for coordination and review. This report supersedes all of these previous documents in all cases of duplicate information.

Cactus Basins: Alternatives Evaluation, May 1986 and Cactus Basins: Alternatives Evaluation, Addendum, July 1986, presents two different systems of detention storage in the Cactus Basin area. This document was used to coordinate the detention system presented in this plan.

Future Hydrology Report: Feeder Drains, April 1986, contains information used in defining the feeder drains which discharge into the major lateral drains.

Future Hydrology Report: Major Lateral Drains, April 1986, contains information used in defining major lateral drains which discharge into the Rialto Channel.

Existing Hydrology: Rialto Channel, Undated (1986), and Addendum: Existing Hydrology Report, Rialto Channel Hydrology/Hydraulics Study, March 1986, presents hydrologic information based on development conditions at that time.

COORDINATION

The hydrologic and hydraulic criteria, the alignment of the major and minor drain lines, and the definition and operation of detention basins within the full drainage system have been coordinated with San Bernardino County and the Cities of Rialto and Fontana at regular project meetings. At various points in the project, key aspects of the comprehensive storm drain plan were coordinated with the City of Colton, the U.S. Army Corps of Engineers and the California Department of Transportation.

CHAPTER 2

CHAPTER 2

HYDROLOGIC DESIGN CRITERIA

Design discharges, hydrographs and runoff volumes were determined using methods and criteria conforming to the San Bernardino County Hydrology Manual, May 1983 (Hydrology Manual). Special hydrologic considerations and applications were coordinated with the San Bernardino County Flood Control District, Water Resources Division at the regular project meetings. The general hydrolgic methods and criteria are briefly described in this chapter. Basic data and special modelling considerations are presented in Volume II, Hydrologic and Hydraulic Design Data of this comprehensive storm drainage plan.

Both the Rational and Unit Hydrograph Methods were necessary and appropriate for defining the hydrology for the drainage system. These two methods are summarized briefly below. For a more complete description of these methods the reader is referred to the Hydrology Manual.

RATIONAL METHOD

The rational method is based on the direct relationship between peak discharge and rainfall intensity, drainage area, and a runoff coefficient representing the ratio of runoff to rainfall. This relationship is expressed by the equation:

$$Q = CIA$$

where:

Q = the peak discharge in cubic feet per second (cfs)
C = a runoff coefficient representing the ratio of runoff depth to rainfall depth (dimensionless)
I = the time-average rainfall intensity for a storm duration equal to the time of concentration (inches/hour)
A = drainage area (acres)

The values of the runoff coefficient (C) and the rainfall intensity (I) are based on a study of drainage area characteristics such as type and condition of the runoff surfaces and the time of concentration. The time of concentration for the basin along with depth-duration curves for precipitation at various frequencies are used to establish the rainfall intensity. Drainage areas were directly measured from topographic base mapping (the most recent U. S. Geological Survey Quadrangles enlarged to a scale of 1" = 1000'). Tables in the Hydrology Manual were the basis of estimating runoff coefficients from land use and soil type information. For downstream additional drainage areas, the travel time calculated using the normal depth assumption was added to the time of concentration resulting in a reduced intensity of rainfall over a larger area. In this study, the rational method was determined to be appropriate for watersheds up to 500 acres in area.

UNIT HYDROGRAPH METHOD

The Unit Hydrograph method assumes that watershed discharge is related to the total volume of runoff and that, for a given duration rainfall, the hydrograph time base should remain constant. The unit hydrogaph is defined as time distribution of rates of runoff which results from one inch of effective rainfall during a unit period of time over the tributary watershed upstream of the point of concentration. The Los Angeles District of the U.S. Army Corps of Engineers has determined dimensionless curves of cumulative runoff for various geographic areas within San Bernardino County. These curves are summation hydrographs modified so that the percent of ultimate discharge is related to time expressed in percent of lag. Given a watershed's lag and drainage area these curves are used to predict the watershed's unit hydrograph. In this study the Valley Curve was used throughout the drainage area. Lag is defined as the time at which half the volume of the unit hydrograph has occurred, and is determined by an empirical relation involving physical dimensions of the watershed. Drainage areas were measured from base topographic mapping.

The Hydrology Manual establishes the use of a hypothetical rainfall distribution in which various duration storm volumes are nested around the sixteenth hour of a 24-hour event. Rainfall isohyetal mapping presented in the Hydrology Manual was used to determine point rainfall depths over the study area. Depth-area-frequency reduction curves, also presented in the Hydrology Manual, were used to refine these intensities for the appropriate spatial extent of the design storms.

For the determination of rainfall losses such as infiltration and depression storage, the Hydrology Manual defines a method of determining low loss rate percentages and adjusted loss rates. These parameters are related to land use, soil type and percent imperviousness.

The methodology used for channel and drain routing was the convex routing approach. For reservoir hydrograph routing, the modified Puls method was used. This approach accounts for the storage and outflow relationships of individual reservoirs. To aid in the modelling of the drainage system's reservoirs, the concept of flow-by reservoir was used. All of these routing techniques were utilized through application of subroutines in the AES computer program FLOODSB.

GENERAL CRITERIA

The general criteria used in formulating the hydrologic analyses of the comprehensive storm drain plan are briefly listed on the following page.

1. At the point the street section is inadequate to convey a 10-year storm flow, a storm drain is to be provided to handle a minimum 10-year design flow.

2. The minimum size pipe presented in this Master Plan is limited to a 36-inch diameter line such that the pipe is at least one-third full during a 10-year design storm.

3. The combined storm drain and street capacity at any point should be adequate to convey runoff from a 25-year storm. The difference between the 10-year design peak discharge and the 25-year design peak discharge is carried in the street. If this difference exceeds the street capacity, the storm drain size is increased accordingly.

   This criterion required a minimum 25-year storm design for all major lateral drains, because inadequate slope in their east-west orientation limited any significant street capacity. The following lateral lines draining to the Rialto Channel (Line A) were designed for a 25-year design storm:

   a. Summit Avenue Drain (Line B)
   b. Base Line Road Drain (Line D)
   c. Foothill Boulevard Drain (Line E)
   d. San Bernardino Avenue Drain (Line G)

4. In the coordination of hydrologic criteria, certain drainage lines were identified as key facilities where a 100-year storm design is appropriate for regional flood control and the protection of major transportation routes. These facilities are listed below.

   a. Rialto Channel (Line A)
   b. Highland Avenue Channel (Line C)
   c. East Fontana Drain (Atchison, Topeka and Santa Fe Railroad - Line F)
   d. Interstate Highway 10 Channel (Existing Facility)

BASIN ROUTING

Seven detention basins have been included in this comprehensive storm drain plan. Descriptions of these basins are presented in Chapter 5, "Discussion of Drainage Systems". Generally, two types of basin operation were utilized, flowby and flow through. Where feasible, basins were planned for flowby operation. Flowby operation involves a basin off line of the major drain contributing to it. Discharges in excess of a control amount are diverted to the basin to reduce the peak of the flood hydrograph. In cases where a parallel drain was infeasible, basins were planned for flow through operation. Flow through basins detain and route the incoming flood hydrographs through defined storage-outflow relationships. The criteria for defining the operation of these basins follows:

> Basin outlets and control flowby discharges are to be defined to ensure no spillage occurs under the condition of two back-to-back twenty-four (24) hour design storms.

RESULTS

Final discharges for each individual drain line are presented on each profile in Chapter 10, "Plans, Profiles, and Cost Estimates". Basin inflow and outflow hydrographs for each of the five Cactus Basins included in this comprehensive drain plan are presented in Figures 2-1 through 2-5.

The Merrill and Linden Basins are planned with no improvements to outlet capacities, and are, therefore, modelled as retention basins. The Linden Basin's existing drain discharges directly to Linden Avenue. The Randall Avenue Drain is designed to collect up to 15 cfs of this discharge. It was coordinated with the District that the upstream diversions to these basins would be limited to discharges in excess of 900 cfs along Line F. This criteria will limit discharges to the basins to occur only for events larger than a 10-year event (approximate), and will ensure ample storage capacity for two back-to-back 100-year design storms.

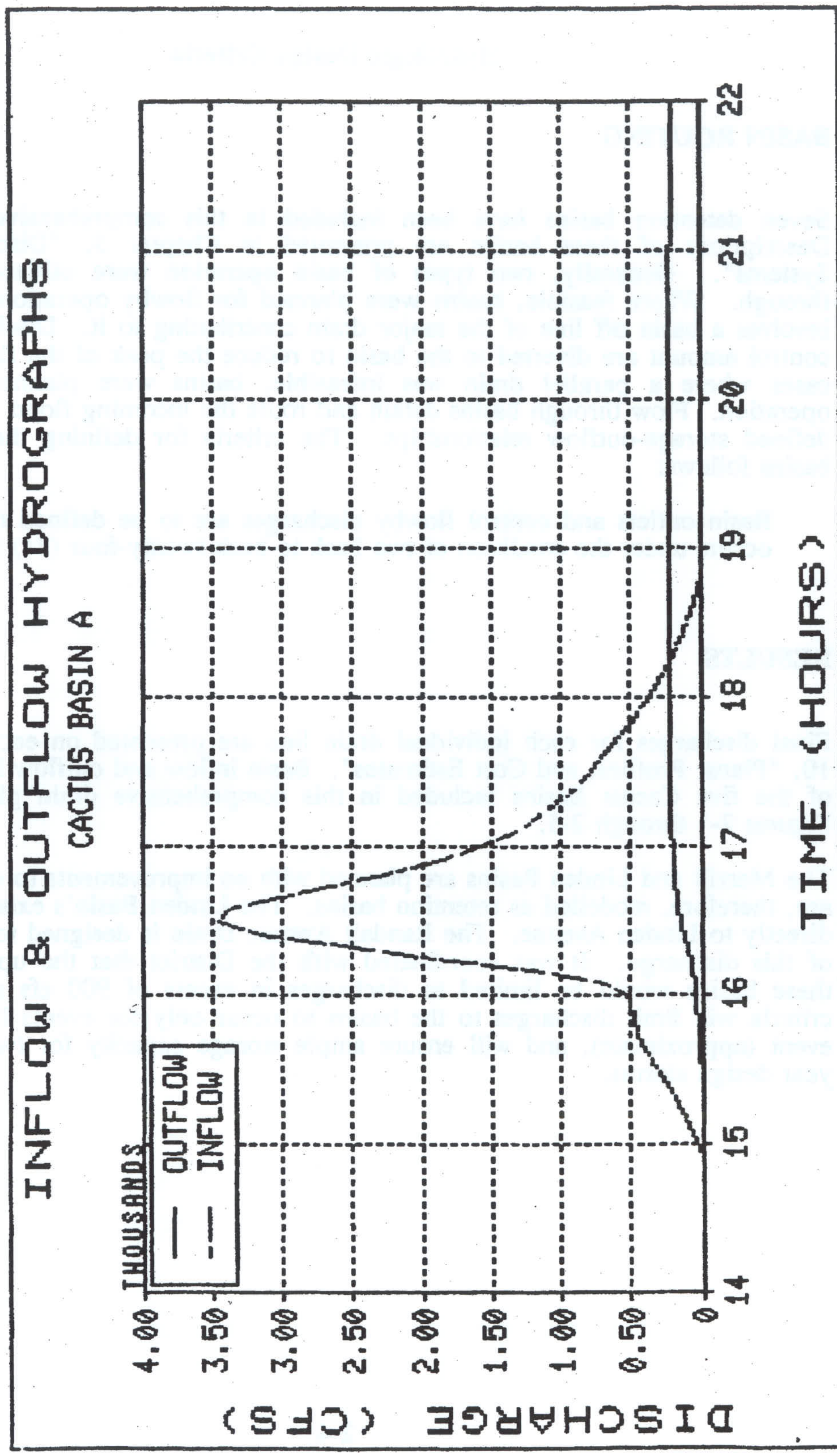

INFLOW & OUTFLOW HYDROGRAPHS
CACTUS BASIN A
THOUSANDS
OUTFLOW
INFLOW
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0
14
15
16
17
18
19
20
21
22
TIME (HOURS)
DISCHARGE (CFS)

FIGURE 2-1

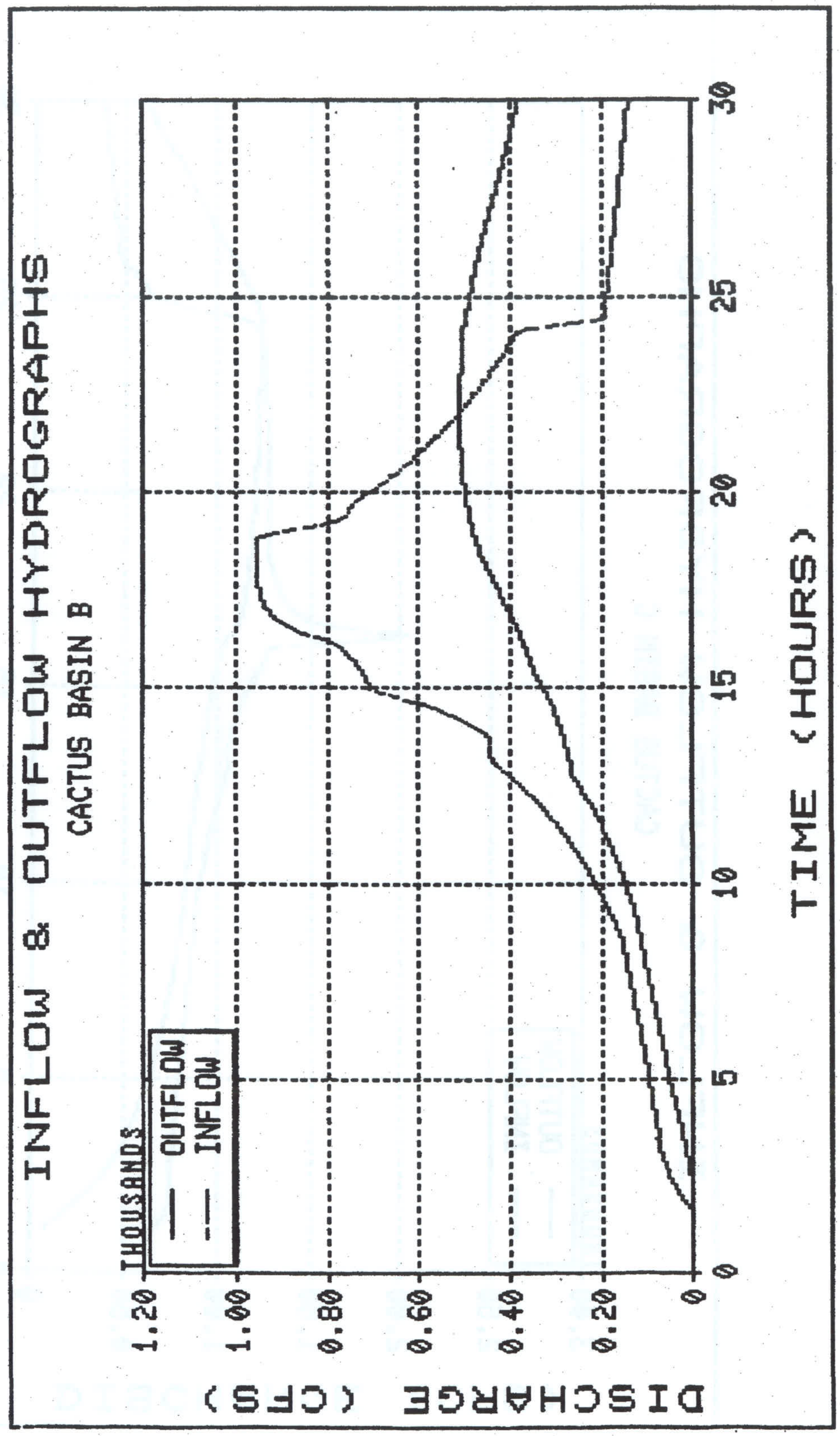

INFLOW & OUTFLOW HYDROGRAPHS
CACTUS BASIN B
THOUSANDS
OUTFLOW
INFLOW
DISCHARGE (CFS)
1.20
1.00
0.80
0.60
0.40
0.20
0
0
5
10
15
20
25
30
TIME (HOURS)

FIGURE 2-2

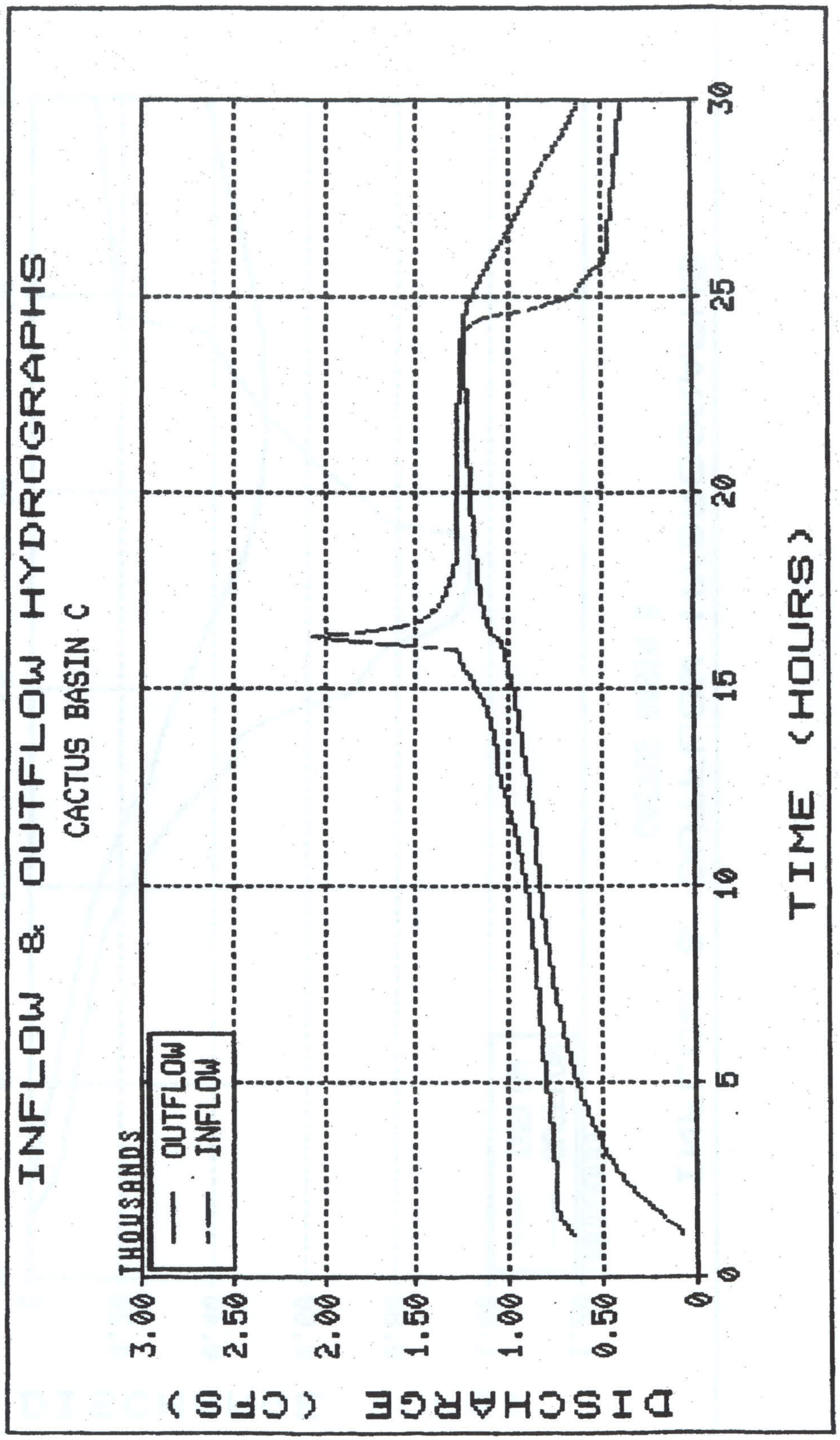
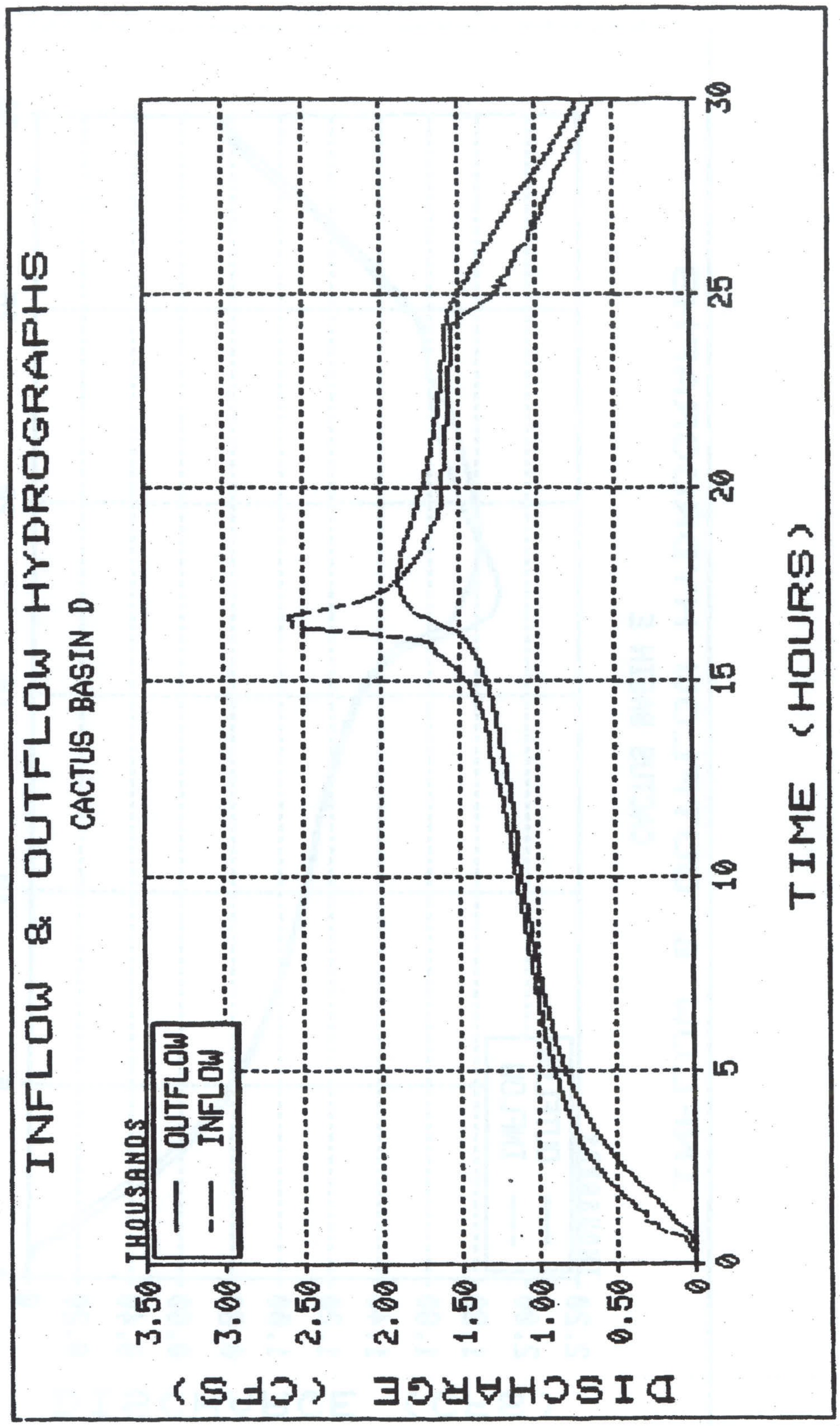

INFLOW & OUTFLOW HYDROGRAPHS
CACTUS BASIN C
THOUSANDS
OUTFLOW
INFLOW
DISCHARGE (CFS)
3.00
2.50
2.00
1.50
1.00
0.50
0
5
10
15
20
25
30
TIME (HOURS)

FIGURE 2-3



INFLOW & OUTFLOW HYDROGRAPHS
CACTUS BASIN D
THOUSANDS
OUTFLOW
INFLOW
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0
DISCHARGE (CFS)
0
5
10
15
20
25
30
TIME (HOURS)

FIGURE 2-4

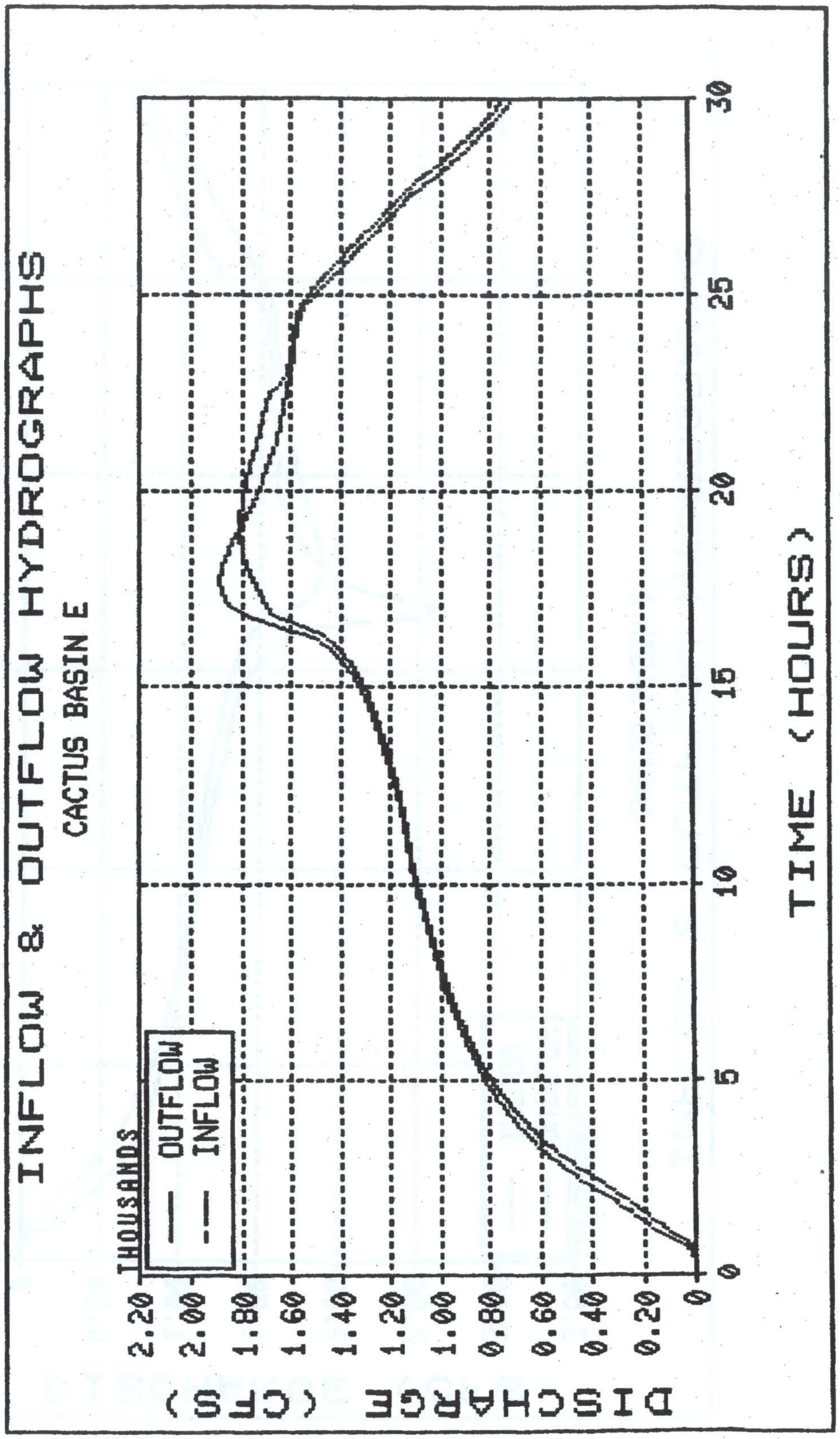

INFLOW & OUTFLOW HYDROGRAPHS
CACTUS BASIN E
THOUSANDS
OUTFLOW
INFLOW
DISCHARGE (CFS)
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0
0
5
10
15
20
25
30
TIME (HOURS)

FIGURE 2-5

CHAPTER 3

CHAPTER 3

HYDRAULIC DESIGN CRITERIA

The general assumptions and criteria for the definition of drainage facilities including feeders, laterals, basin outlets and channels are briefly described in this chapter. A detailed description of hydraulic methodologies, basic data, and results are presented in Volume II, Hydrologic and Hydraulic Design Data of this comprehensive storm drainage plan. All the calculations for sizing the open channels and closed conduits were completed in conformance with criteria presented in the Design Manual, Hydraulics, Los Angeles County Flood Control District, March 1982, hereafter referred to as the Hydraulics Manual.

The key requirement for sizing the hydraulic facilities, other than the peak discharges determined in the hydrologic analyses of the alternatives, is the determination of channel inverts and slopes. In general, the drainage system is designed to follow the ground surface elevation in order to minimize excavations. All open channels are designed with the tops of the walls or levees at or below the adjacent ground surface to allow interception of surface flows. Superelevation was not considered in the sizing of any reach section. Due to high velocities with scour and erosion potential, the District has required the future facilities to be concrete lined for the whole drainage system. For road and railroad crossings reinforced concrete box culverts were defined.

Storm drain capacity was determined by "Manning's" formula. The following lists the criteria and assumptions were used to size the open channel and closed conduit sections. These criteria have been coordinated with the District.

CHANNELS

For open channel reaches, a concrete lined trapezoidal section was defined. Trapezoidal sections were selected to minimize the construction costs. The channel bottom width or base width was set to a minimum of 12 feet for maintenance and vehicle access.

An invert profile of the existing Rialto Channel was developed with the data from available "as built" plans and topograghic mapping provided by the City of Rialto and the District. This profile was verified through field reconnaissance of the channel by staff of JMM and Bill Mann and Associates. A new invert profile was determined for defining the alternative channel facilities. Some breaks in slope were required to avoid excess excavation, to minimize the need for fill and to avoid the need to raise road crossing elevations. The selected sections were found not to be constrained by the District's Right-of-Way for the Rialto Channel. Criteria used are listed below.

1. Trapezoid, concrete lined channel sections (T.C.C.).
2. Manning roughness value, "n" = 0.014.
3. Trapezoidal side slope value "Z" :

   Less than 10 feet in height Z = 1.5
   10 feet to 20 feet in height Z = 1.75.

4. Freeboard in additional to the normal water surface:

   For average flow velocities of 35 fps or less 2.5 feet
   For average flow velocities greater than 35 fps 3.5 feet.

6. Determination of depth rounded up to nearest 0.5 foot.

CULVERTS

In sizing the culverts, it was assumed that flow from the lateral drains will be confluent with the main channel at the upstream of any parallel transportation crossing. For the major laterals, normal depth was determined in the culverts by Manning's equation. In sizing culverts along the Rialto Channel, energy losses (entrance losses and friction losses) were determined to define the depth at the culvert outlet. The specific energy at the culvert entrances was assumed to equal the normal conditions for the upstream channel. This approach allowed for reduced culvert sizes when culverts were shorter than the length needed to reach normal depth.

With improved efficiency of the planned channel sections of the Rialto Channel, the specific energy at culvert crossings will be increased and, therefore, the capacity of some existing culverts will be increased.

Any existing culvert with adequate capacity will be retained. For those existing culverts with inadequate capacity, additional boxes will be added to the existing structure to increase the capacity. The assumptions and criteria are listed below.

1. Reinforced Concrete Boxes (R.C.B.).
2. Manning's roughness value, "n" = 0.013.
3. Open channel flow conditions assumed.
4. Piers will be needed for box width larger than 14 feet.
5. Freeboard of 0.5 foot in addition to flow depth.
6. Where reasonable, a minimum depth of eight (8) feet was maintained.

Hydraulic Design Criteria

The following lists the existing culvert crossings of the Rialto Channel that are included in this comprehensive storm drain plan.

Bloomington Avenue
Lilac and San Bernardino Avenues
Willow Avenue
Valley Boulevard
Southern Pacific Railroad
Riverside Avenue

PIPES

Manning's equation was applied in sizing the pipe sections. It was assumed that pipes are flowing full but not under pressure. The pipe size is then determined by using the next larger standard pipe size from the calculated pipe size. Other criteria are listed below.

1. Reinforced Concrete Pipes (R.C.P.).
2. Manning's roughness value, "n" = 0.013.
3. A minimum pipe diameter of 36 inches.

OUTLETS

The assumptions and criteria for sizing basin outlet culverts are listed below.

1. Outlet culverts have sharp-edge inlets.
2. Outlet culverts have steep slopes.
3. Outlet culverts have conditions of free outflow or unsubmerged exit, and discharge is entirely dependent on the entrance conditions.

TRANSITIONS

Transitions are used at culverts inlets and outlets to produce gradual changes in water prism cross sections and to provide smoother water flow and reduce energy loss. The assumptions and criteria for sizing the transitions are listed below.

1. The length of inlet transition is about equal to the length difference between T.C.C. waterway surface width and the R.C.B. or R.C.P. opening width.

2. The length of outlet transition is about three times the length difference between T.C.C. waterway surface width and the R.C.B. or R.C.P. opening width.

CHAPTER 4

CHAPTER 4

EXISTING HYDROLOGY AND HYDRAULICS

GENERAL INFORMATION

The Rialto Channel, currently, drains a 25.6 square mile area of alluvial fan and lowlands to the Santa Ana River. Lytle Creek lies immediately to the north and effectively prevents any runoff from the nearby San Gabriel Mountains from entering the study area. The slope is generally north to south and is quite regular, varying from 1.5 percent near Interstate Highway 10 (I-10) to three percent near the intersection of Sierra and Riverside Avenues.

That portion of the drainage lying south of I-10 is either undeveloped or is in industrial use, primarily oil tank farms, a railyard for the Southern Pacific Railroad, and a landfill. The sewage treatment plant for the City of Rialto lies along the east and central portions of the drainage, while the City of Fontana occupies the west side. A small part of the eastern boundary of the drainage lies within the City of Colton, north and south of I-10. Between the developed areas of Rialto and Fontana lies an area of rural character which is undergoing rapid conversion to tract housing. This area was formerly under agricultural use with pasture, orchards, and grapes as the main crops. North of Highland Avenue, the land is still relatively undeveloped, with some isolated industrial activity and single family residences.

The Rialto Channel extends five and one-half miles from the Santa Ana River to the Lower Cactus Basin at Etiwanda and Cactus Avenues. For the first three and one-half miles (to Bloomington Avenue), the channel is generally from eight to eleven feet deep, with sizable concrete culverts under nearly every road crossing. Above Bloomington, the culverts are generally small diameter corregated metal pipes (CMP). The upper 7,000 feet of channel (above the Santa Fe Railroad tracks) is from four to six feet deep. The only concrete-lined portion of the Rialto Channel is in the lower section from Santa Ana Avenue to Aqua Mansa Road. This lower stretch has a permanent flow of about 5 cfs due to effluent from the Rialto Sewage Treatment Plant. At the head of the Rialto Channel are the three existing Cactus Basins. The Middle and Lower Basins were constructed as water percolation basins in the latter 1960's. Due to a problem with a low lying storm drain from an adjacent subdivision, the basins serve a very limited role in flood control at the present time. As an interim measure to reduce flow entering the Lower Cactus Basin, the City of Rialto has created a small diversion to take flows from Baseline Road up into the Upper Cactus Basin, which is immediately above Base Line Road.

It is still being actively excavated as a source of fill. It is connected to the Middle Basin by means of a 30-inch culvert.

The only secondary trunk connecting directly to Rialto Channel is the Freeway Channel which lies along the north side of I-10 and drains from just east of Sierra Avenue. A second east-west trunk lies along the north side of the Santa Fe Railroad tracks extending from the west drainage boundary to Linden Avenue. Called the East Fontana Drain, it does not connect to the Rialto Channel, but instead drains to two water percolation basins (the Merrill and Linden Basins) connected in series. Overflow from the Linden Basin would drain south to the Freeway Channel.

Several large storm pipes drain to the Rialto Channel. These include an 84-inch line on Valley Boulevard (Colton Drain) and a 5 x 11 foot drain down Bloomington Avenue. A 90-inch pipe extending west along Randall is under design. There is an existing storm pipe along Base Line Road extending east from Lilac Avenue to Lytle Creek. Normally, this pipe prevents runoff from more frequent storm events from entering the Rialto Drainage. However, runoff in excess of about 100 cfs will flow across Base Line Road and into the Study Area under current conditions. Therefore, this drainage area is considered in the analysis of existing hydrology. Additionally, there are three other storm drains in the Rialto Channel drainage area. Two drains, Palmerro-Kaiser Drain and Tamarind Drain, feed the East Fontana Drain. An additional drain follows Ayala Avenue north of Highland Avenue.

HYDROLOGIC METHODS

Drainage area boundaries are largely the same as those for Project 3-3 of the Verpet Study (Verpet Engineering Company, 1973) with modifications suggested by the Rialto City Drainage Engineer (Clay Cabrinha, personal communication) and actual observation of street drainage during two winter (1985) rainfall events. The subbasins conform to the natural and man-made drainage features and are generally large enough to be modeled by the Unit Hydrograph method. The subbasins range in size from 386 acres to 5,358 acres.

The existing hydrology was modeled by use of the Unit Hydrograph Method as described in the Hydrology Manual. Computer software conforming to the standards set by the Hydrology Manual and developed by Advanced Engineering Software (AES) (1984) was utilized. A single storm covering the entire basin simultaneously was assumed in the analysis, therefore, the same rainfall depths and depth-area reduction factors were applied to the full watershed. Basic hydrologic data including rainfall, soils, land use, and subbasin information, in addition to descriptions of key modelling assumptions, are presented in Volume II, <u>Hydrologic and Hydraulic Data</u> of this comprehensive storm drain master plan.

HYDROLOGIC RESULTS

The results of the model runs for the 10, 25, and 100-year storm events are summarized for key points in Table 4-1. Computer output for each of these events are presented in Volumes III to VI, inclusive. For the 100-year event, flow in the upper portion of the Rialto Channel is about 3,400 cfs. It increased to 9,700 cfs at I-10 and is just under 11,000 cfs at Aqua Mansa Road near the Santa Ana River. Peak flow from the Freeway Channel is over 4,700 cfs. Peak flow in the East Fontana Drain is 2,600 cfs. Flowby from subbasin eleven is about 650 cfs. Total runoff volume from all eleven subbasins is 8,870 acre-feet for the 100-year event.

Examination of the output for the 100-year event shows that all percolation basins are filled well before the peak rainfall in the 16th hour of the 24-hour event. Sizable reduction of peak inflow though a basin occurs only at the 10-year event for the Linden-Merrill Basins. Inflow and outflow hydrographs for the Linden and Merrill Basins are presented in Figures 4-1 to 4-6 for the 10, 25, and 100-year events. The computer runs were conducted under the condition that the bottom drains in all the percolation basins were open throughout the storm events.

HYDRAULIC RESULTS

Hydraulic analyses of existing drainage system capacity are summarized in Table 4-1 and 4-3. Table 4-2 is the summary of existing Rialto Channel capacities. In general, the existing channel capacity will not quite handle events with a recurrence interval of 10-years. For severe storms (10-years and greater) overflows and ponding would be expected. Flood evaluations were not conducted in this study to quantify these hazards. Please note that capacities of existing culverts used in the plan may increase due to improved channel sections upstream and downstream. This evaluation of existing culverts was independent of upstream and downstream constraints. Table 4-3 is the summary of the existing culvert capacities on Rialto Channel. Culvert capacities estimated under two types of normal flow conditions, full flow conditions, and open channel conditions (with 0.5 freeboard) were presented in the table. An inventory of inlets and crossings on the Rialto Channel is given in Table 4-4.

TABLE 4-1

RIALTO CHANNEL HYDROLOGY - EXISTING CONDITIONS

Peak Flow In Cubic Feet Per Second

LOCATION	100-YEAR	25-YEAR	10-YEAR
Inflow to Upper Cactus Basin	4,351	3,247	2,908
Outflow From Lower Cactus Basin	3,461	2,666	2,308
Rialto Channel at Pacific Electric RR	3,783	2,919	2,408
Bloomington Drain	1,458	1,151	982
Rialto Channel at Bloomington	4,886	3,266	2,641
Colton Drain	1,082	851	723
East Fontana Drain	2,618	2,056	1,751
Outflow From Linden Basin	2,050	1,446	704
I-10 Freeway Channel at Linden	2,322	1,825	1,553
I-10 Freeway Channel at Cedar	4,348	2,791	2,265
Rialto Channel at I-10 Freeway	9,749	6,453	5,695
Rialto Channel at Santa Ana Avenue	10,115	7,307	5,976

TABLE 4-2

SUMMARY OF EXISTING RIALTO CHANNEL CAPACITY

LOCATION	CAPACITY (cfs)
Below Cactus Basins	1,820
Foothill Boulevard	1,100
Pacific Electric Railroad	1,230
ATSF Railroad	1,620
Bloomington Avenue	3,720
I-10 Freeway	5,320
Santa Ana Avenue	5,790

TABLE 4-3

EXISTING CULVERT CAPACITIES ON RIALTO CHANNEL

CULVERTS, INLETS & CROSSINGS DESCRIPTIONS	CULVERT SIZE & TYPE DEPTH x WIDTH	EXISTING SLOPE	MANNING'S n	FULL FLOW Q (cfs)	OPEN CHANNEL Q_2 (cfs)
Aqua Mansa Road	2 - 7′ x 10′ RCB	0.02558	0.014	3858	4425
Road X-ing U/S of Aqua Mansa	2 - 10′ x 13.5′ RCB	0.01765	0.014	7717	9060
Slover Avenue	3 - 36" x 58" CMPA	0.00196	0.025	100	
Cameron Way/Riverside Road	1 - 13.5′ x 15′ RCB	0.01226	0.014	5558	6502
Southern Pacific Railroad(SPRR)	2 - 14.5′ x 15′ RCB	0.01868	0.014	15106	17595
I - 10 Culvert	1 - 4.8′ x 6.9′ RCB				
	1 - 5.0′ x 6.9′ RCB	0.00421	0.014	1652	1334
	1 - 4.8′ x 6.8′ RCB				
	1 - 4.8′ x 7.8′ RCB				
Valley Blvd.	2 - 10′ x 14′ RCB	0.00413	0.014	3911	4610
Willow Avenue	2 - 9′ x 12′ RCB	0.01129	0.014	4586	5338
Lilac and San Bernardino Ave.	2 - 9′ x 12′ RCB	0.01691	0.014	5613	6532
Bloomington Avenue	2 - 9′ x 12′ RCB	0.01285	0.014	4893	5695
Randall Avenue	2 - 44" x 72" CMPA	0.01444	0.025	326	
Merrill Avenue	2 - 44" x 72" CMPA	0.015	0.025	332	
AT & SF Railroad	2 - 44" x 72" CMPA	0.01617	0.025	346	
Access Road	2 - 44" x 72" CMPA	0.01698	0.025	354	
Cactus Avenue	2 - 44" x 72" CMPA	0.02093	0.025	392	
Access Road	2 - 44" x 72" CMPA	0.01667	0.025	351	
Rialto Avenue	2 - 44" x 72" CMPA (Starts)		0.02387	0.025	420
	1 - 3.5′ x 8.2′ RCB (Ends)				
Pacific Electric Railroad (PER)	2 - 44" x 72" CMPA	0.12889	0.025	975	
Second Street	3 - 36" x 58" CMPA	0.01757	0.025	298	

TABLE 4-3 (CONTINUED)

EXISTING CULVERT CAPACITIES ON RIALTO CHANNEL

CULVERTS, INLETS & CROSSINGS DESCRIPTIONS	CULVERT SIZE & TYPE DEPTH x WIDTH	EXISTING SLOPE	MANNING'S n	FULL FLOW Q (cfs)	OPEN CHANNEL Q_2 (cfs)
Foothill Blvd.	2 - 59" x 81" CMPA	0.01607	0.025	560	
Rosewood Avenue	3 - 36" x 58" CMPA	0.0125	0.025	251	
Etiwanda Avenue	1 - 6' x 8' RCB	0.00664	0.014	596	668

TABLE 4-4

INVENTORY OF INLETS AND CROSSINGS ON RIALTO CHANNEL

STATIONS	CULVERTS, INLETS, & CROSSINGS DESCRIPTIONS
0+00	Santa Ana River
16 + 80	
	Aqua Mansa Road
17 + 30	
18 + 40	Large Diameter Steel Pipe Crossing
20 + 30	24" CMP Drain From East Side
23 + 30	24" CMP Drain From East Side
28 + 50	Begin Road X-ing
	Road X-ing U/S of Aqua Mansa
28 + 80	End Road X-ing
29 + 80	36" RCP from Treatment Plant from West
31 + 20	24" CSP Drain from East Side
33 + 80	24" CMP Drain from East Side
36 + 00	24" CSP Drain from West Side (Inlet Plugged)
47 + 50	42" CMP Drain from West Side
60 + 80	18" x 30" CMPA from West Side
67 + 20	24" Steel Pipe from East Side
69 + 00	
	Miscellaneous Pipe Crossings (14 > 1', 7 > 6") Including a Foot Walk on 1' Diameter Pipes
71 + 40	
71 + 80	6" Steel Drain from East Side
73 + 00	8" Steel Drain from West Side
73 + 20	10" Steel Drain from East Side
73 + 70	12" Steel Drain from West Side
73 + 90	20'+ x 2' Drainage Ditch from West Side
74 + 00	24" VCP Buried Sewer Line
75 + 40	Pipe Crossings (P-172056, P-172050) 2 - 8", 1 -4", 3 - 16, 11' clearance above invert
77 + 40	6" Steel Drain from East Side
78 + 00	8" Steel Drain from East Side
78 + 50	Drainage Ditch from East Side
84 + 80	36" + x 66" CMPA Drain from West Side, 6' x 10' Channel with Rail & Wire Sides from West Side
84 + 80	Begin Slover Ave.

TABLE 4-4 (CONTINUED)

INVENTORY OF INLETS AND CROSSINGS ON RIALTO CHANNEL

STATIONS	CULVERTS, INLETS & CROSSINGS DESCRIPTIONS
	Slover Avenue
	20' Wide Overflow Spillway
85 + 70	End Slover Ave.
92 + 30	18" CMP Drain from East Side
92 + 30	Begin Cameron Way/Riverside Road
	1' x 1' Concrete Box, 1' CMP and 12" CMP Drain from East Side into RCB
	Cameron Way/Riverside Road
94 + 90	End Cameron Way/Riverside Road
100 + 80	24" Clay Pipe From East Side
100 + 80	Begin SPRR
102 + 50	24" Diameter Gate Inlets From East Side
104 + 00	3 - 24" Gate Inlets from Both Sides
	Southern Pacific Railroad(SPRR)
106 + 00	End SPRR
106 + 10	Side Channel Inlet From Both Sides
106 + 30	Begin I - 10 Freeway
	I - 10 Freeway Culvet
107 + 00	8" x 5' Catch Basin from West Side
108 + 30	4' CMP from West Side
108 + 80	8" x 5' Catch Basin from West Side
109 + 30	End I - 10
109 + 50	Concrete Trapezoidal Channel (I - 10 Channel) B = 8', D = 2.5'
109 + 50	Drainage Ditch from East Side
113 + 60	84" RCP With Box Outlet from East Side
114 + 00	Begin Valley Blvd.
	Valley Blvd.
114 + 10	29" x 42" CMPA from West Side
115 + 20	End Valley Blvd.
129 + 00	Begin Willow Ave.
	Willow Avenue
130 + 10	End Willow Ave.

TABLE 4-4 (CONTINUED)

INVENTORY OF INLETS AND CROSSINGS ON RIALTO CHANNEL

STATIONS	CULVERTS, INLETS & CROSSINGS DESCRIPTIONS
147 + 60	Begin Lilac/S.B. Ave.
	Lilac and San Bernardino Ave.
148 + 90	24" RCP from 21' Catch Basin from West Side
149 + 00	End Lilac/S.B. Ave.
159 + 50	24" RCP Drain from West Side
160 + 00	6 - 3" Holes in Subdivision Boundary Wall
169 + 60	Begin Bloomington Ave.
	Bloomington Avenue
169 + 90	52" CMP from East Side
171 + 40	End Bloomington Ave.
176 + 80	Begin Randall Ave.
	Randall Avenue
177 + 70	End Randall Ave.
196 + 40	24" RCP Drain from West Side
201 + 40	24" RCP Drains from Both Sides
203 + 30	Begin Merrill Ave.
	Merrill Avenue
203 + 70	2' RCP Drain from 21' Catch Basin from West Side
204 + 10	End Merrill Ave.
210 + 70	24" x 18" CSPA Drain from West Side
219 + 00	Begin AT & SF Railroad
	AT & SF Railroad
220 + 70	End AT & SF Railroad
220 + 80	15" CSP Drain from East Side
222 + 20	Begin Access Road
	Access Road
222 + 80	End Access Road
224 + 10	Begin Cactus Ave.
	Cactus Avenue
225 + 20	End Cactus Ave.
225 + 30	2' x 12' Concrete Inlet from East Side
226 + 90	Begin Access Road
	Access Road
227 + 50	End Access Road

TABLE 4-4 (CONTINUED)

INVENTORY OF INLETS AND CROSSINGS ON RIALTO CHANNEL

STATIONS	CULVERTS, INLETS & CROSSINGS DESCRIPTIONS
228 + 60	24" CMP from West Side
232 + 60	1' CMP from West Side
232 + 60	Begin Rialto Ave.
	Rialto Avenue
233 + 80	24" RCP Inlet from 21' Catch Basin from West Side
233 + 80	24" RCP Inlet from 7' & 3' Catch Basins from East Side
236 + 20	End Rialto Ave.
240 + 00	Begin PER
	Pacific Electric Railroad (PER)
240 + 50	End PER
240 + 50	Rip Rap Ditch from West Side
242 + 20	24" RCP from Catch Basin from West Side
242 + 20	Begin Second Street
	Second Street
	with Road Dip for overflow
243 + 00	End Second Street
255 + 00	Side Channel - B = 4', D = 1', Z = 1 from West Side
256 + 50	5' x 8' Rock Ditch from East Side
257 + 70	36" CMP from East Side
257 + 90	1' x 3' AC Ditch from West Side
257 + 90	Begin Foothill Blvd.
	36" CMP from West Side
	Foothill Blvd.
	2' x 3' Grate Opening
	36" CMP from West Side
259 + 00	End Foothill Blvd.
259 + 00	1' x 3' AC Ditch from West Side
263 + 30	2 - 20" x 28" CSPA from West Side
264 + 30	2' Drain With Flap Gate from West Side
271 + 10	Begin Rosewood Ave.
	Rosewood Avenue
	2 - 8" CMP Street Drains in Curbs for Both Side of Street

TABLE 4-4 (CONTINUED)

INVENTORY OF INLETS AND CROSSINGS ON RIALTO CHANNEL

STATIONS	CULVERTS, INLETS & CROSSINGS DESCRIPTIONS
271 + 90	End Rosewood Ave.
284 + 50	Begin Etiwanda Ave.
	Etiwanda Avenue
286 + 00	End Etiwanda Ave.

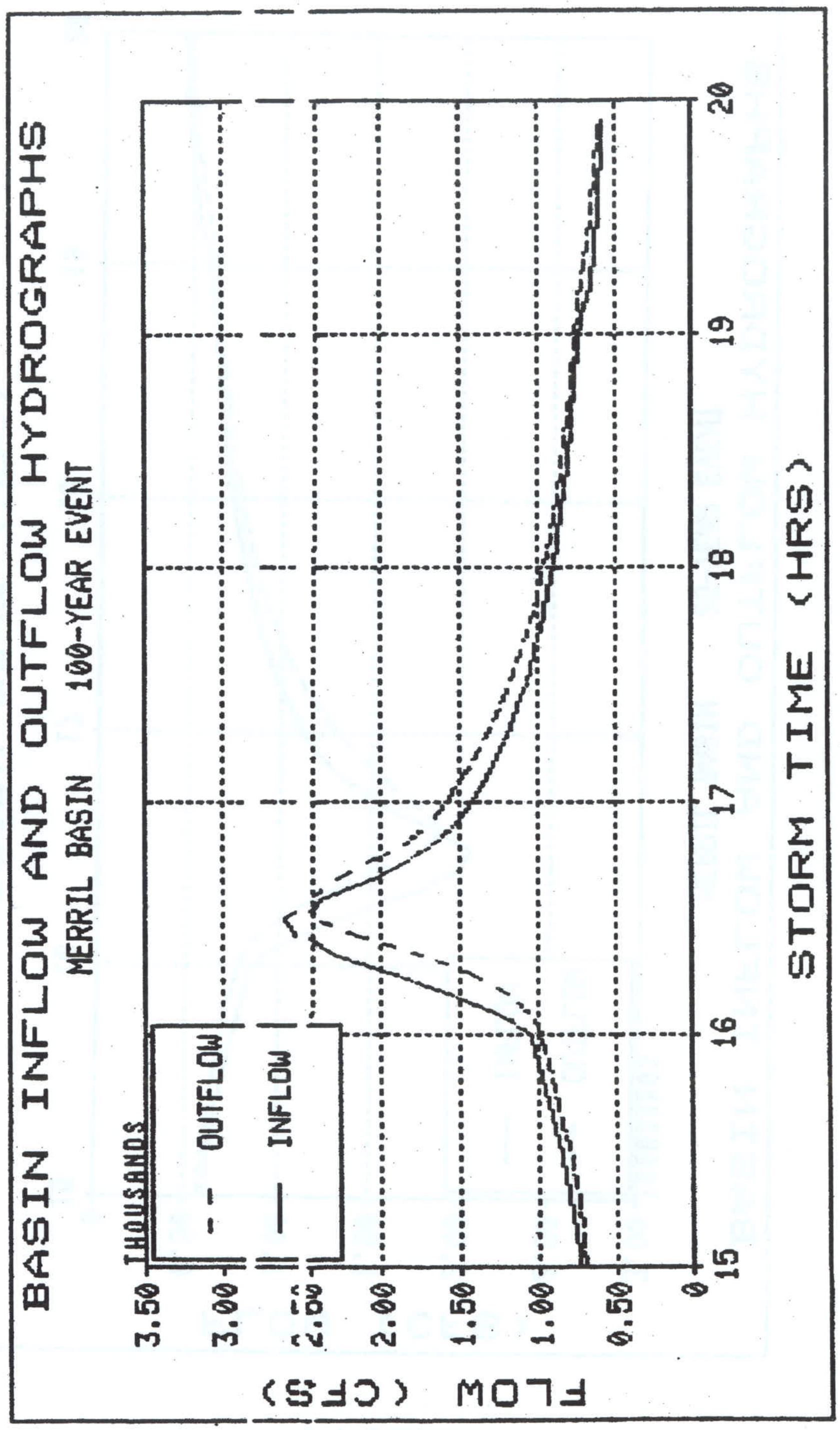

BASIN INFLOW AND OUTFLOW HYDROGRAPHS
MERRIL BASIN 100-YEAR EVENT
THOUSANDS
OUTFLOW
INFLOW
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0
15
16
17
18
19
20
FLOW (CFS)
STORM TIME (HRS)

FIGURE 4-1

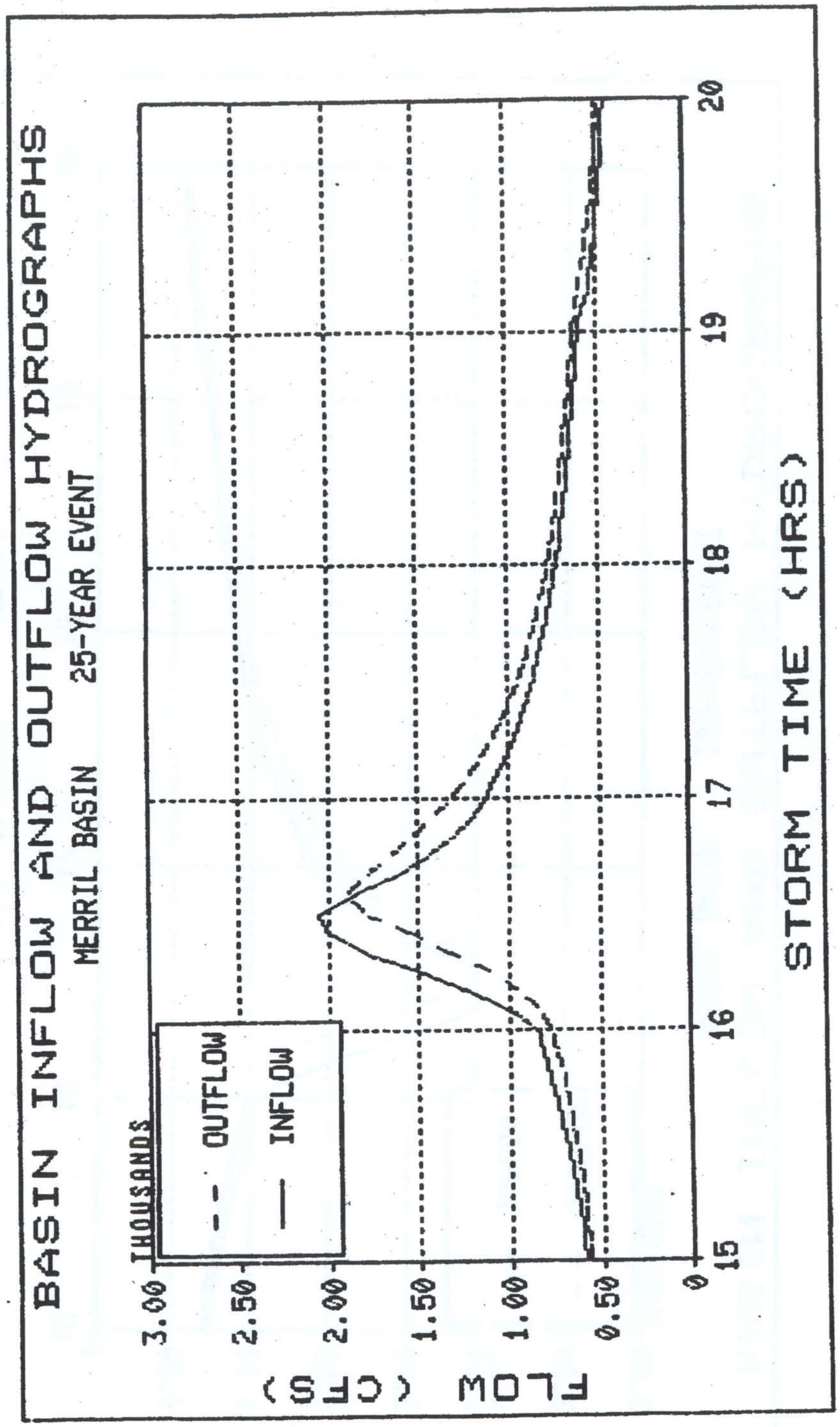
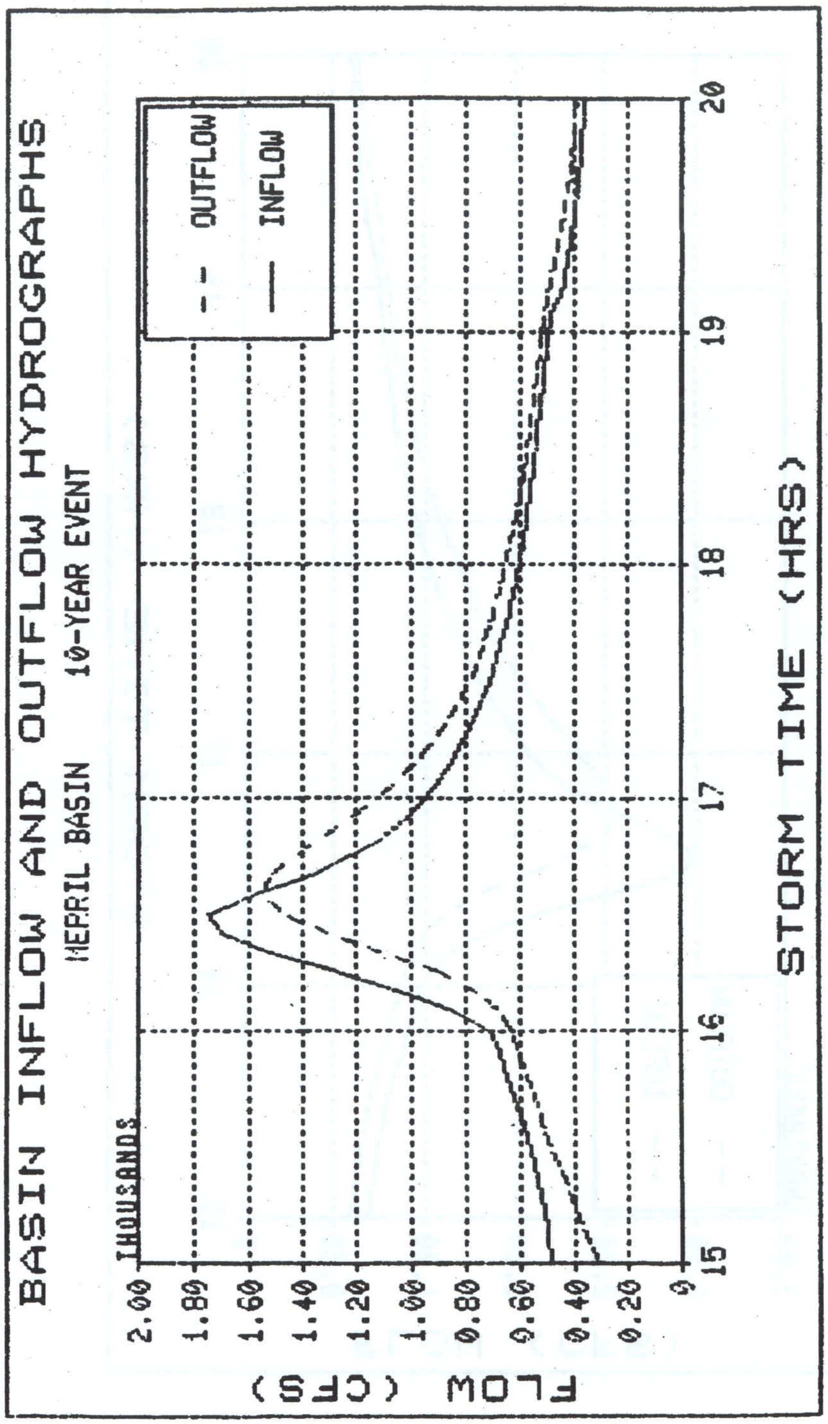

BASIN INFLOW AND OUTFLOW HYDROGRAPHS
MERRIL BASIN 25-YEAR EVENT
THOUSANDS
OUTFLOW
INFLOW
3.00
2.50
2.00
1.50
1.00
0.50
0
15
16
17
18
19
20
FLOW (CFS)
STORM TIME (HRS)

FIGURE 4-2



BASIN INFLOW AND OUTFLOW HYDROGRAPHS
MERRIL BASIN 10-YEAR EVENT
OUTFLOW
INFLOW
THOUSANDS
FLOW (CFS)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0
15
16
17
18
19
20
STORM TIME (HRS)

FIGURE 4-3

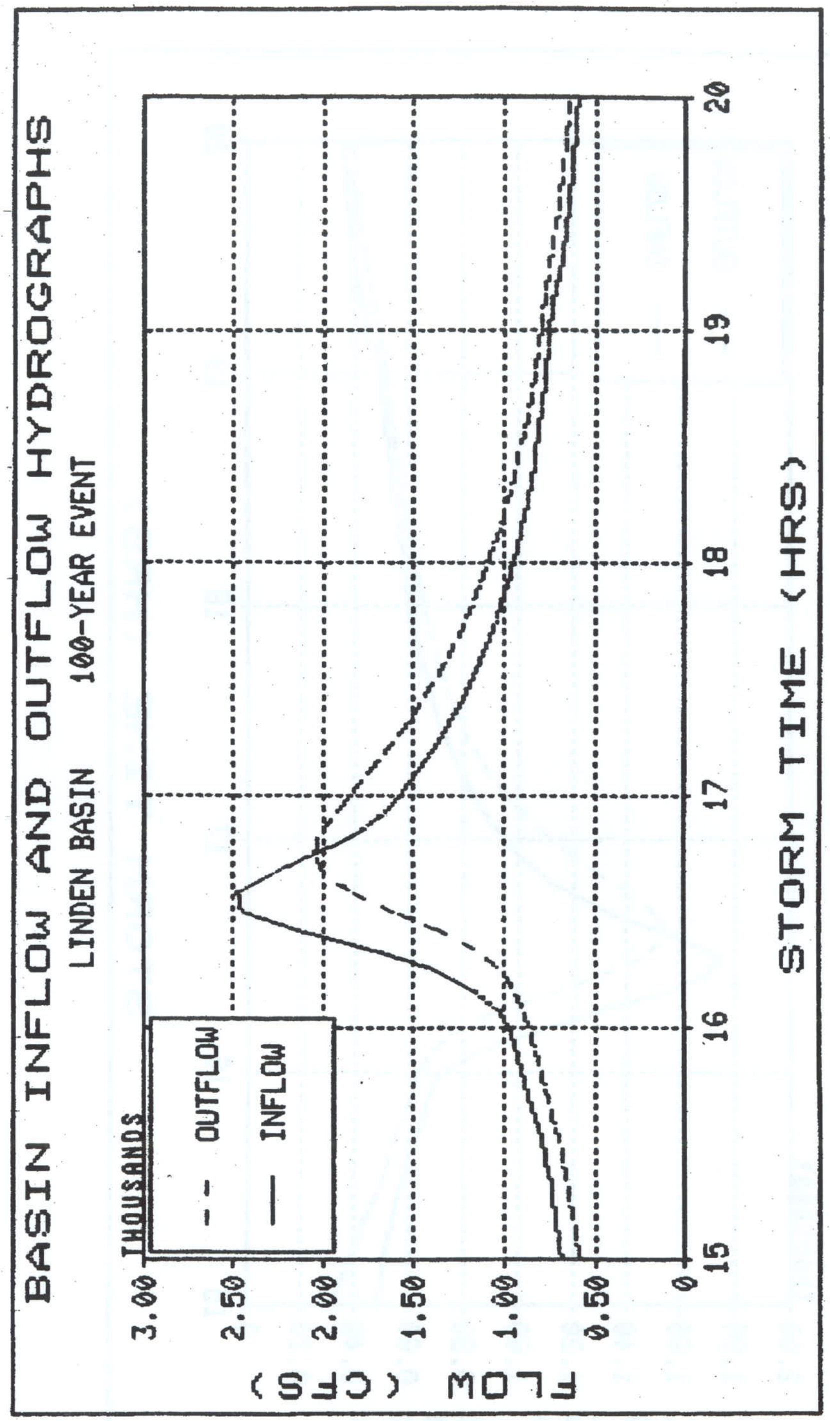

BASIN INFLOW AND OUTFLOW HYDROGRAPHS
LINDEN BASIN 100-YEAR EVENT
THOUSANDS
OUTFLOW
INFLOW
3.00
2.50
2.00
1.50
1.00
0.50
0
15
16
17
18
19
20
FLOW (CFS)
STORM TIME (HRS)

FIGURE 4-4

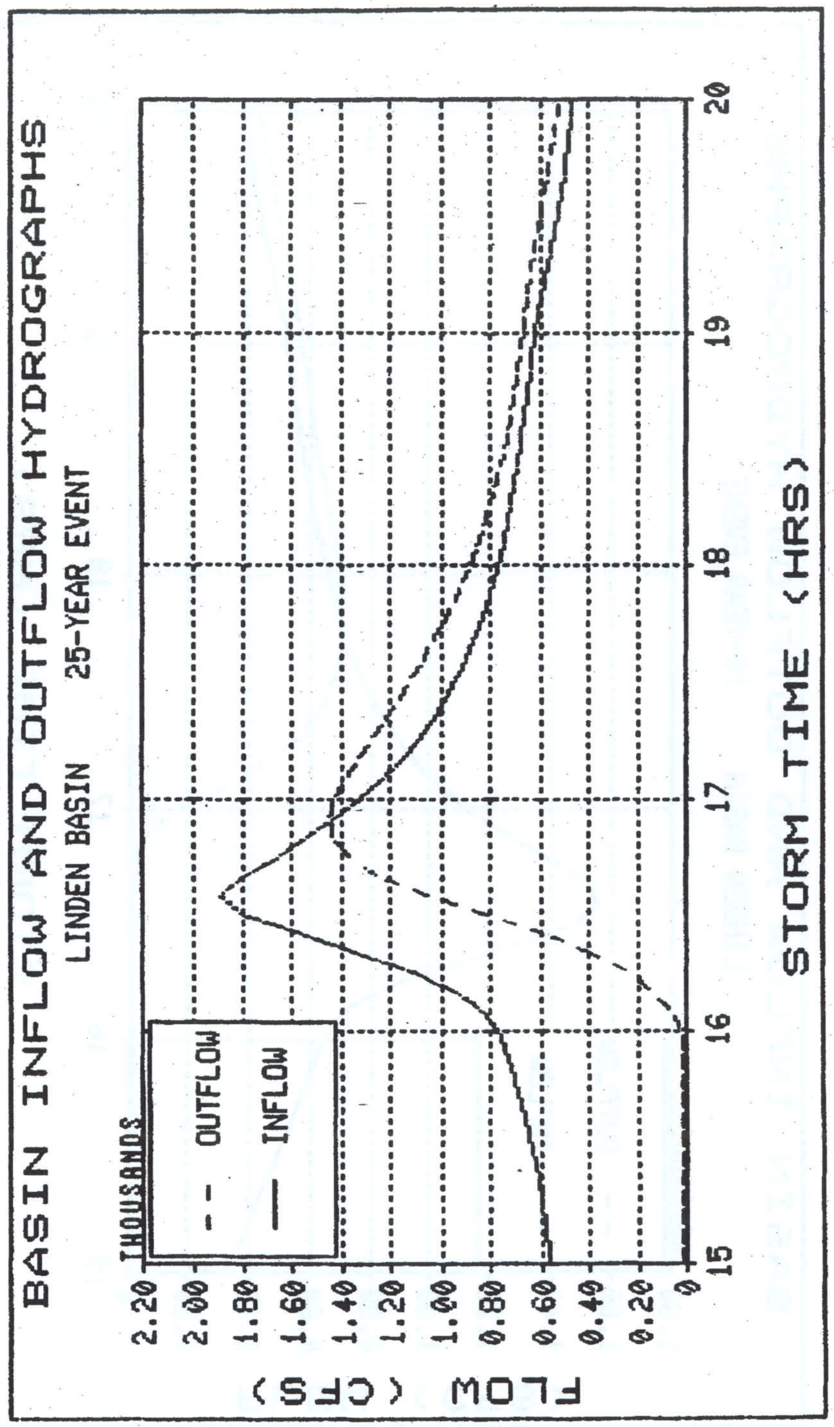
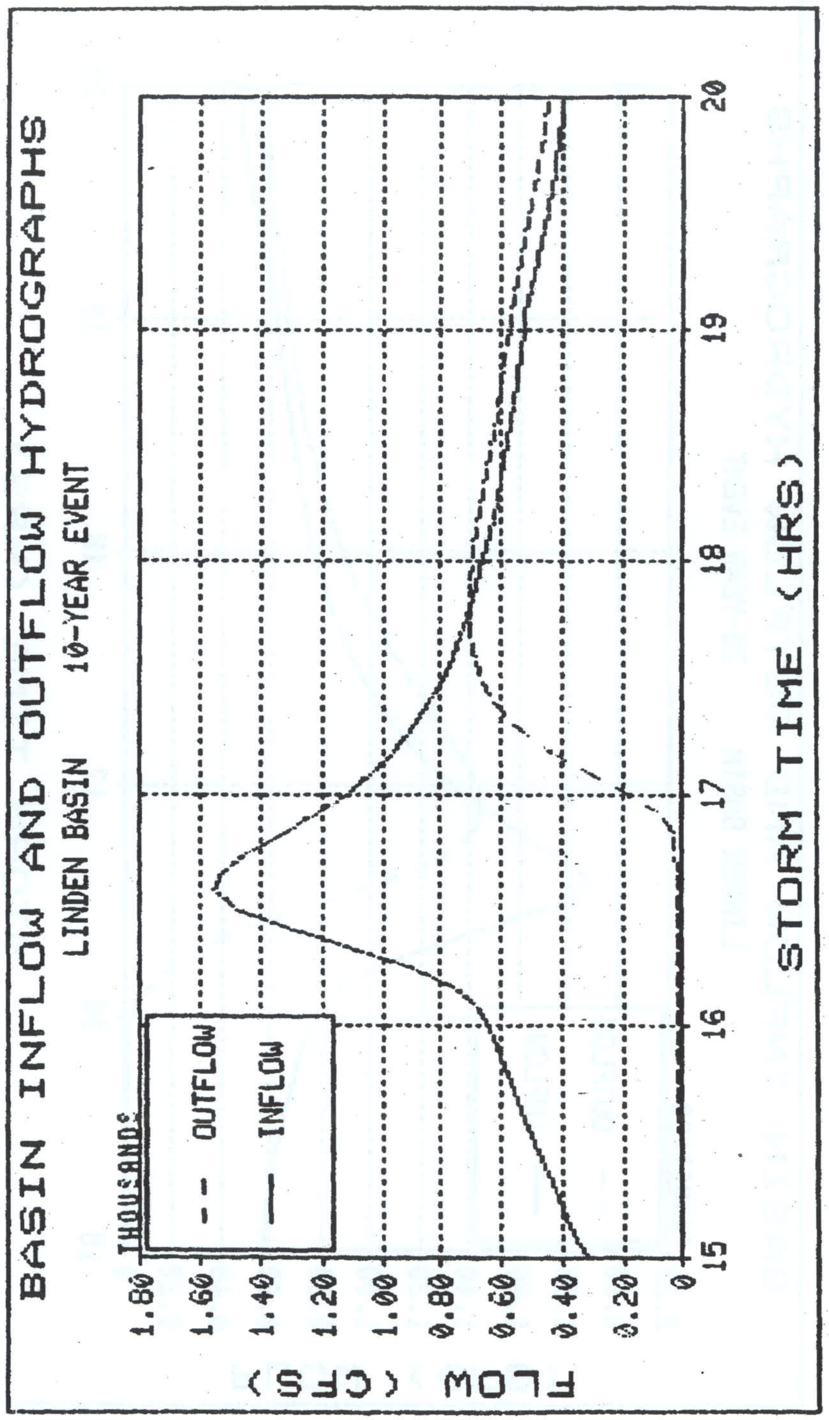

BASIN INFLOW AND OUTFLOW HYDROGRAPHS
LINDEN BASIN
25-YEAR EVENT
THOUSANDS
OUTFLOW
INFLOW
FLOW (CFS)
STORM TIME (HRS)
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0
15
16
17
18
19
20

FIGURE 4-5



BASIN INFLOW AND OUTFLOW HYDROGRAPHS
LINDEN BASIN 10-YEAR EVENT
THOUSANDS
OUTFLOW
INFLOW
FLOW (CFS)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0
15
16
17
18
19
20
STORM TIME (HRS)

FIGURE 4-6

CHAPTER 5

CHAPTER 5

DISCUSSION OF DRAINAGE SYSTEMS

The watershed area draining to the Rialto Channel has been divided into ten major drainage units which each have independent drainage systems. These drainage systems including the Rialto Channel and Cactus Basins are discussed below and presented in Figure 5-1 (Shts. 1 to 3, incl.), Storm Drain System Index Map. Information presented includes descriptions of the types and locations or alignments of drainage facilities comprising the drainage system. More detailed information is presented for each drainage system in Chapter 10, "Plans, Profiles and Cost Estimates" of this report.

LINE A SYSTEM

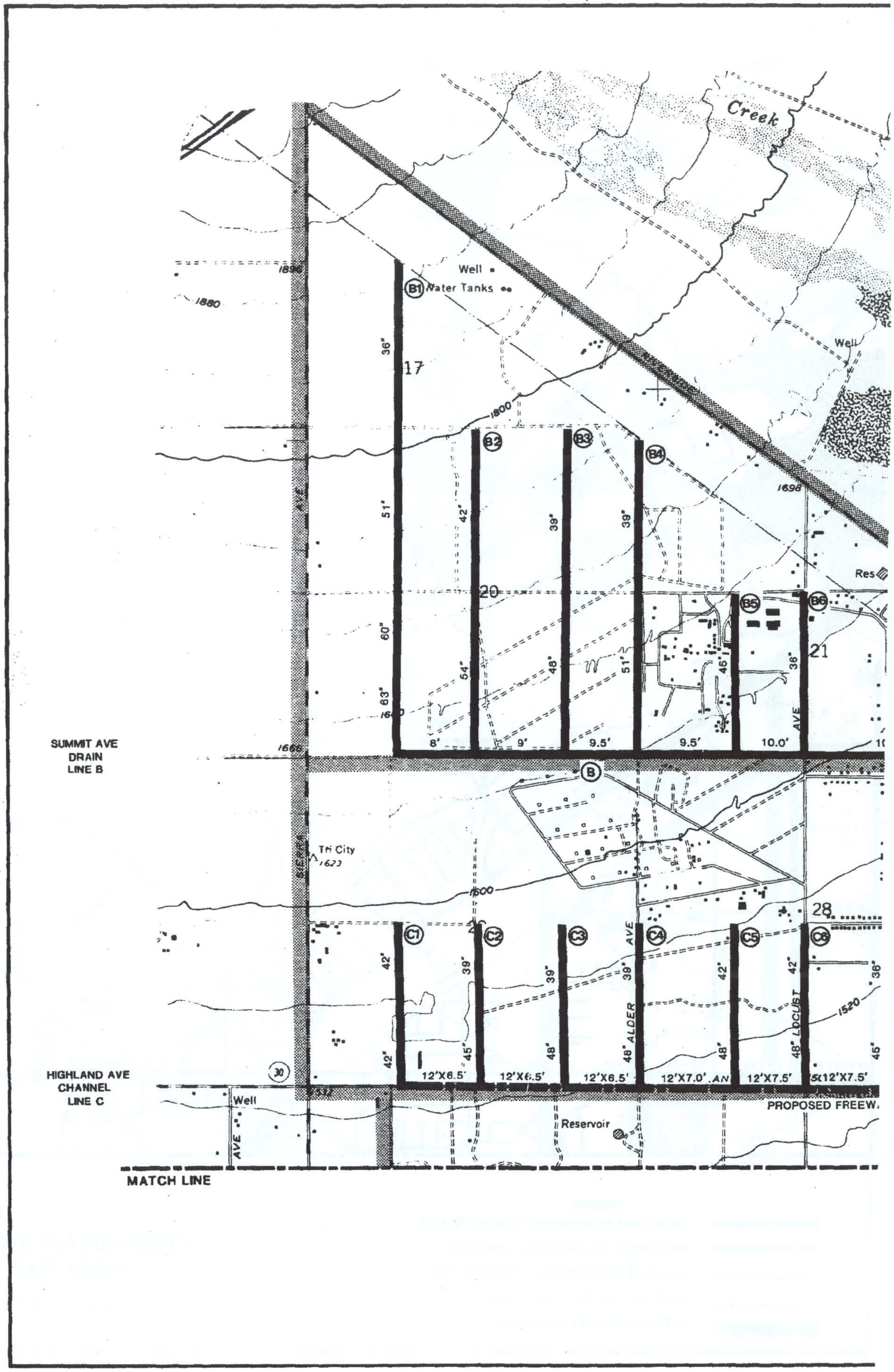
The Line A drainage system includes the Rialto Channel, the primary artery for the full study, and the Cactus Basin detention system. Line A follows the Rialto Channel from its mouth at the Santa Ana River up through three flow-through basins and a channel which parallels two other basins up to where the channel joins Line C just above Highland Avenue. The only other drain in this system is Line A1 which follows through the two flow-by basins and their outlet structures. All facilities in the Line A drainage system have been sized for controlling a 100-year recurrence interval design storm.

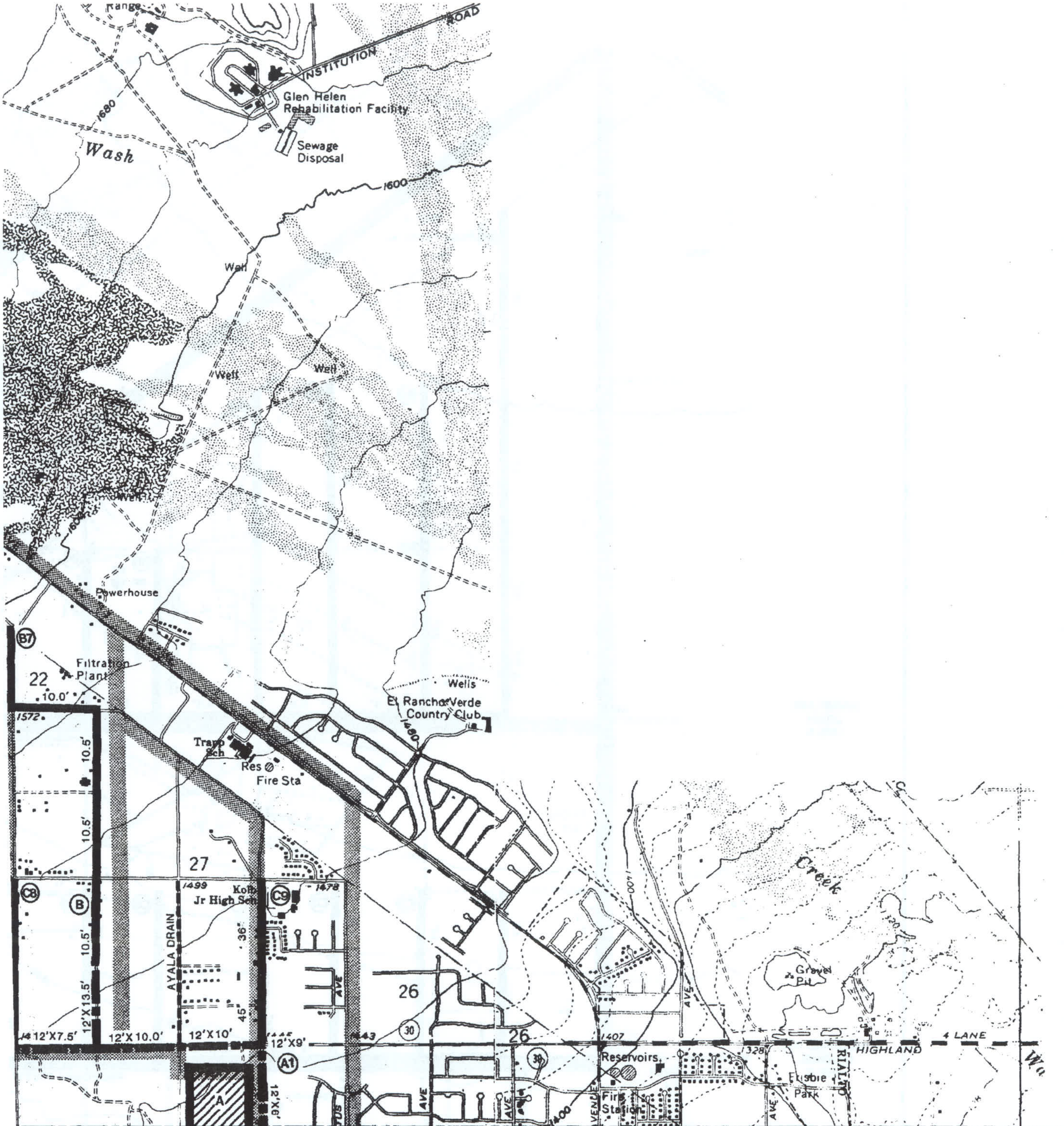
Rialto Channel

The alignment of the improved trapezoidal concrete lined channel (T.C.C.) follows the existing channel. Where feasible and where adequate conveyance was available for passing the design 100-year discharges, existing road crossings and culverts were incorporated into the plan. In some cases, existing culverts which were undersized for the design discharge were augmented with an additional side culvert to meet the required capacity.

Cactus Basins

This comprehensive drainage plan utilizes the majority of the District's right-of-way in the planned upper Cactus Basins area for detention storage. Figure 5-2 shows a plan of the three new Cactus Basins planned for this location. This area extends north of Base Line Road up to Easton Street; it is west of Cactus Avenue and is east


Creek
Well
B1 Water Tanks
Well
17
20
21
28
B2
B3
B4
B5
B6
Res
36"
51"
60"
63"
42"
54"
39"
48"
39"
51"
45"
36"
8'
9'
9.5'
9.5'
10.0'
SUMMIT AVE
DRAIN
LINE B
B
Tri City
1623
SIERRA AVE
C1
C2
C3
C4
C5
C6
42"
42"
39"
45"
39"
48"
39"
48"
42"
48"
42"
48"
36"
45"
ALDER AVE
LOCUST
12'X6.5'
12'X6.5'
12'X6.5'
12'X7.0'
12'X7.5'
12'X7.5'
HIGHLAND AVE
CHANNEL
LINE C
30
Well
AVE
Reservoir
PROPOSED FREEWA
MATCH LINE



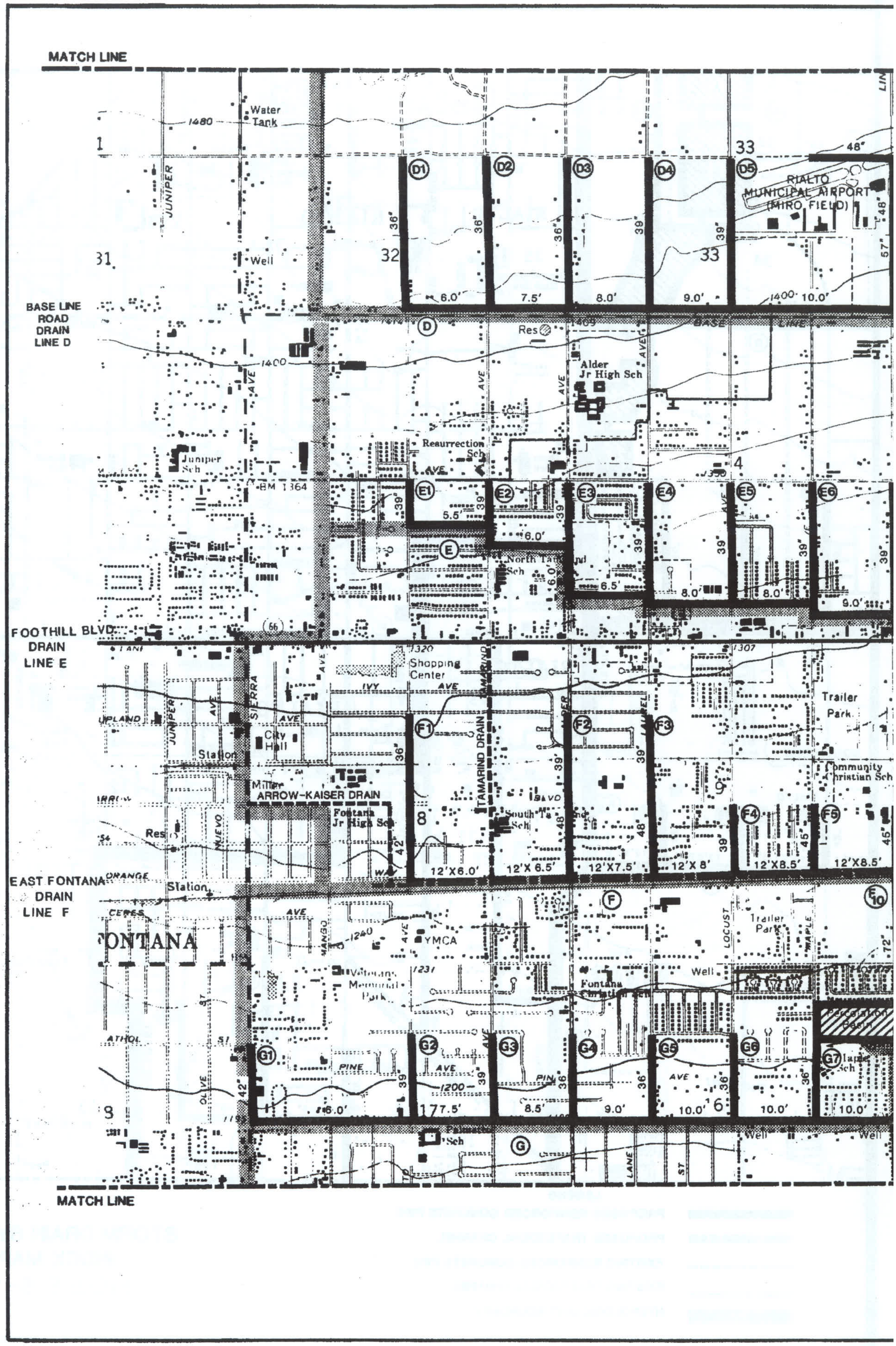
LEGEND

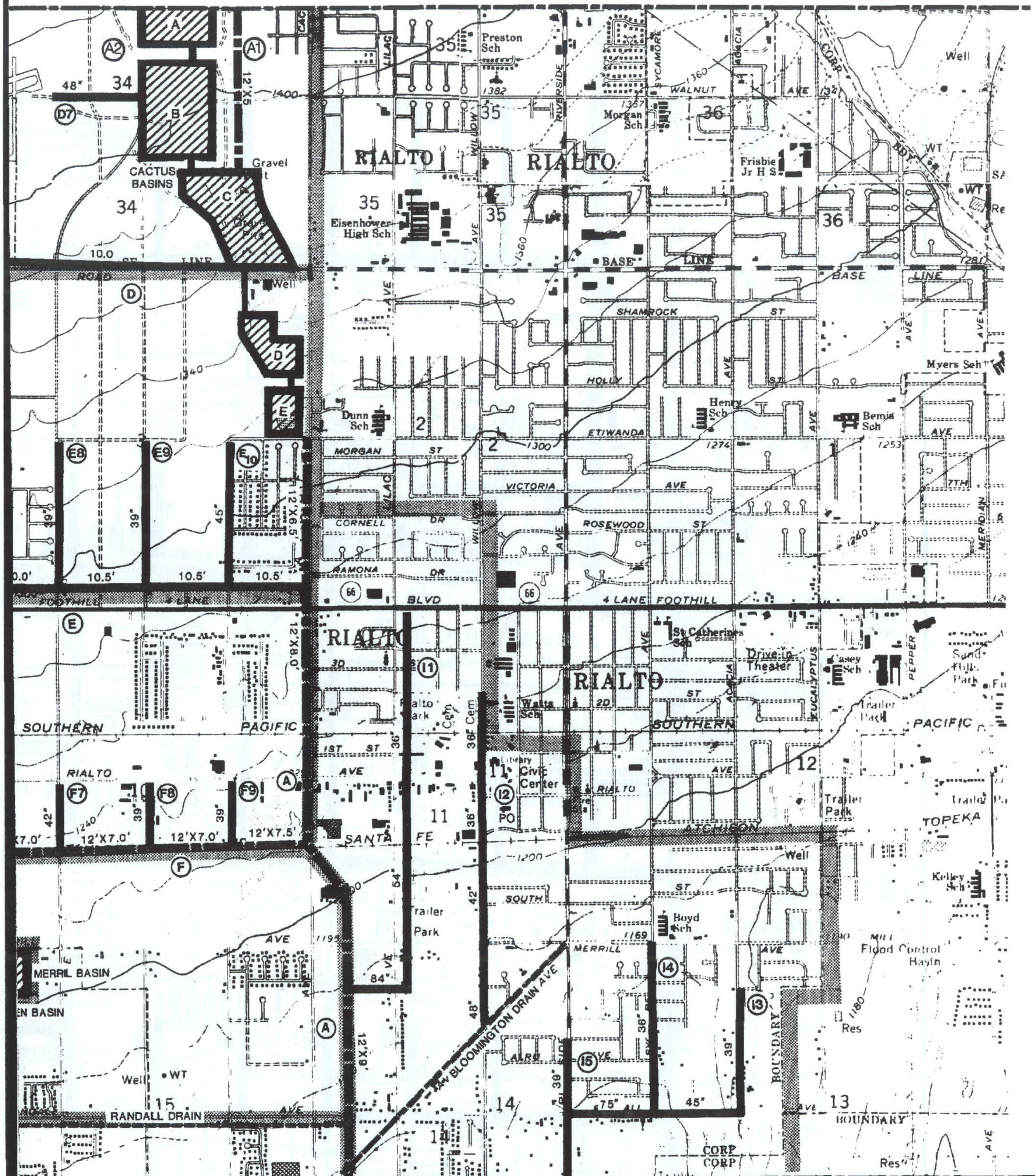
(solid heavy line)	PROPOSED REINFORCED CONCRETE PIPE
(heavy dashed line)	PROPOSED TRAPEZOIDAL CHANNEL
(light dashed line)	EXISTING REINFORCED CONCRETE PIPE
(long dashed line)	EXISTING TRAPEZOIDAL CHANNEL
(shaded band)	HYDROLOGIC UNIT BOUNDARY

STORM DRAIN SYSTEM INDEX MAP

FIGURE 5-1

sht. 1 of 3


MATCH LINE
BASE LINE ROAD DRAIN LINE D
FOOTHILL BLVD. DRAIN LINE E
EAST FONTANA DRAIN LINE F
MATCH LINE
RIALTO MUNICIPAL AIRPORT (MIRO FIELD)
Water Tank
Well
Res
Alder Jr High Sch
Resurrection Sch
Juniper Sch
North Tamarind Sch
Shopping Center
Trailer Park
City Hall
Station
ARROW-KAISER DRAIN
Fontana Jr High Sch
TAMARIND DRAIN
South Tamarind Sch
Community Christian Sch
FONTANA
YMCA
Veterans Memorial Park
Fontana Christian Sch
Well
Trailer Park
Percolation Basin
Maple Sch
D1
D2
D3
D4
D5
E1
E2
E3
E4
E5
E6
F1
F2
F3
F4
F5
G1
G2
G3
G4
G5
G6
G7
6.0'
7.5'
8.0'
9.0'
10.0'
5.5'
6.0'
6.5'
8.0'
8.0'
9.0'
12'X6.0'
12'X 6.5'
12'X7.5'
12'X 8'
12'X8.5'
12'X8.5'
6.0'
7.5'
8.5'
9.0'
10.0'
10.0'
10.0'



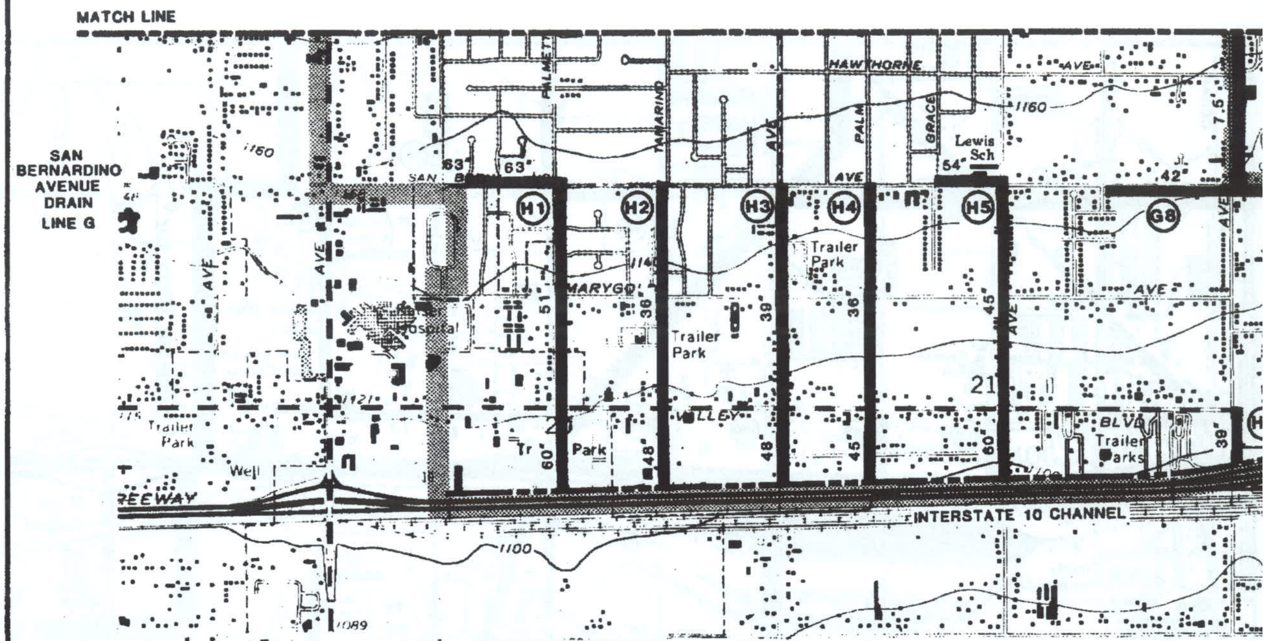
LEGEND

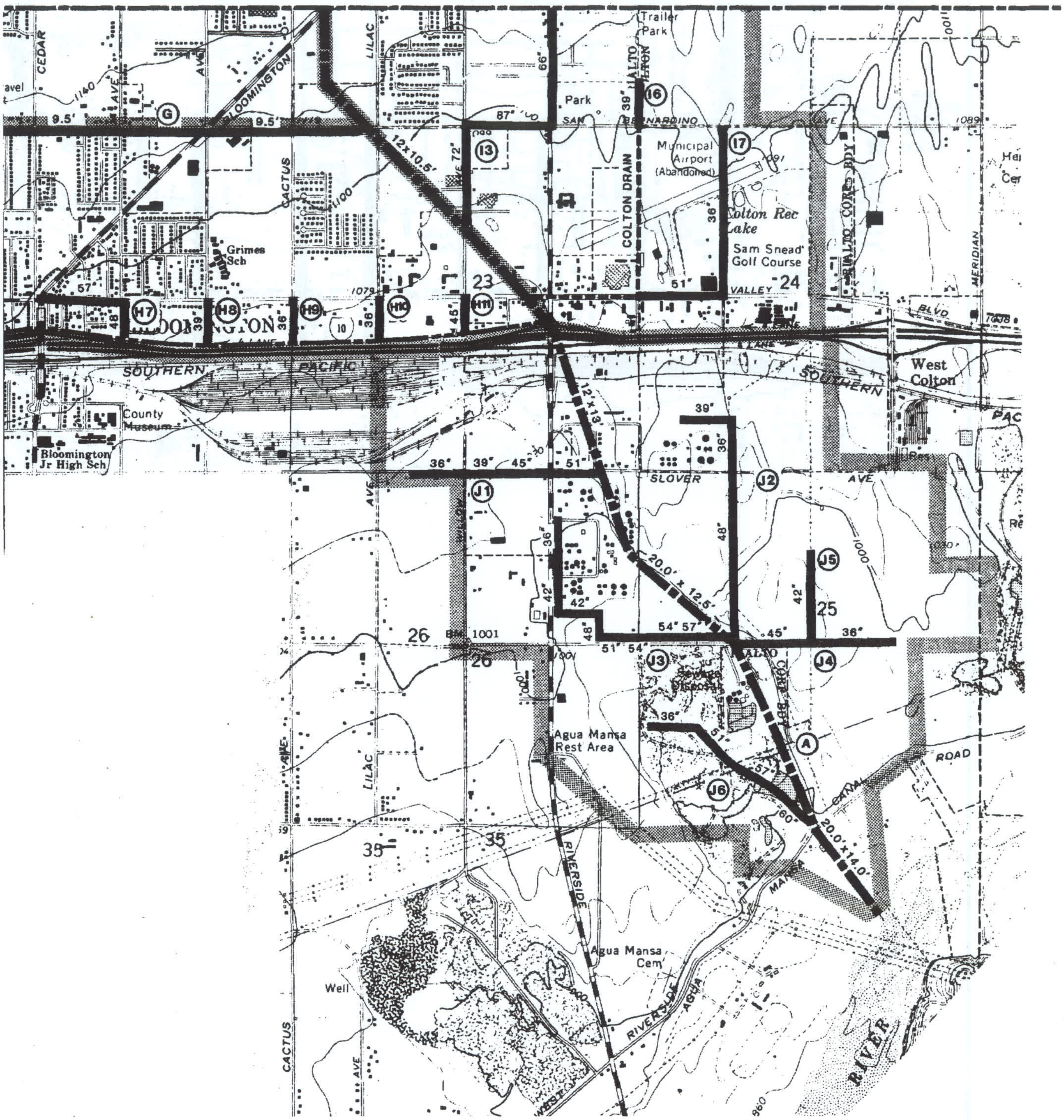
- PROPOSED REINFORCED CONCRETE PIPE
- PROPOSED TRAPEZOIDAL CHANNEL
- EXISTING REINFORCED CONCRETE PIPE
- EXISTING TRAPEZOIDAL CHANNEL
- HYDROLOGIC UNIT BOUNDARY

STORM DRAIN SYSTEM INDEX MAP

FIGURE 5-1

sht. 2 of 3


MATCH LINE
SAN BERNARDINO AVENUE DRAIN LINE G
HAWTHORNE
AVE
PALMETTO
TAMARIND
PALM
GRACE
Lewis Sch
1160
63"
63"
54"
42"
7.5'
H1
H2
H3
H4
H5
G8
Trailer Park
MARYGO
Hospital
51
36
39
36
45
21
Trailer Park
BLVD
Trailer Parks
VALLEY
60"
48"
48"
45"
60"
39"
Well
FREEWAY
INTERSTATE 10 CHANNEL
1100
1089
1121



LEGEND

PROPOSED REINFORCED CONCRETE PIPE

PROPOSED TRAPEZOIDAL CHANNEL

EXISTING REINFORCED CONCRETE PIPE

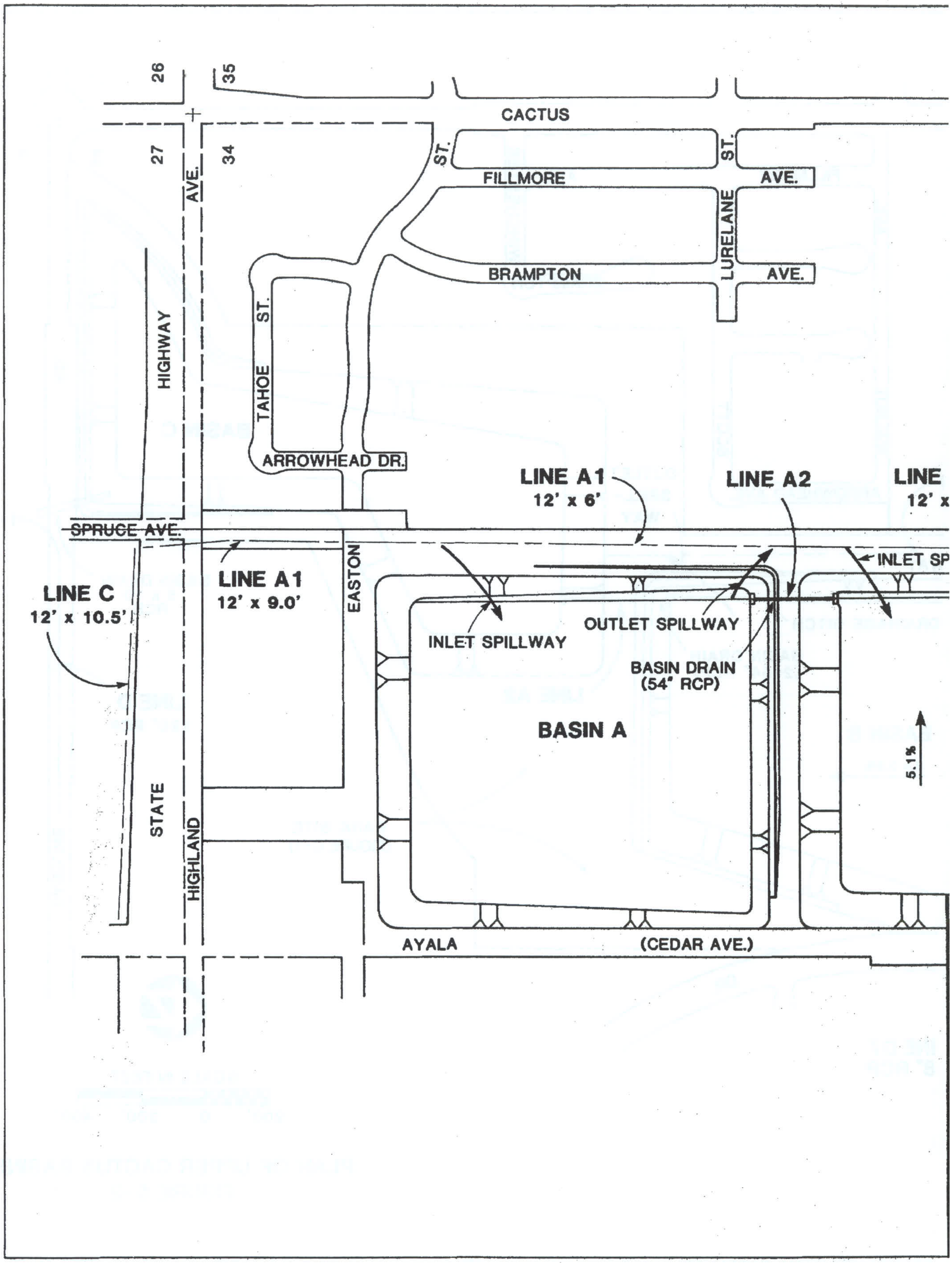
EXISTING TRAPEZOIDAL CHANNEL

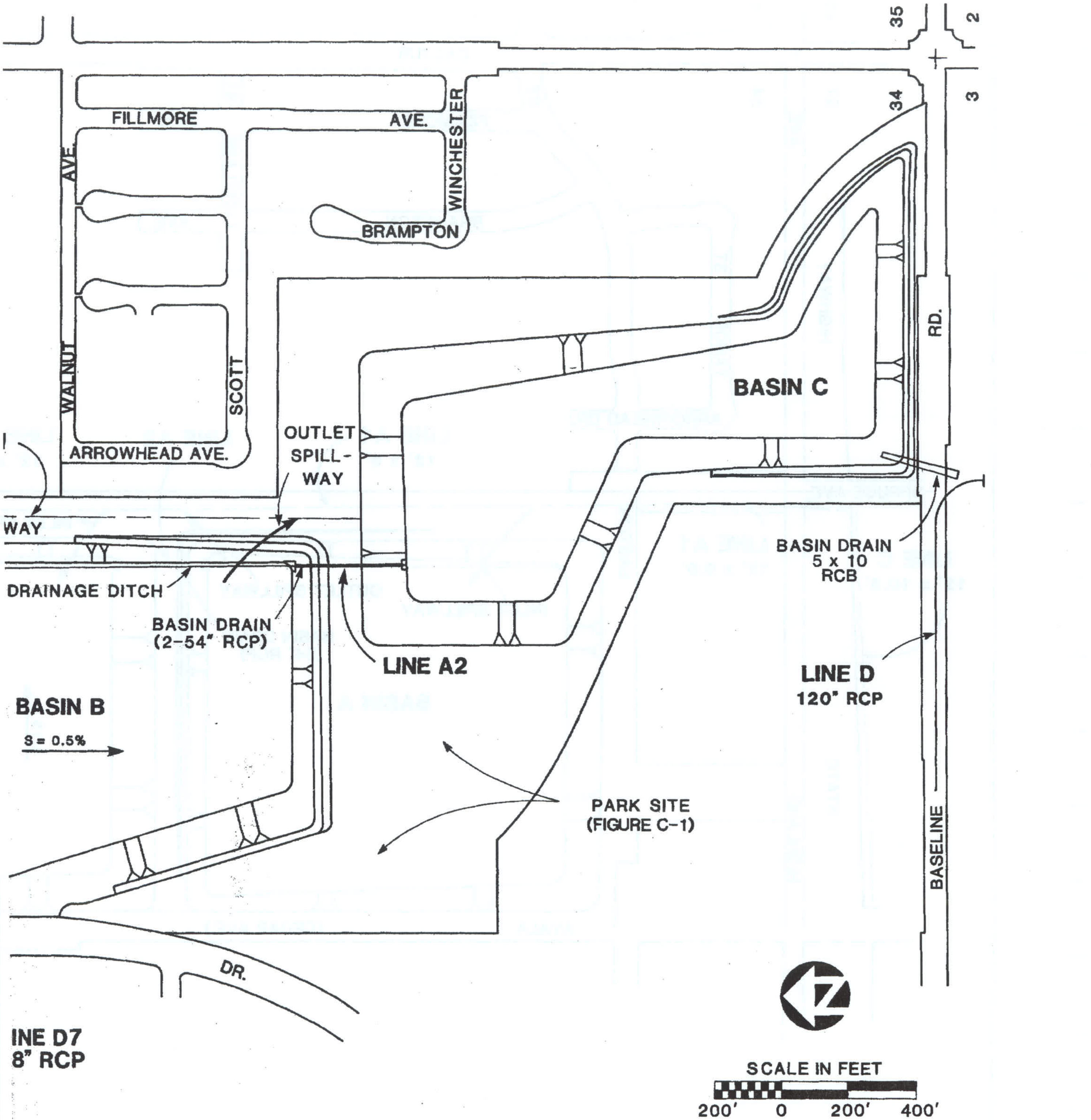
HYDROLOGIC UNIT BOUNDARY

STORM DRAIN SYSTEM INDEX MAP

FIGURE 5-1

sht. 3 of 3


26
35
27
34
CACTUS
ST.
FILLMORE
ST.
AVE.
AVE.
LURELANE
BRAMPTON
AVE.
TAHOE
ST.
HIGHWAY
ARROWHEAD DR.
LINE A1
12' x 6'
LINE A2
LINE
12' x
SPRUCE AVE.
EASTON
INLET SP
LINE C
12' x 10.5'
LINE A1
12' x 9.0'
INLET SPILLWAY
OUTLET SPILLWAY
BASIN DRAIN
(54" RCP)
BASIN A
5.1%
STATE
HIGHLAND
AYALA
(CEDAR AVE.)



PLAN OF UPPER CACTUS BASINS
FIGURE 5-2