LITTLE JOHNSON/SECURITY CREEK DRAINAGE BASIN PLANNING STUDY

Prepared for
El Paso County
Department of Public Works

Prepared by
SIMONS, LI & ASSOCIATES, INC.
in cooperation with
KIOWA ENGINEERING CORPORATION

APRIL, 1988

Kiowa Engineering Corporation

RETURN WITHIN 2 WEEKS TO:
CITY OF COLORADO SPRINGS
STORM WATER & SUBDIVISION
101 W. COSTILLA, SUITE 113
COLORADO SPRINGS, CO 80903
(719) 578-6212

April 8, 1988

Mr. Alan Morrice, P.E.
Manager
El Paso County
Stormwater Management Division
Department of Public Works
3105 North Stone
Colorado Springs, CO 80907

RE: Little Johnson/Security Creek Drainage Basin Planning Study
(SLA Project No. PCO.EPC.01)

Dear Mr. Morrice:

On behalf of Simons, Li & Associates, Inc. (SLA), and the Kiowa Engineering Corporation, I would like to transmit the above-referenced study for the County's use. We have appreciated the opportunity of working with El Paso County on this project, and we remain available to answer any questions you may have concerning the study.

Members of the staff who contributed to the preparation of this report include:

Project Principal and Manager	Richard N. Wray, P.E.
Project Engineer	James Y. Chang, P.E.
Technician	Elizabeth A. Klein
Technical Typist	Rusty Shukle

Again, we thank you and look forward to working with the County in the implementation of the improvements defined herein.

Respectfully Submitted,

KIOWA ENGINEERING CORPORATION

Richard N. Wray, P.E.
President
for SIMONS, LI & ASSOCIATES, INC.

RNW/rms
[illegible]
Enclosure

EXECUTIVE SUMMARY

Introduction

The El Paso County Department of Public Works, in an effort to further assess the existing and long-term stormwater management needs of the County, authorized the preparation of the Little Johnson/Security Creek Drainage Basin Planning Study. The County retained the firm of Simons, Li & Associates, Inc. (SLA) to prepare the study. The Kiowa Engineering Corporation, under a separate agreement with SLA, and with the permission of the County, assisted in the completion and presentation of the study results. The study was initiated on April 28, 1987, and was presented to the El Paso County Board of County Commissioners for approval of the drainage basin fees on March 10, 1988.

The purpose of the study is to assist local officials and developers in planning, design and management of the Little Johnson/Security Creek basins existing and future stormwater facilities. The facilities proposed consist of open channels, closed conduits and detention ponds, which upon their implementation will provide for safe and orderly conveyance of stormwater, and mitigate the risk of flooding damages within the study area. The facilities proposed would serve a drainage area of approximately 3,140 acres consisting of developed and undeveloped ground. Portions of the City of Colorado Springs and the City of Fountain lie within the study area, however, the majority of the basin is in unincorporated El Paso County.

Project Schedule and Coordination

The duration of the study was eleven months, from notice to proceed to the approval of the drainage basin fees. Three public notices were published in local newspapers, in an effort to inform the general public of the intent and scope of the study, and to announce workshops or other public meetings so that information could be gathered, the study findings presented, and to solicit planning input from concerned entities or individuals. During the course of the public meetings, and during the presentation of key technical findings, the County, local developers, and City agencies were provided technical data and draft reports to assist them in concurrent planning and design efforts within the study area. Presented below is a chronological summary of the key study milestones and presentations.

SUMMARY OF SCHEDULE
LITTLE JOHNSON/SECURITY CREEK
DRAINAGE BASIN PLANNING STUDY

Contract Notice to Proceed	April 27, 1987
Public Notice Issued	May 6, 1987
Aerial Map Compilation	June 10, 1987
Hydrology Analysis	June 30, 1987
Alternative Plan Development	July - August, 1987
Workshop to Discuss Alternatives	September 9, 1987
Preliminary Design Development	September - October, 1987
Draft Submittal to EPCDPW	October 24, 1987
Presentations to Drainage Board	November - December, 1987
Presentation to EPC Planning Commission	January, 1988
Workshop with Commissioners	February 10, 1988
Presentation to EPC Commissioners	March, 1988

Technical Analysis

The hydrologic analysis conducted in the study produced peak flow rates for the 10- and 100-year frequency, 24-hour storm durations. The hydrologic analysis focused on the existing and future development conditions. The "Draft, City/County Drainage Criteria Manual", dated April 1987 was followed when determining basin characteristics, rainfall patterns, and future rates of runoff within the study area. The results of this analysis are contained in Chapters II and III of this report. A technical addendum containing the computerized printout of the hydrology is on file with El Paso County Department of Public Works.

A hydraulic analysis of existing and proposed storm drainage facilities was carried out as part of the study scope. This analysis assisted in determining the location of inadequate or undersized storm drainage facilities, the location of existing and future flood prone areas, flood damages, and in sizing the facilities proposed herein. Along Security Creek, a HEC-2 water surface profile analysis was completed in order to assess the flood prone areas adjacent to the Security Creek drainage channel. The HEC-2 data is contained in a technical addendum and is on file with the El Paso County Department of Public Works. A more detailed description of the hydraulic analysis is contained in Chapter IV.

Development of Alternatives

Various alternatives of storm drainage systems were developed. These included:

1. Full conveyance of runoff via pipes/conduits.
2. Full conveyance of runoff via channels.
3. Stormwater retention facilities.
4. Stormwater detention facilities.
5. Rehabilitation or reconstruction of existing facilities.
6. Combinations of the above.

The hydraulics of each alternative was evaluated, and the feasibility of each storm drainage alternative determined. Factors influencing an alternate's feasibility include cost, constructability, utility conflicts, right-of-way requirements, aesthetics, land use, and operations and maintenance. A workshop was conducted with interested parties to discuss the alternatives, and to assist in formulating the most feasible alternate to advance into the preliminary design phase.

Selected Alternative

As a direct result of the alternative plan workshop, and through consultation with El Paso County, an alternate was selected for preliminary design evaluation. The selected alternative is discussed by basin below:

Little Johnson Drainage: The selected alternate involves a system of closed conduits and open channels to convey runoff to three detention ponds within the basin. The detention ponds have been sized to reduce the rate of runoff and, therefore, reduce the size of the outfall facilities which drain the pond system to Fountain Creek. The capacity of the individual components range from 10- to 100-year conveyance. This system is detailed on Sheets 11 through 17 of the drawings. Total cost of the system is estimated at $7,883,300, exclusive of the cost of minor or local drainage systems.

Security Drainage Basin: This system is a piped system, which conveys runoff from the existing areas of Security, Coloardo, to an improved Security Creek drainageway. The Security Creek is then conveyed to Fountain Creek via a closed conduit starting at Crawford Avenue. This outfall conduit parallels the existing Fountain Valley conduit. The capacity of the system ranges from 10- to 100-year conveyance. Total cost of this system is estimated at $6,402,600.

Widefield Drainage Basin: The selected alternate for this basin involves the upgrading and construction of new storm sewers within the existing areas of Widefield, Colorado. The storm sewer system conveys flow to a rehabilitated Security Creek channel, which then outfalls to the Crews Gulch drainageway. The capacity of the system ranges from the 10- to 100-year. Total cost of the system is estimated at $3,007,600.

Carson Street Basin: The selected alternative in this basin consists of a 10-year capacity storm sewer, which will convey flow from developing areas through the existing Southmoor Subdivision in the City of Fountain. The system outfalls to Fountain Creek. Total cost of the system is estimated at $285,600, exclusive of local or minor drainage systems.

Drainage Basin Fees

Using the total costs for each system, a basin fee was developed for each drainage basin within the study area. A discussion of how the fees were determined is contained in Chapter VI of this report. On March 10, 1988, the El Paso County Board of County Commissioners approved the following drainage basin fees to be assessed against unplatted acreage within the study area.

Summary of Drainage Basin Fees
Little Johnson/Security Creek Drainage Basin
Planning Study

Basin Name	Fees ($/acre)
Little Johnson	Drainage Fee = 5,282 Land Fee = 350
Security	5,306
Widefield	5,529
Carson Street	3,480
Direct Flow Areas	3,480

Within the existing areas of Little Johnson, Security, and Widefield Basins, the collection of drainage fees from developers will not cover the entire costs of the drainage facilities proposed herein. Accordingly, funding mechanisms such as capital improvement programs, special or local improvement districts, block grant programs, or a combination of these will be needed to construct portions of each of these systems. In any case, final designs and more refined cost estimates will have to be produced to further identify the level of funding which will be required to construct storm drainage facilities within existing developed areas. A discussion of construction prioritization, implementation, and other recommendations are contained in Chapter VI of the report.

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VI. PRELIMINARY DESIGN AND COST ESTIMATE

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I. INTRODUCTION

Authorization

This study covering the alternative development aspects of the Little Johnson/Security Creek Drainage Basin Planning Study (study) was authorized under the terms of the agreement between El Paso County (County) and Simons, Li & Associates, Inc. (SLA) dated April 27, 1987.

Purpose and Scope

The purpose of the study is to identify feasible stormwater management plans to satisfy the existing and future needs within the Little Johnson/Security Creek Basin and the Widefield Basin. The specific scope of work for this study includes the following tasks:

1. Meet initially and biweekly with the County to: insure compliance with the services required by this agreement, obtain existing data and general information from participating entities, solicit desires of participating entities and other interested agencies or groups in order to develop alternate plans, procure current information relative to development plans in the basin, procure information relative to right-of-way limitations and potential hazards due to flooding, and avoid duplication of effort whenever possible by utilizing existing information available from other agencies.
2. Contact the County, individuals, and other agencies who have knowledge and/or interest in the study area.
3. Utilize County policies and criteria and applicable information where possible.
4. Perform hydraulic and hydrologic analyses within the study area.
5. Identify existing and potential drainage problems.
6. Develop improvement alternatives to reduce existing and potential flooding problems.
7. Examine the operation and maintenance aspects of the alternatives.
8. Conduct an economic analysis of each alternative.
9. Prepare a written report discussing all items examined in the study.

Summary of Data Obtained

Listed below is the technical report collected for the use in this study:

1. Soil Survey for El Paso County, Colorado, dated June 1980.

2. Draft "City of Colorado Springs/El Paso County Drainage Criteria Manual", prepared by City of Colorado Springs, El Paso County, and HDR Infrastructure, Inc., dated May 1987.

3. "Flood Insurance Studies for Colorado Springs, and El Paso County, Colorado", prepared by the Federal Emergency Management Agency (FEMA), 1986.

4. "Peterson Field Drainage Master Plan", prepared by URS/NES, dated September 1984.

5. "Windmill Gulch Master Drainage Study", prepared by Finn & Associates, Ltd., dated July 1984.

In addition to the above listed reports there were a number of drainage study reports, sketch plans, preliminary and final design drawings, land use maps, proposed development plans, and existing drainage facility maps that were provided by the County, local agencies, private entities, and individuals for the use of the project.

Mapping and Surveying

As part of the agreement, detailed mapping for the study area at a scale of 1" = 200' with 2-foot contour intervals was prepared by Landmark Mapping in May 1987, with the exception of the area to the northeast of Little Johnson Reservoir. The mapping covering the northeast portion of Little Johnson Reservoir area were dated in November, 1986, and obtained from OEW Consulting Engineers.

A detailed site inspection of the study area was conducted, and photos were taken documenting the key drainage features. This data is contained in Section IV.

Acknowledgements

During the course of the preparation of this study, officials from El Paso County and others provided technical input and guidance. Specifically, we would like to thank the El Paso County Department of Public Works, the

County Attorney's Office, and the El Paso County Land Use Department for their time and assistance.

We would also like to thank the City of Colorado Springs, City of Fountain, Fountain Mutual Irrigation Co., MVE, Inc., CEW Consulting Engineers, Wilson & Company, Land Development Consultants, Inc., Leigh Whitehead & Associates, Transit Mix Concrete, and George Jury and Associates, Inc. for their provision of planning and technical documents associated with each of their developments.

II. STUDY AREA DESCRIPTION

Location

The study area as defined in the agreement is generally described as the entire watershed for the Little Johnson Reservoir area, Security area, and Widefield area. More specifically, the boundaries for the Little Johnson Reservoir and Security areas consist of Drennen Road on the north, Fountain Creek on the southwest, and Windmill Gulch Basin Boundary on the east. The boundaries for the Widefield area consist of Crews Gulch on the southeast, Fountain Creek on the southwest, and Windmill Gulch Basin Boundary on the north. The total study area encompasses approximately five square miles. The general location of the study area is shown on Figure 1.

Climate

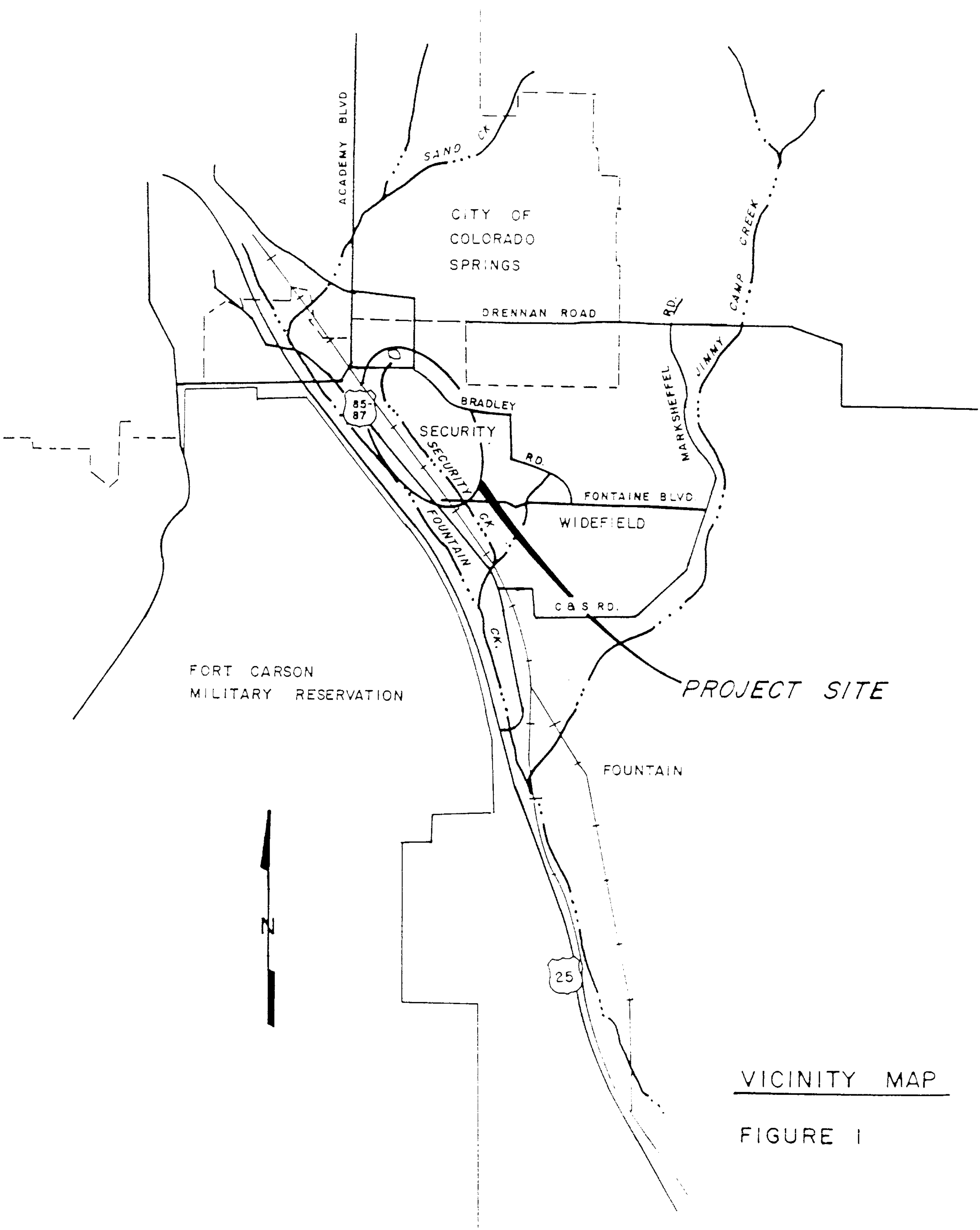
The study area can be described, in general as high plains, with total precipitation amounts typical of a semi-arid region. Winters are generally cold and dry, and summers relatively cool and dry. Precipitation ranges from 14 to 16 inches per year, with the majority of this precipitation occurring in spring and summer in the form of rainfall. Thunderstorms are common during the summer months, and are typified by quick-moving low pressure cells which draw moisture from the Gulf of Mexico into the region. Average temperatures range from about 30°F in the winter to 75°F in the summer. The relative humidity ranges from about 25 percent in the summer to 45 percent in the winter.

Soils Characteristics

The study area is predominantly made up of Type A and B soil groups with some C groups along U.S. Highway 85/87 and the railroad, as described in the El Paso County Soil Survey. Figure 2 shows the extent of the various soil groups which occur in the study area. This soil information was used to develop the hydrologic parameters for use in the modeling process.

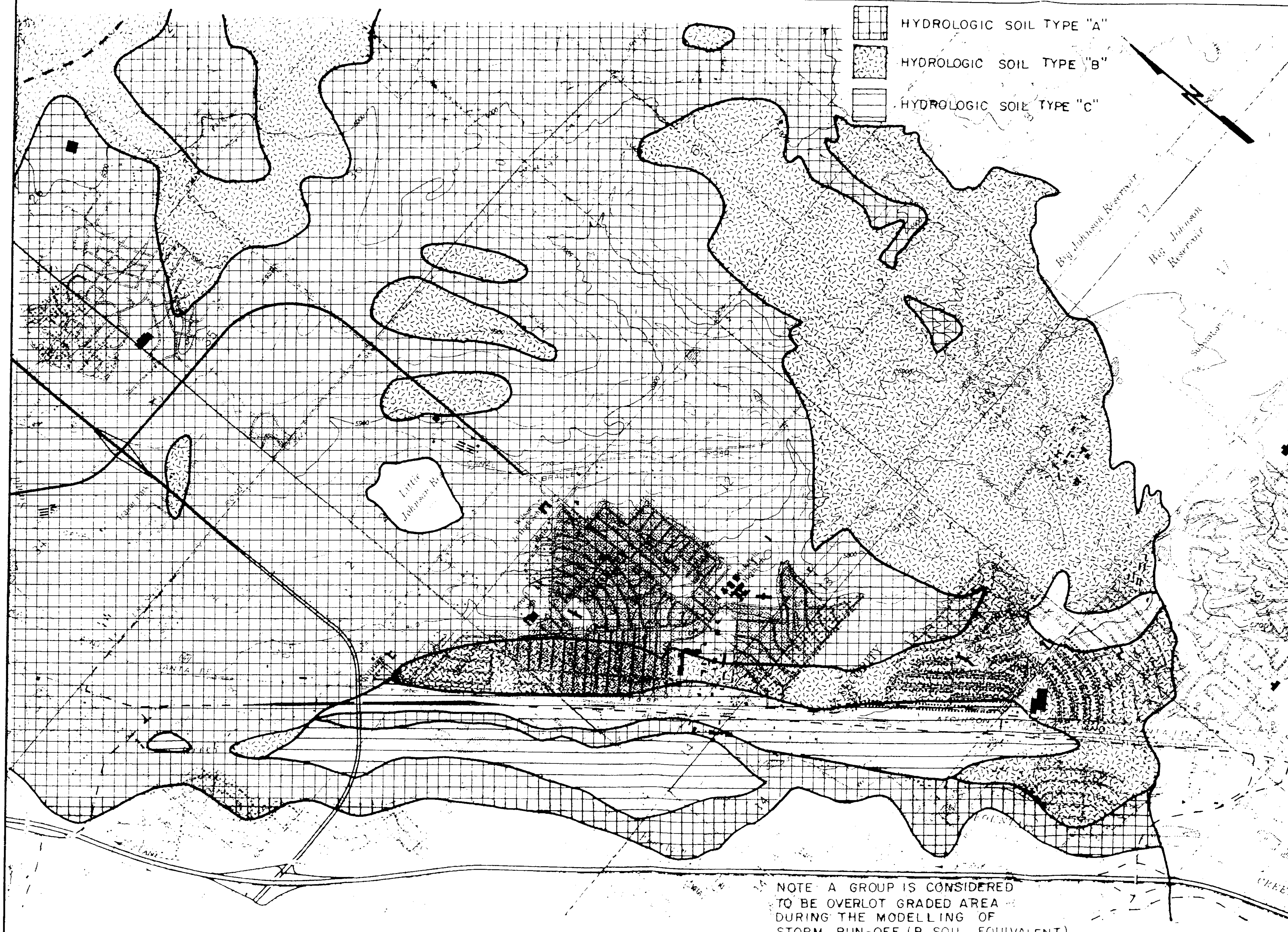
Major Drainage Basins

The entire study area was divided into two major basins. A discussion of the major features of these areas is presented below:



VICINITY MAP

FIGURE I



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LITTLE JOHNSON / SECURITY
DRAINAGE BASIN PLANNING STUDY
SOILS MAP

Project No.	PCO-EPC C
Date:	10/87
Design:	JYC
Drawn:	EAK
Check:	JYC
Revisions:	

FIG. 2

1. Little Johnson/Security Basins

The Little Johnson/Security Basins consist of three drainage zones: (1) area to the north side of Canal No. 4, (2) area between Canal No. 4 and U.S. Highway 85/87, and (3) area between U.S. Highway 85/87 and Fountain Creek. The first zone is approximately 50 percent developed. Major developments include: a residential area at the northwest side of Drennan Road and Hancock Expressway, a residential area at the northeast side of Canal No. 4 and Hancock Expressway, and an industrial area along both sides of Hancock Expressway. The potential future developments includes commercial, industrial, and office area for the undeveloped site near Hancock Expressway and Drennan Road. The area north of Drennan Road lies within the City of Colorado Springs. Currently, all the drainage flows are either directly or indirectly discharged into Canal No. 4. Portions of the Canal No. 4 have been improved and realigned due to the improvements on Bradley Road on the east side of Hancock Expressway. The second zone consists mainly of residential areas in Security, south of Bradley Road. Between the area south of Bradley Road and existing Security area, there are residential development activities that are currently underway. Areas along both sides of Academy Boulevard are currently under gravel mining operations. Little Johnson Reservoir is an abandoned reservoir and there are plans to develop this area into residences. The area just west of Little Johnson Reservoir is now an open space and is also proposed to be developed into a residential area. The area just southeast of Little Johnson Reservoir is to be developed into a planned business park. Bradley Road is currently a two-lane road and is to be widened to a four-lane road in the near future. All drainage flows in this zone eventually drain to Security Creek just north of U.S. Highway 85/87 and the railroad. Security Creek starts at the intersection of Cody Drive and Cactus Drive, and runs parallel to the railroad. The Creek drains into Crews Gulch in the Widefield area. Crews Gulch is also referred to as the Big Johnson drainage and Widefield Creek, however, "Crews Gulch" will be used throughout this report. Zone 3 primarily is an open space area. A small portion of the land near the northeast side of Academy Boulevard and U.S. Highway 85/87 is developed as a trailer court and an industrial area. Drainage flows from this area flow directly into Fountain Creek.

2. Widefield Basin

This basin is divided into two drainage zones by U.S. Highway 85/87 and the railroad. Areas north of the railroad are mainly residential, with some commercial development along Security and Fontaine Boulevards. Grinnell Street and a parallel concrete ditch convey most of the drainage flow from the northeast part of the basin. The rest of the area drains to Security Creek and Crews Gulch. The area south of the railroad consists of residential area and light industrial development. These are direct flow areas flowing into Crews Gulch or Fountain Creek.

III. HYDROLOGIC ANALYSIS

Runoff Model

The runoff model used to determine the peak flow and volumes within the study area is the SCS Computer Program for the Project Formulation Hydrology (TR-20). The version is available for the IBM PC-XT, AT, or a compatible machine. The use of this hydrological model is in compliance with the City of Colorado Springs/El Paso County Drainage Criteria Manual (Criteria Manual).

Basin Characteristics

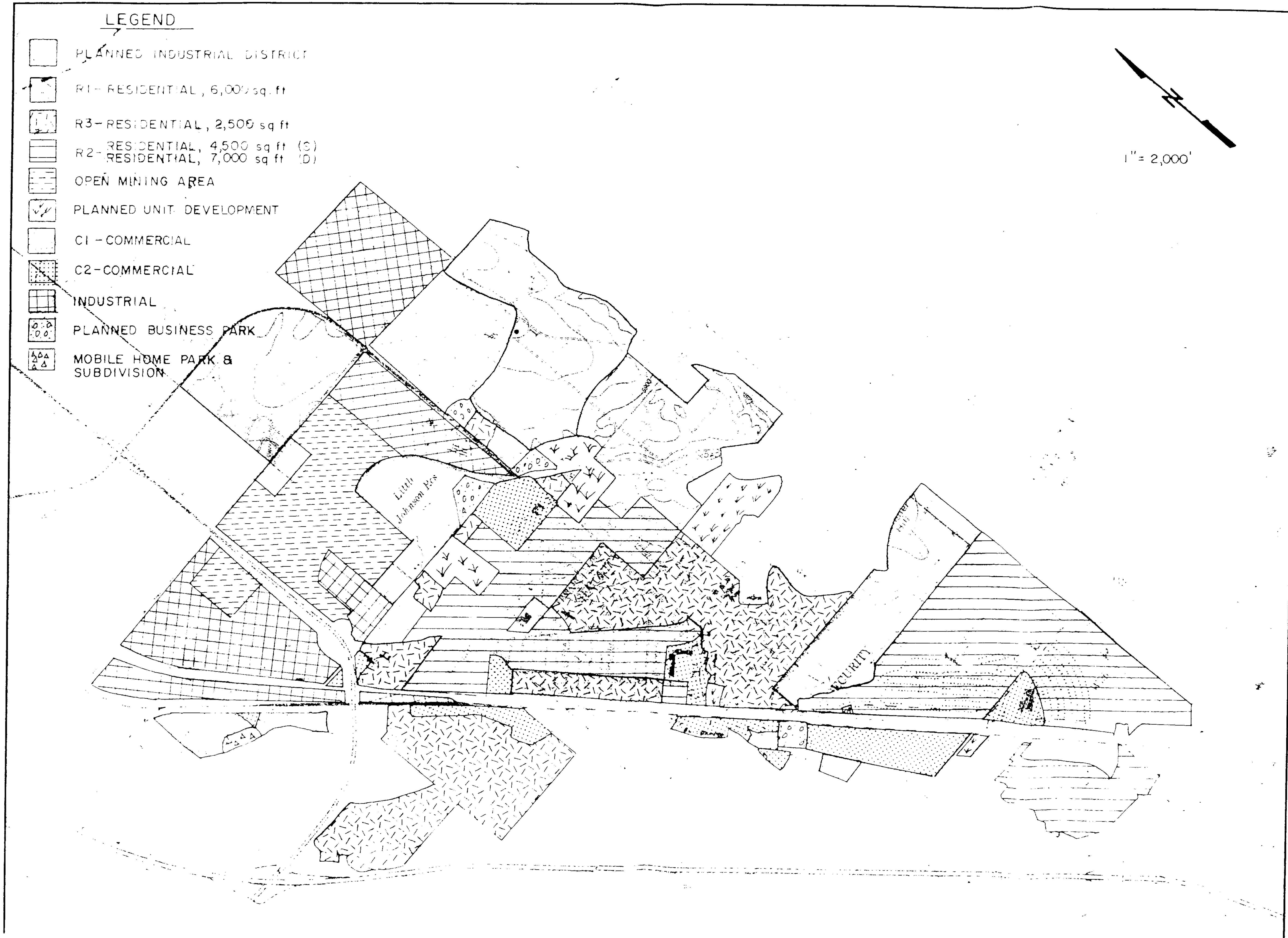
The total study area was divided into 88 sub-basins, 48 routing elements and 45 design points on Figure 3 (See Map Pocket). The sub-basin characteristics such as area, curve number, time of concentration, routing coefficients, channel type and length, and flow velocities were determined from predescribed mapping information, zoning and land use maps, soils map, field investigation, and personal conversation with county staff. A summary of the basin characteristics is included in Table 1.

Basin Designation System

A numbering system was developed for the entire study area. In general, numbers 1 through 46, 62 through 77, 84 and 88 were assigned for the sub-basins in the Little Johnson/Security area and numbers 47 through 57, 78 through 83, and 85 were assigned for the Widefield area. A hydrological basin map which contains all the sub-basins and basin groups is shown on Figure 3 (See Map Pocket).

Impervious Land Density

The existing and future impervious land density used for the study is presented in Figure 4. The different impervious designations were defined using the El Paso County land use map dated February 22, 1985. Existing and future land uses for the Little Johnson Reservoir and adjacent areas were defined based upon input from El Paso County engineering staff, proposed sketch and plot plans, and discussions with property owners. Aerial photographs (dated May, 1987) were also used to determine the extent of existing



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LITTLE JOHNSON / SECURITY CREEK
DRAINAGE BASIN PLANNING STUDY
LAND USE MAP

FIG 4

Table 1. TR-20 Hydrologic Basin Parameter.

Basin I.D.	% Imperviousness		Soil Type		Curve Number(CN)		Time of Concentration(Hr)	
	Existing	Future	Existing	Future	Existing	Future	Existing	Future
1	2	85	2/3 A 1/3 B	B	46	85	0.64	0.13
2	65	65	B	B	82	82	0.31	0.31
3	65	65	B	B	82	82	0.23	0.23
4	13	85	1/2 A 1/2 B	B	46	88	0.72	0.20
5	2	67	A	B	39	86	0.52	0.25
6	27	72	2/3 A 1/3 B	B	54	88	0.62	0.62
7	72	72	A	A	81	81	0.28	0.04
8	2	85	A	B	39	92	0.28	0.27
9	2	67	A	B	39	86	0.58	0.23
10	2	65	A	B	39	85	0.26	0.23
11	2	65	A	B	39	85	0.58	0.61
12	2	68	A	B	39	86	0.52	0.28
13	2	75	A	B	39	88	0.22	0.23
14	2	65	A	B	39	85	0.26	0.56
15	27	75	4/5 A 1/5 B	4/5 A 1/5 B	72	88	0.45	0.41
16	65	65	3/4 A 1/4 B	3/4 A 1/4 B	84	84	0.55	0.55
17	65	65	A	A	77	77	0.56	0.56
18	65	65	A	B	77	85	0.48	0.48
19	2	65	A	B	39	85	0.29	0.29
21	60	65	A	A	77	77	0.12	0.12
22	5	65	A	B	40	85	0.25	0.11
23	85	85	A	B	85	92	0.33	0.40
24	5	85	A	B	42	92	0.50	0.90
25	2	75	A	B	39	89	0.71	1.22
26	65	65	A	B	85	85	0.33	0.33
27	49	65	B	B	81	85	0.49	0.45
28	35	75	4/5 A 1/5 B	B	54	89	0.27	0.29
29	65	65	1/3 A 2/3 B	1/3 A 2/3 B	82	82	1.36	1.36
30	56	56	1/2 A 1/2 B	1/2 A 1/2 B	81	81	0.78	0.78
31	5	65	A	B	40	85	0.14	0.11
32	59	59	A	A	79	79	0.14	0.14
33	70	70	A	A	80	80	0.45	0.45
34	70	70	A	A	80	80	0.48	0.48
35	65	65	A	A	77	77	0.25	0.25
36	2	70	A	B	39	83	0.58	0.25

Table 1. TR-20 Hydrologic Basin Parameter (continued).

Basin I.D.	% Imperviousness Existing	% Imperviousness Future	Soil Type Existing	Soil Type Future	Curve Number(CN) Existing	Curve Number(CN) Future	Time of Concentration(Hr) Existing	Time of Concentration(Hr) Future
37	65	65	A	A	77	77	0.52	0.52
38	40	40	A	A	73	73	0.21	0.21
39	65	65	A	A	77	77	0.59	0.59
40	65	65	1/5 A 4/5 B	1/5 A 4/5 B	82	82	0.92	0.92
41	95	95	1/2 A 1/2 B	1/2 A 1/2 B	92	92	0.54	0.54
42	95	95	2/3 A 1/3 B	2/3 A 1/3 B	92	92	0.28	0.28
43	46	46	A	A	73	73	0.52	0.52
44	65	65	A	A	77	77	0.24	0.24
45	65	65	1/2 A 1/2 B	1/2 A 1/2 B	77	77	0.36	0.36
46	75	75	B	B	90	90	0.13	0.13
47	65	65	B	B	85	85	1.01	1.01
48	65	65	1/3 A 2/3 B	B	85	85	0.27	0.27
49	65	65	B	B	85	85	0.35	0.35
50	58	58	B	B	83	83	0.60	0.60
51	65	65	B	B	85	85	0.50	0.50
52	2	65	B	B	61	85	0.53	0.26
53	18	65	B	B	78	85	0.45	0.30
54	2	52	B	B	61	81	0.26	0.38
55	53	53	2/3 A 1/3 B	2/3 A 1/3 B	77	77	0.37	0.37
56	76	76	B	B	90	90	0.65	0.65
57	68	68	1/3 A 2/3 B	1/3 A 2/3 B	85	85	0.64	0.64
58	2	77	A	B	39	90	0.13	0.13
59	65	65	4/5 A 1/5 B	4/5 A 1/5 B	77	77	0.35	0.35
60	65	65	1/2 A 1/2 B	1/2 A 1/2 B	82	82	0.63	0.63
61	65	65	B	B	85	85	0.50	0.50
62	25	72	A	B	54	81	0.93	0.62
63	15	72	A	B	51	88	0.32	0.22
64	19	72	A	B	53	88	0.39	0.39
65	72	72	A	B	81	88	0.25	0.33
66	12	85	A	B	69	92	0.20	0.17
67	29	85	A	B	72	92	0.25	0.25
68	65	65	B	B	85	85	0.20	0.20
69	65	65	A	A	77	77	0.31	0.31
70	75	75	A	A	81	81	0.18	0.18

Table 1. TR-20 Hydrologic Basin Parameter (continued).

Basin I.D.	% Imperviousness Existing	% Imperviousness Future	Soil Type Existing	Soil Type Future	Curve Number(CN) Existing	Curve Number(CN) Future	Time of Concentration(Hr) Existing	Time of Concentration(Hr) Future
71	2	2	C	C	75	75	0.58	0.58
72	4	4	C	C	75	75	0.48	0.48
73	2	2	C	C	75	75	1.38	1.38
74	2	43	1/2 A 1/2 C	1/2 A 1/2 C	39	39	0.74	0.74
75	2	43	C	C	74	84	1.42	1.42
76	2	2	C	C	74	74	0.52	0.52
77	82	82	2/3 A 1/3 C	B	91	91	0.30	0.30
78	25	85	C	C	80	94	1.78	1.78
79	30	30	C	C	81	81	0.58	0.58
80	65	65	B	B	85	85	1.22	1.22
81	67	67	B	B	86	86	0.53	0.33
82	40	40	B	B	76	76	0.11	0.11
83	65	65	B	B	85	85	0.18	0.18
84	31	31	A	A	72	72	0.36	0.36
85	65	65	C	C	90	90	0.25	0.25
86	2	85	1/3 B 2/3 A	B	46	92	0.50	0.38
87	65	65	B	B	85	85	0.22	0.22
88	2	65	A	B	39	85	1.67	1.10

developed areas. Areas presently under construction were considered as existing developments for purposes of this study.

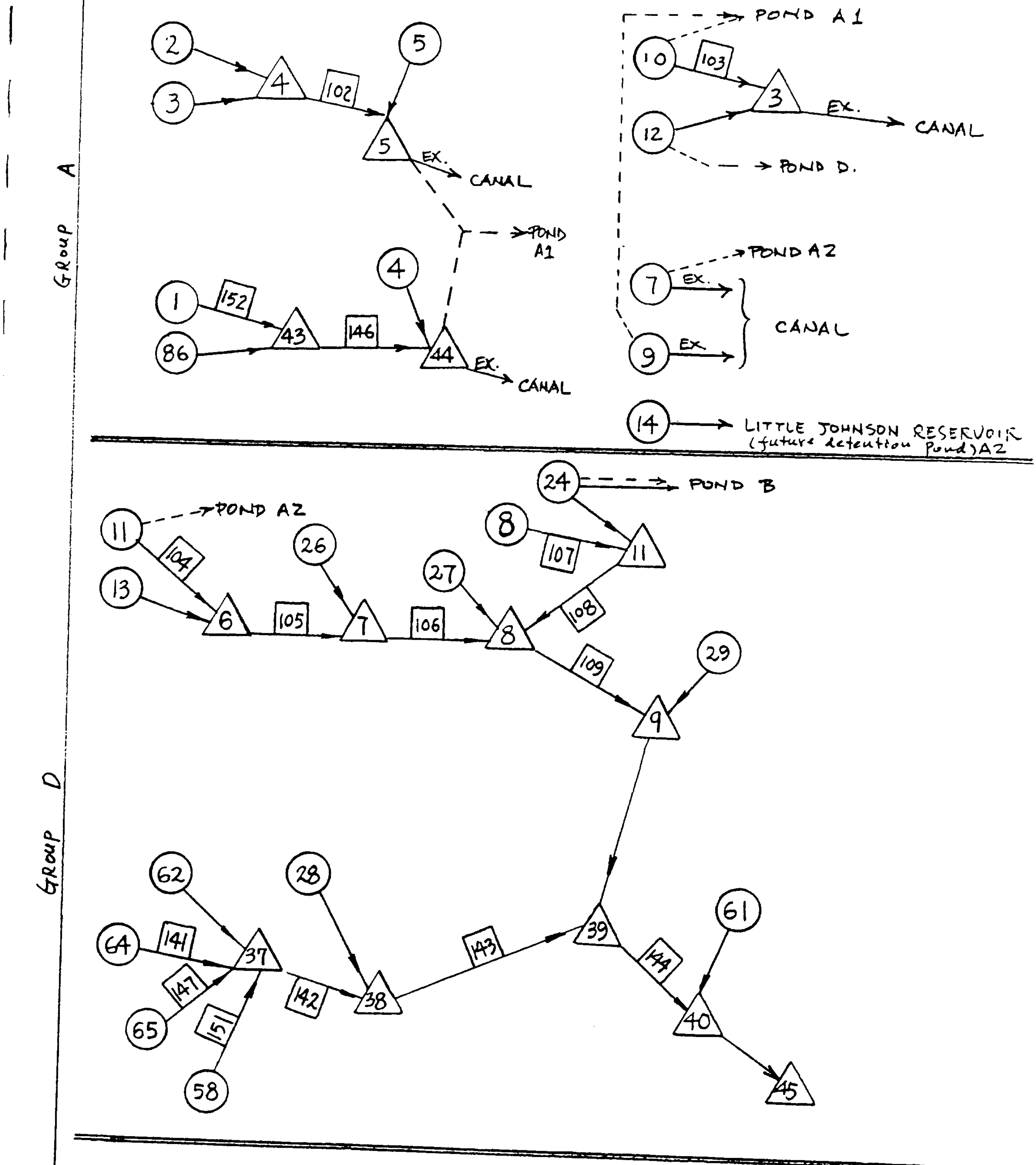
To determine imperviousness for the various land uses, selected areas of residential, commercial, and industrial were calculated in detail using the aerial photographs. The Criteria Manual was also referenced for the defining of imperviousness for each type of development.

Design Rainfall

Rainfall amounts for the 10- and 100-year storm events were compiled using the Precipitation - Frequency Atlas of the Western United States, Volume III, Colorado. Comparison of 100-year 2-hour and 24-hour storm runoff by using CUHP and TR-20 during the course of this study concluded that calibration of basin parameters were needed. Since the CUHP program and its 2-hour storm distribution were mainly designed for the Metropolitan Denver area, it was recommended that the 24-hour Type-IIA storm distribution be used for the study. The use of the 24-hour storm distribution is in conformance with the Draft City/County Storm Drainage Criteria Manual. Precipitation amounts used were 3.0 inches and 4.5 inches for the 24-hour storm of 10- and 100-year frequencies, respectively.

Results

The results of the hydrological analysis are presented in several formats. A hydrological basin map for both the 10- and 100-year storm under the existing and future (without drainage improvements) basin conditions is presented in Figure 3 (See Map Pocket). The map shows the routing scheme for all the sub-basins and presents the routing element and basin numbers and design points for easy reference to the computer output (under separate cover). A simplified TR-20 flow diagram has been prepared as Figure 5. A summary of peak discharges for all storms and all hydrologic points are summarized in Table 2. A technical addendum with the TR-20 computer program input and output is on file with the El Paso County Department of Public Works.



NOTE: FOR GROUP LOCATION SEE Fig 3 (Pocket)

Figure 5. TR-20 Flow Diagram.

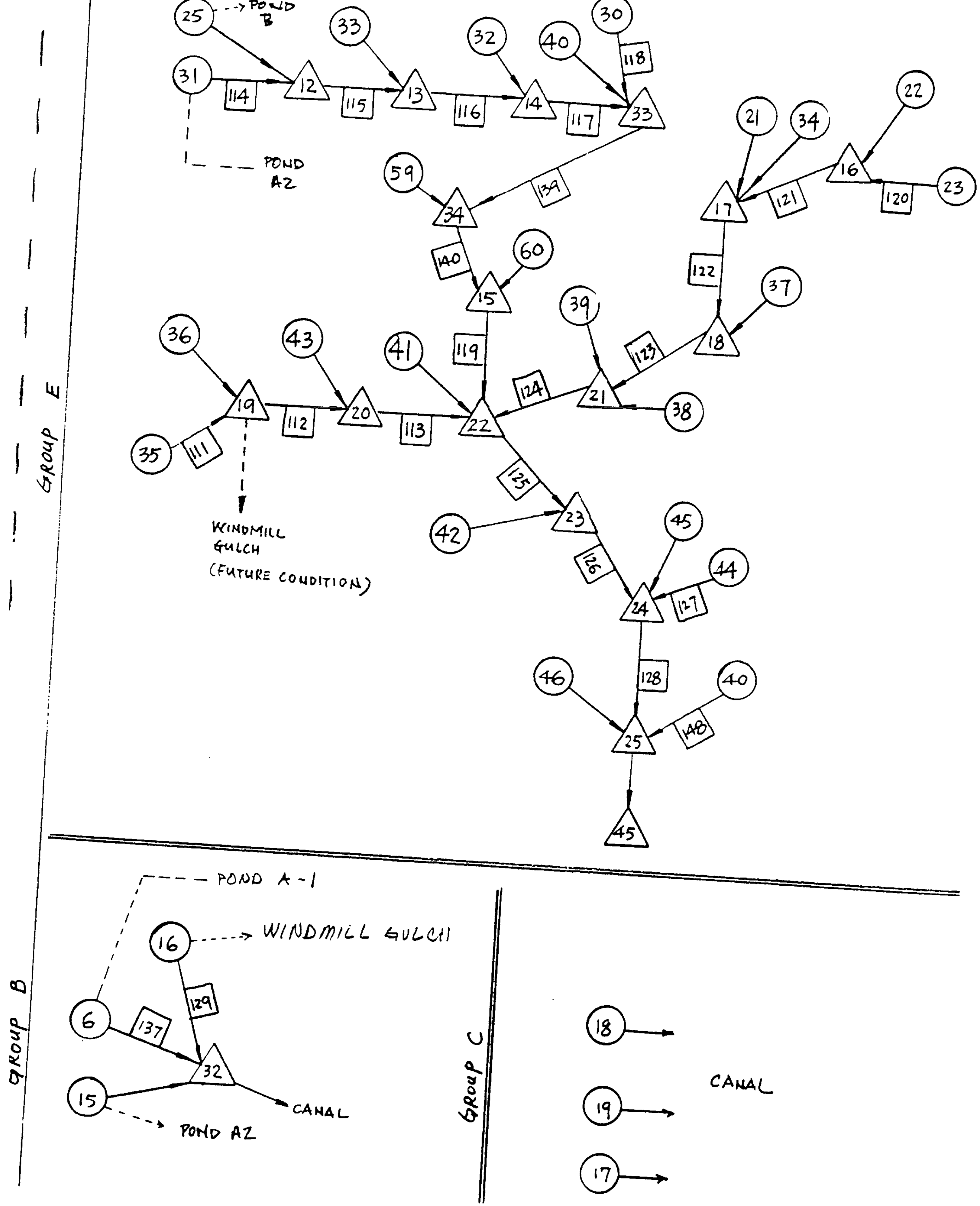


Figure 5. TR-20 Flow Diagram (continued).

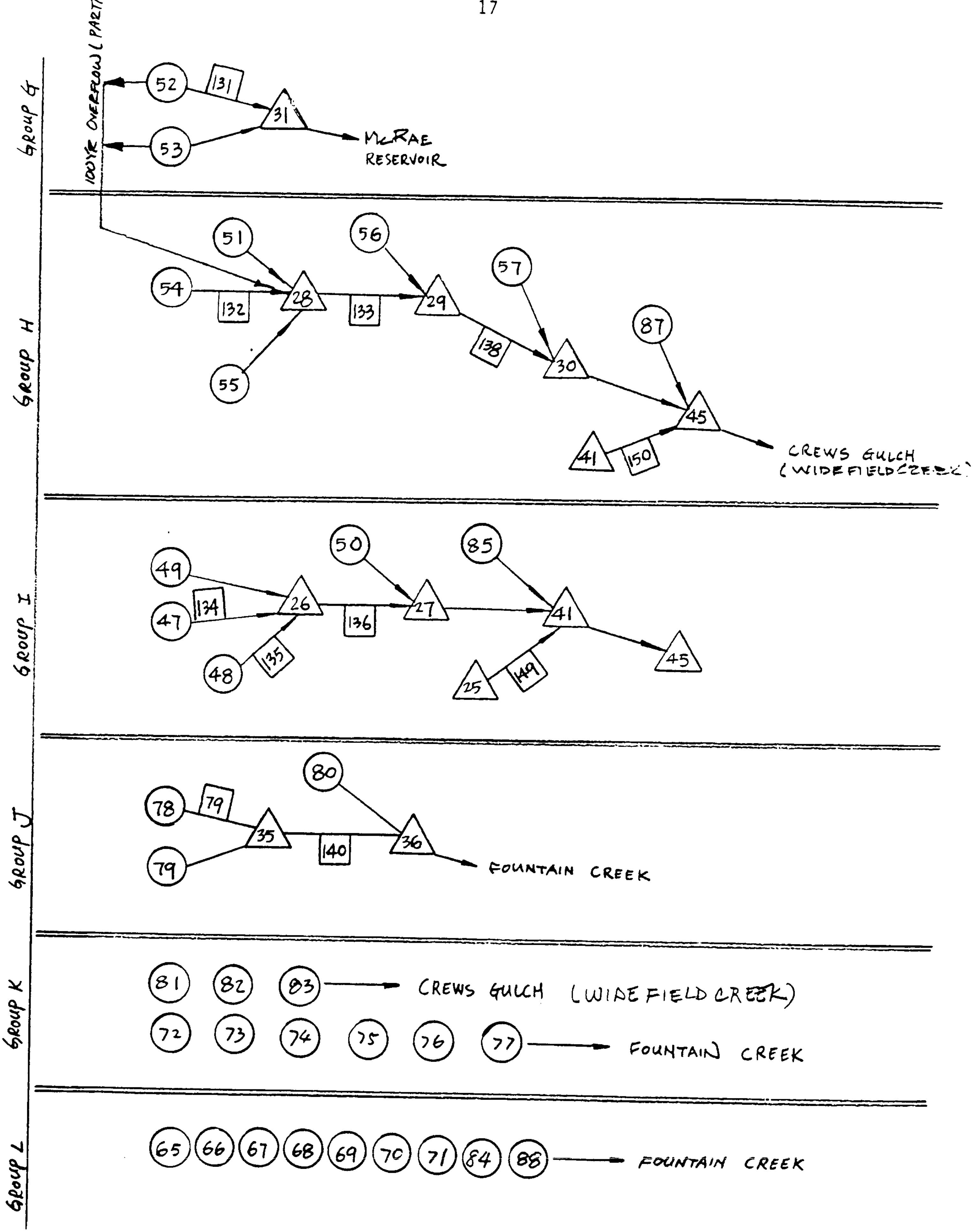


Figure 5. TR-20 Flow Diagram (continued).

Table 2. Summary of Discharge.

Design Point: Basin No.	Design Point: Design Point No.	Drainage Area (sq.mi.)	Location (Group)	TR-20 24-Hour Storm (Type II-A): 100-Yr Peak Flow (cfs): Existing Condition	100-Yr Peak Flow (cfs): Future Condition	10-Yr Peak Flow (cfs): Existing Condition	10-Yr Peak Flow (cfs): Future Condition
1		0.09	A	6	251	0	140
2		0.08	A	178	178	92	92 *
3		0.02	A	51	51	26	26 *
4		0.09	A	6	253	0	146
5		0.11	A	1	294	0	163
6		0.18	A	45	340	5	188
7		0.05	A	97	133	50	72
8		0.03	D	0	83	0	50
9		0.06	A	1	162	0	90
10		0.02	A	0	46	0	25
11		0.13	D	1	217	0	114
12		0.10	A	1	239	0	134
13		0.02	D	0	58	0	33
14		0.12		1	220	0	116
15		0.05	B	56	113	23	63
16		0.10	B	169	169	88	88
17		0.08	B	102	102	46	46
18		0.08	C	110	151	50	80
19		0.04	C	0	96	0	53
21		0.04	E	83	83	41	41
22		0.04	E	1	128	0	72
23		0.03	E	58	67	31	40
24		0.07	D	2	119	0	70
25		0.06	E	0	68	0	38
26		0.04	D	86	86	46	46
27		0.06	D	95	116	47	62
28		0.05	D	22	127	2	73
29		0.06	D	54	54	26	26
30		0.05	E	63	63	31	31
31		0.01	E	0	26	0	14
32		0.04	E	102	102	51	51
33		0.08	E	140	140	67	67
34		0.04	E	63	63	30	30
35		0.04	E	70	70	34	34
36		0.05	E	0	80	0	40
37		0.09	E	117	117	53	53
38		0.02	E	30	30	13	13
39		0.03	E	36	36	16	16
40		0.12	E	136	136	67	67
41		0.05	E	119	119	71	71
42		0.02	E	71	71	43	43
43		0.05	E	77	77	34	34
44		0.03	E	53	53	26	26

Table 2. Summary of Discharge (continued).

Design Point: Basin No.	Design Point: Design Point No.	Drainage Area (sq.mi.)	Location (Group)	TR-20 24-Hour Storm (Type II-A): 100-Yr Peak Flow (cfs): Existing Condition	100-Yr Peak Flow (cfs): Future Condition	10-Yr Peak Flow (cfs): Existing Condition	10-Yr Peak Flow (cfs): Future Condition
45		0.08	E	138	138	64	64
46		0.01	E	33	33	20	20
47		0.04	I	41	41	22	22
48		0.05	I	145	145	80	80
49		0.13	I	284	284	153	153
50		0.06	I	91	91	46	46
51		0.11	H	210	210	112	112
52		0.27	G	148	674	36	367
53		0.23	G	359	551	166	298
54		0.04	H	32	70	8	35
55		0.04	H	62	62	29	29
56		0.10	H	187	187	107	107
57		0.02	H	30	30	16	16
58		0.02	D	0	59	0	36
59		0.09	E	159	159	73	73
60		0.03	E	46	46	23	23
61		0.09	D	164	164	87	87
62		0.14	D	25	199	3	96
63		0.02		6	53	0	31
64		0.09	D	49	276	4	161
65		0.02	D	46	54	24	30
66		0.04	L	52	117	20	72
67		0.03	L	42	82	18	50
68		0.02	L	45	45	25	25
69		0.01	L	21	21	10	10
70		0.01	L	22	22	11	11
71		0.05	L	62	62	27	27
72		0.06	K	79	79	34	34
73		0.12	K	70	70	30	30
74		0.10	K	1	1	0	0
75		0.11	K	59	93	25	48
76		0.04	K	48	48	20	20
77		0.03	K	79	79	47	47
78		0.17	J	179	395	84	242
79		0.05	J	102	102	52	52
80		0.10	J	101	101	52	52
81		0.05	K	91	113	49	62
82		0.01	K	18	18	9	9
83		0.02	K	49	49	27	2
84		0.04	L	49	58	20	24
85		0.03	I	90	90	53	53
86		0.01	A	2	47	0	29
87		0.03	H	64	64	35	35
88		0.14	L	1	160	0	80

Table 2. Summary of Discharge (continued).

Design Point: Basin No.	Design Point: Design Point No.	Drainage Area (sq.mi.)	Location (Group)	TR-20 24-Hour Storm (Type II-A): 100-Yr Peak Flow (cfs): Existing Condition	100-Yr Peak Flow (cfs): Future Condition	10-Yr Peak Flow (cfs): Existing Condition	10-Yr Peak Flow (cfs): Future Condition
	3	0.11	A	1	279	0	155
	4	0.10	A	228	228	118	118
	5	0.22	A	228	495	115	259
	6	0.15	D	1	252	0	132
	7	0.19	D	86	333	46	176
	8	0.34	D	176	610	90	332
	9	0.41	D	194	629	98	340
	11	0.10	D	2	161	0	95
	12	0.07	E	1	72	0	41
	13	0.15	E	140	195	67	98
	14	0.19	E	215	258	103	120
	15	0.49	E	523	577	246	271
	16	0.07	E	58	188	31	107
	17	0.14	E	184	316	90	167
	18	0.23	E	270	395	126	199
	19	0.09	E	70	243	34	132
	20	0.13	E	148	310	67	159
	21	0.28	E	328	449	151	220
	22	0.95	E	1106	1154	529	557
	23	0.98	E	1174	1224	569	598
	24	1.09	E	1363	1413	658	686
	25	1.90	E	1733	2836	814	1375
	26	0.21	I	427	427	229	229
	27	0.27	I	499	499	264	264
	28	0.18	H	300	340	147	173
	29	0.28	H	479	519	250	276
	30	0.30	H	505	546	265	290
	31	0.50	G	495	1213	183	670
	32	0.40	B	349	710	156	377
	33	0.37	E	326	378	154	187
	34	0.46	E	483	536	227	253
	35	0.22	J	193	482	91	265
	36	0.31	J	291	529	142	298
	37	0.27	D	87	507	22	261
	38	0.31	D	104	632	23	334
	39	0.72	D	298	1253	100	670
	40	0.80	D	436	1412	172	747
	41	2.20	I	2303	3416	1122	1662
	43	0.10	A	7	298	0	169
	44	0.19	A	12	550	0	314
	45	2.52	H	2850	3996	1403	1976

* Assumes no attenuation due to the Foxhills Subdivision pond.

IV. HYDRAULIC ANALYSIS AND FLOODPLAIN DELINEATION

A hydraulic analysis for the study area has been conducted for the 10- and 100-year frequencies. This work consisted of analyzing the local storm sewer and street drainage systems and an analysis of the open channel (Security Creek) which drains the majority of the study area. A discussion of existing systems follows.

Description of Existing Storm Drainage Systems

Presented on Table 3 is an inventory of the existing storm drainage system(s) within the study area. The hydraulic capacities have been calculated using topographic mapping in combination with field inspections of these systems. The facilities listed in Table 3 lie within the Widefield, Security, and Little Johnson sub-basins. A discussion of each follows.

1. Little Johnson Basin

This portion of the study area lies within hydrologic group A, B, and C as shown on Figure 3 (See Map Pocket). The predominant features of the area are the Fountain Mutual Canal No. 4, and the Little Johnson Reservoir Basin. These two facilities have acted to keep the historic flows from crossing Bradley Road to very small amounts, and thereby protected the Security area. Urban development has placed an increasing storm drainage conveyance burden on the Fountain Mutual Canal No. 4. Developed flows entering the canal at times of high irrigation use have caused overtopping and maintenance problems at several locations along the canal's length. Future flows will only serve to worsen the flooding potential the canal represents, unless the canal is improved to meet the anticipated design flows.

The Little Johnson Reservoir is a former irrigation water storage facility that was taken out of operation in the 1970's. An outlet pipe exists under the embankment into a historic drainage path, however, the size and condition of this outlet has not been verified. The land underlying the reservoir is currently under consideration for residential development. Disregarding any stormwater diversion by the Canal No. 4, the Little Johnson Reservoir has adequate volume to store the historic runoff tributary to the Reservoir. The structural integrity of the embankment has not been investigated as part of this study.

Table 3. Structure Inventory.

Sheet No.	Hydrologic Sub-Basin	Size/Description	Maximum Capacity (Flowing Full)
1	2	Drennan Road Storm Sewer 30" to 42" RCP. Outfalls to Foxhills Pond.	110 cfs
	2	Foxhills Detention Pond: 2 - 24" RCP Outlet	5 acre-feet
3	62, 89	Colorado 83 (Academy Boulevard) Storm Sewer System 18" to 42" RCP. Outfalls to Fountain Creek.	110 cfs
	89	11.5' x 1.3' Trestle under D&RGWR (Partially Plugged)	160 cfs
	89	30" CMP under D&RGWR (Partially Plugged)	50 cfs
4, 5	86	72" CMP under Hancock, North of Schlage Lock.	280 cfs
	6	24" RCP Storm Sewer, Yucatan Drive to Hancock Expressway	25 cfs
	15	Hancock Expressway Storm Sewer System, Yucatan to Bradley Road 36" RCP Outfalls to Fountain Mutual Canal No. 4	70 cfs
	15	Concrete Channel, Hancock to Cantrell Drive, Outfalls to Fountain Mutual Canal No. 4	25 cfs
5	11	24" CMP under Bradley near Hennings Drive	17 cfs
	24	Bradley Village Storm Sewer System North 18" to 42" RCP, Outfalls to Low Area West of Subdivision	90 cfs
	24	Bradley Village Storm Sewer System South 18" to 24", Outfalls to Cassidy Street Storm Sewer System	15 cfs
	25, 26	Cassidy Street Storm Sewer System, Tuttle Drive to Cassidy Street and Cactus Drive 24" RCP	18 cfs

Table 3. Structure Inventory (continued).

Sheet No.	Hydrologic Sub-Basin	Size/Description	Maximum Capacity (Flowing Full)
5	21	Hunters Run Detention Pond. Outfalls to 8' H x 1.5' W Concrete Channel via 10" PVC Outlet	< 3 acre-feet
5	24-27	Cactus Drive Storm Sewer System, 18" to 36" RCP. Outfalls to Ivanhoe Drive Storm Sewer.	40 cfs (maximum)
6	29	Ivanhoe Drive Storm Sewer 36" RCP. Outfall to Chimayo Drive Storm Sewer.	40 cfs
	29	Chimayo Drive Storm Sewer System, 45" x 29" RCP. Outfalls to Security Creek.	45 cfs
6	61	2' Inlet and 18" CMP to Security Creek at Norman through Hallum Place Cul-De-Sacs	20 cfs, ea.
6	61	8' x 6' RCB, on Security Creek, between Hallum Place and Chimayo Drive	440 cfs
	61	Security Creek, Open Grasslined Channel, to Sumac Drive, Extended.	< 200 cfs
6, 8	61	Security Creek Trapezoidal Concrete Channel, Sumac Drive to Main Street	300 cfs
7	35	Pheasant Run Detention Pond. Outfalls to Norman Drive, via 18" RCP and Swale	< 3 acre-feet
7, 8	42, 44	Main Street Storm Sewer, 24" to 42" RCP Outfalls to Security Creek	40 cfs
8	61	Security Creek Culvert under Main Street 72" x 43" CSP	110 cfs
8, 10	85	Security Creek Trapezoidal Concrete Channel, Main Street to Fontaine Boulevard	300 cfs
8	45	Twin 18" CMP, Chatfield Drive and Grand Avenue	40 cfs ea.
8	78	36" RCP Storm Sewer within Shopping Area. Outlet Location Unconfirmed. System being Relocated by Developer.	40 cfs (estimate)

Table 3. Structure Inventory (continued).

Sheet No.	Hydrologic Sub-Basin	Size/Description	Maximum Capacity (Flowing Full)
9	54	Fontaine Boulevard and Grinnell Street Detention Pond, Outfalls via 24" RCP to Fontaine Boulevard Storm Sewer	< 5 acre-feet
9	49	Twin 36" RCP (Two Locations) under McBurney Boulevard (Widefield Canal) Outfall to Crews Gulch via 24" RCP	120 cfs
9, 10	55, 56	Fontaine Boulevard Storm Sewer System 24" RCP to 42" CMP. Outfalls to Security Creek	20 - 60 cfs
10	85	Security Creek Culvert under Fontaine Boulevard, 7' x 5.5' CSP	200 cfs
10	87	Security Creek Trapezoidal Concrete Channel, Fontaine Boulevard to Crews Gulch	300 cfs
10	57	Concrete Cross Pan to Security Creek at Grinnell Street and Widefield Boulevard	30 cfs
	49	36" CMP at Willis Drive and Security Boulevard Outfalls to Security Creek	40 cfs

An existing 36-inch storm sewer in Hancock collects flow from the Clearview Estates area, and the commercial industrial areas east of Hancock, to Yucatan. This system is highly dependent upon the hydraulic grade of the Canal No. 4, and has been calculated to be under capacity to serve the current development. Overtopping of this system forces flow west over Hancock, and is eventually picked up by Canal No. 4. The interaction between the Hancock storm sewer and Canal No. 4 is largely responsible for the local flooding problems along Bradley Road and in the northern portions of Security.

The areas tributary to Canal No. 4 east of Hancock Boulevard are conveyed to the Canal via a storm sewer system. The Canal has been reconstructed within this area, and eventually carries stormwater into the Windmill Gulch Basin.

A stormwater detention pond serves the Foxhills and Pinehurst Station Subdivisions. This pond is drained by two 24-inch outlet pipes, and was designed to control the design flow(s) to historic levels. The City of Colorado Springs has expressed an interest in abandoning this pond because of operation and maintenance concerns. A hydraulic review of the pond revealed that the pond volume is insufficient in capacity to lower the peak flow rate to match the outlet (for the hydrologic criteria applied in this report). The pond at the Foxhills Subdivision was therefore assumed to be eliminated for the purpose of estimating peak discharges and sizing of downstream facilities.

The balance of the Little Johnson Basin is drained by small culverts under roadways. A storm sewer system for State Highway 83 (Academy Boulevard) outfalls to the Fountain Creek, however, is of inadequate size to convey any additional runoff. Flows which do pass across Bradley enter the Security Creek via the street and storm sewer systems within Cody and Ivanhoe Drives.

2. Security Basin

This area has predominantly single-family residential development, and is drained by streets and small diameter storm sewers. The entire basin, bounded by Crawford Street on the south, is tributary to the Security Creek, which extends along the Denver and Rio Grande Western Railroad (D&RGWR) upstream to Cody Drive. The high impervious area in combination with the moderate-to-steep street slopes deliver stormwater to the lower portions of the basin at too high a rate for the storm sewer system(s) and Security Creek to carry it away.

The two existing storm sewer systems, the Cassidy-Ivanhoe Drive storm sewer and the Main Street storm sewer have both been surcharged in recent years. These systems have been calculated to be over capacity, and unable to convey additional runoff without expansion. These systems are adversely impacted by the Security Creek hydraulic inadequacies. Structural damages to properties adjacent to these systems have been limited to the Main Street and Security Boulevard commercial areas.

The Security Creek begins at approximately Cody Drive, and extends south along the east side of the D&RGWR tracks to Main Street. The channel is poorly defined, and grasslined until approximately Sumac Drive. From this point a concrete lining extends up to Main Street. Two culverts cross the Security Creek. A recently constructed culvert near Kenny's Nursery has adequate capacity to handle existing condition flow rates. The Main Street crossing has an inadequate capacity. Relatively minor flooding has been calculated to be caused by the inadequate conveyance capacities of the Security Creek, the damage which does occur could be solved by reconstructing the Main Street culverts.

Two detention ponds have been constructed in the upper portions of the Security Basin. One pond serves the Pheasant Run Subdivision Filing No. 1, and the other pond serves Pheasant Run Filing No. 2. These ponds were constructed to limit flows originating within the subdivisions to historic levels. Both ponds have been overtopped in heavy rainstorms since their construction in 1986. The flows which have overtopped the ponds have moved into the Security area streets.

3. Widefield Basin

Similar to the Security Basin, the Widefield Basin has predominantly single-family development which is drained through mainly street and limited sections of storm sewers to Security Creek. The Security Creek is concrete-lined from Main Street to its outfall at Crews Gulch. The Fontaine Boulevard culvert at Security Creek has an inadequate capacity and forces flood flows west across Highway 85/87. The creek has an inadequate hydraulic capacity from Fontaine Street to Crews Gulch.

The Fontaine Boulevard storm sewer conveys storm flows from Grinnell Street to Security Creek. This system has been overtopped and has caused stormwater to move into commercial areas south of Fontaine Boulevard. This system includes an existing detention pond and outlet north of Fontaine at Fordham Street. The system has recently been extended to Grinnell and catch inlets installed at the intersection of Grinnell and Fontaine Boulevard. Prior to recent storm sewer extension, flows which have entered the Widefield Basin at Grinnell Street have overtopped Fontaine Boulevard and moved overland into the residential areas south of the detention pond. Several residences have experienced flood damages on an annual basis in recent years.

Floodplain Delineation

A hydraulic analysis was conducted of the study area to determine the extend of flooding along the major flow paths and drainageways. The U.S. Army Corps of Engineers HEC-2 Water Surface Profile Program was utilized to determine the 10- and 100-year floodplain boundaries and depths for Security Creek. Along streets which are known to have experienced local flooding such as Security Boulevard, Main Street, and Norman Drive, uniform flow calculations were applied to determine the limit and extent of flooding.

Channel cross section data was obtained from the Federal Emergency Management Agency (FEMA) Flood Insurance Study conducted for Security Creek in 1981. This data includes field measured channel cross sections, which correlated well with the topographic mapping prepared as part of this Drainage Basin Planning Study. Channel roughness coefficients were determined through the use of photographs and from a field survey. The HEC-2 input and output are contained within the Technical Addendum of this report, and is on file with the El Paso County Department of Public Works.

Presented on Sheets 6, 7, 8, and 10 is the existing 100-year floodplain boundary. With the exception of the area in the vicinity of the Security Creek channel, the flooding depths are all shallow in nature. Depths on the overbanks are estimated to be between one- and three-feet. This is an expected result since the channel is constricted at several locations by inadequate culverts. As stated above, these culverts force the flood flows overland through residential areas and across Highway 85/87, which fill low-lying areas.

Flooding along streets in the 100-year event occurs along Security Boulevard, Main Street, and Widefield Boulevard, mostly along the commercial areas in Security and Widefield. Areas of localized intersection flooding occurs along Norman Drive, Willis Drive, and Security Boulevard. Discussions with residents during the field survey portions of this study confirmed these local problems.

Flood Damage Analysis

The hydraulic data was used to generate flood damage estimates for the study area. Depth versus damage data compiled by FEMA was used to estimate the dollar value of structural and content damage for businesses and residences determined to lie within the 10- and 100-year floodplain.

A field check of the floodplain was conducted to verify the flooding limits and structure types were noted. A total of 75 single-family residences and eight businesses were determined to lie within the 100-year floodplain. No significant structures were determined to lie within the 10-year floodplain. Typical 100-year flood depths ranged from 0.5 feet to 1.5 feet above the first floor for all structures.

In order to assess the level of flood protection economically justifiable, calculations of the dollar loss associated with the 10- and 100-year flood events were carried out. To do this, several assumptions were made to facilitate the calculations. The major assumptions were:

1. Average single-family house value:

   a. With basement = $70,000
   b. Without basement = $60,000

2. Contents are defined as carpeting, furniture, draperies, personal belongings, plus maintenance associated with the clean up of first floors and basements.

3. Average depth range in the business district was 0.5 feet and 2.0 feet, for the 100-year frequency.

4. Average content value for single-family residences was assumed to be $20,000.

From this analysis, a total of $687,000 in property damages was estimated for the 100-year flood event, and approximately $75,000 worth of damages in the 10-year event. Costs associated with the annual maintenance of streets subject to flooding has not been estimated, however, in recent years the County and local residences have incurred costs associated with a flood cleanup in the range of $10,000 to $50,000 annually. Using this data, annual flood losses have been estimated at $63,000, but does not account for flood damages associated with loss of business and wages, damage to utilities, public inconvenience, structure replacement, or the deterioration of public and private properties adjacent to known flood prone areas.

Basis of Design

The hydraulic analysis of the existing systems and eventual alternatives combined the HEC-2 analysis with normal-depth calculations for proposed storm sewer systems. The analysis enabled the planning of improved channel sections, storm sewers, and crossings for later cost estimation.

Basic design criteria contained in the City/County "Storm Drainage Criteria Manual" were followed when designing street and drainage facilities for the alternative evaluation process. All local facilities were designed to flow full. Proposed channels have been designed to convey the full 100-year flow. Roughness values for the hydraulic calculations ranged from .025 for natural stream bedding to .045 in areas where natural channels were deemed to be overgrown.

The following design criteria were followed in the analysis of existing and proposed systems:

1. Minimum roughness values.

   a. Channel linings and culverts, 0.015.
   b. Corrugated metal pipe (CMP), .024.
   c. Reinforced concrete pipe or corrugated metal pipe, lined, .013.
   d. Natural stream beds, .035.
   e. Maintained grasslined channels, .030.
   f. Street sections, 0.016.

2. Design velocities for grasslined channels were limited to six-feet per second, with maximum side slopes of four horizontal to one vertical (4H:1V).

The criteria which will be applied during the final design of facilities will be subject to specific site constraints.

V. ALTERNATIVE DEVELOPMENT

General

In determining a limited number of most feasible alternatives for analysis to facilitate the designation of the best alternative, the following planning policies have been developed:

1. Separation of irrigation and stormwater flows. The Fountain Mutual Canal No. 4 has had a significant impact upon the existing hydrologic characteristics of the basin. Future stormwater flows will act to further degrade the operation of the Canal system, to a point where the long-term use of the Canal (from the stormwater management point of view), becomes questionable. Therefore, a basic planning policy guiding the planning process is that no mixing of stormwater or irrigation will be considered in the development of alternatives.

2. Criteria. The technical analysis has been completed in conformance with the Criteria Manual, adopted for use by El Paso County in July, 1987.

3. Land Use. Land use data used to prepare the hydrologic analysis has been developed through existing zoning data, as well as site planning maps from individual developments.

4. Detention/Retention. The concept of detention and retention of stormflows has been limited to the development of regional ponds. Regional ponds have been defined as ponds receiving stormwater from more than one subdivision. On-site detention/retention has been specifically ruled out as a future stormwater management alternative, excepting those individual ponds which may serve as an interim facility, prior to the construction of downstream facilities.

5. Separation of the system between areas north of Bradley Road and the existing areas of Widefield and Security should be considered for planning purposes.

6. The natural flow path, prior to the construction of the Fountain Mutual Canal No. 4 shall be used to site drainage improvements.

Based on the above planning policies, regional detention systems, and storm sewer systems have been conceptualized and analyzed for the study area. Presented in the following sections are descriptions summarizing each alternative evaluated. In general, detention systems have been evaluated for the area north of Bradley Road (Little Johnson Basin) which emphasizes regional detention ponds to control the release of flow from the contributing area. Three regional detention system alternatives have been evaluated, which include three sub-alternatives for Alternative 1 and two sub-alternatives for Alternatives 2 and 3. The main difference between the sub-alternatives are the detention pond size and its controlled outflow rate and outlet pipe size. The third sub-alternative for Alternative 1 (Alternative 1-3) was added to reflect the comments obtained from a project workshop held during the course of the study. Storm sewer systems have been evaluated for the Security and Widefield areas south of Bradley Road. These systems include the evaluation of improvements to Security Creek and storm sewer improvements. Two alternatives for the Security Creek improvements have been analyzed for the 100-year storm event, with different outfall points. Two alternatives for the storm sewer improvements have been studied which emphasize the different storm sewer routes and design storms.

A complete listing of cost estimates and design information on all alternatives developed for the regional detention system and storm system/Security Creek system are presented in the technical addendum (under separate cover).

Description of Alternatives

1. Regional Detention Pond System

Alternative 1-1

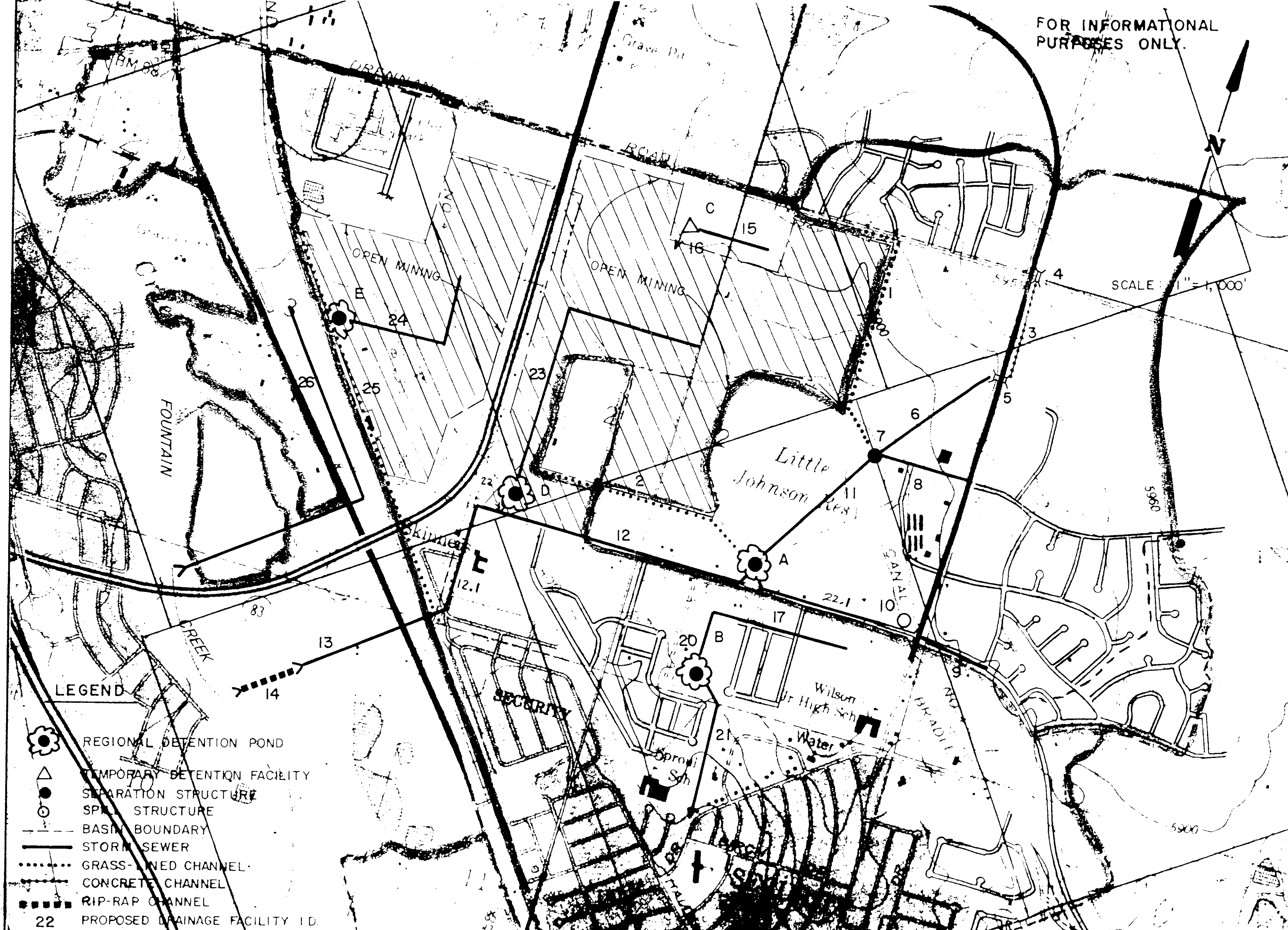
Figure 6 illustrates the conceptual layout of a system collecting the 100-year storm runoff through open channels, storm sewers, and regional detention ponds. This system then releases the flow from the detention pond to a designated outfall point at a very minimum rate. The system includes: (1) regional detention pond at location A to collect the flow conveyed by open channels (Lines 1, 3, and 2), and storm sewers (Lines 6, 8, 11, 9, and 22.1). The controlled outflow from detention pond A will be carried by storm sewers (Lines 12 and 12.1) and daylight at Security Creek. The open channel (Line 1) is located to receive the developed flow from the area just north of Drennan Road. A culvert at location 4 will allow the future developed flow to be transported to open channel at Line 3. A storm sewer at Line 9 will carry a portion of the existing flow to pond A instead of Canal No. 4. A section of an existing canal at location 7 will be relocated to allow the installation of a storm sewers at Lines 6 and 11. A storm sewer at line 8 will carry the future developed flow from the area northeast of Hancock Expressway and Yucatan Road. A spill structure at location 10 will allow the canal to overflow the storm sewer at Line 22.1. The total area to be controlled by detention pond A is highlighted on the map; (2) the regional detention pond at location B is to collect the flow conveyed by storm sewers at Lines 17 and 20. The controlled outflow from pond B will be connected to a proposed storm sewer system via a storm sewer (Line 21). The system will allow the future developed flow to have a minimum impact to the existing area; (3) a temporary detention facility at location C is to collect the local flow from the storm sewer (Line 15) and release the outflow at a minimum rate via an outlet pipe (Line 16). The release flow must be coordinated between property owners; (4) a detention pond at location D to collect the flow conveyed to a storm sewer at Line 23 and release a minimum flow through an outlet pipe (Line 22) into a storm sewer at Line 12.1; (5) a detention pond at location E is to collect the flow carried by a storm sewer at Line 24 and discharge at a minimum rate into the Security Creek; (6) an open channel at Line 25 is to carry the flow from the area bounded by the railroad, Drennan Road, Academy Boulevard, and the open mining limits. A storm sewer at Line 13 is to convey the flow from Line 25 and daylight at Fountain Creek via an energy dissipating channel (Line 14); and (7) a storm sewer at Line 26 is to convey the 10-year future developed flow for the area bounded by the railroad, U.S. Highway 85-87, Drennan Road, and Academy Boulevard. The storm sewer is to be daylighted at Fountain Creek.

Alternative 1-2

Figure 6 contains the same conceptualized system layout as Alternative 1-1. The only difference is in the sizing of ponds A and D. Instead of a minimum release as proposed for Alternative 1-1, the ponds at sites A and D will allow a larger outlet pipe and smaller detention volume to release a flow equivalent to the future 10-year flow. The storm sewer at Lines 12, 12.1, 13, and the open channel (Line 14) must be increased in size to convey the future 10-year storm released from ponds A and D. The remaining facilities are the same as contained in Alternative 1-1.

Alternative 1-3

Figure 7 illustrates a modified version of Alternative 1-2 as the result of a project workshop held during the course of this study. This modified alternative includes: (1) the separation of the detention pond into two ponds at sites A-1 and A-2; (2) the connection of outlet pipe from pond B



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LITTLE JOHNSON/SECURITY CREEK
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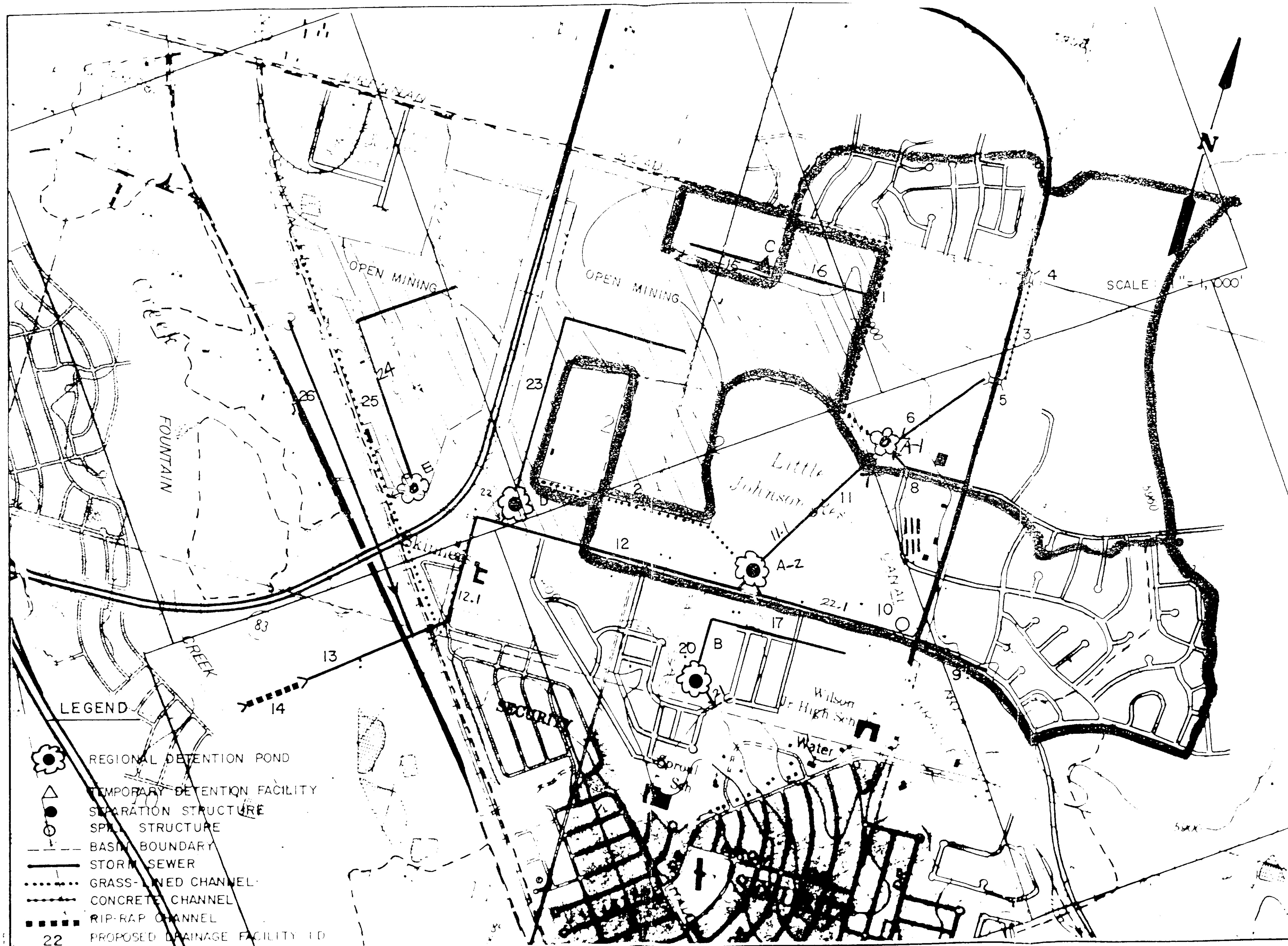
FIG. 6



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LITTLE JOHNSON/ SECURITY CREEK
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REGIONAL DETENTION ALTERNATIVE #1-3

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FIG 7

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LITTLE JOHNSON/ SECURITY CREEK
DRAINAGE BASIN PLANNING STUDY
REGIONAL DETENTION ALTERNATIVE #2-1&2

Project No	CU-EPCO
Date	9/87
Design	
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Revisions	

FIG 8

to an existing storm sewer system near Dooley Way, instead of a new system near Birch Drive; (3) the redirection of the outlet pipe (Line 16) from pond C and discharges into an open channel at Line 1; (4) incorporate detention pond E with future highway interchange location near Bradley Road and Academy Boulevard; and (5) connect storm sewer (Line 25) to the outfall system at Line 13 instead of the direct daylighting at Fountain Creek. The area controlled for pond A-1 and A-2 is highlighted on the alternative drawing.

Alternatives 2-1 and 2-2

Figure 8 illustrates the conceptualized system layout for Alternatives 2-1 and 2-2. Both alternative layouts are very similar to Alternative 1 with the exception of the detention pond location at site A and B. The area controlled for ponds A and B are highlighted on this map. Alternative 2-1 emphasizes the retention pond concept which minimizes the release flow to the downstream system. Alternative 2-2 utilizes the detention pond principal to release a 10-year developed flow through the system for ponds A, B, and D. Ponds C, E, and F still will be sized to release a minimum flow rate due to the physical constraints downstream.

Alternative 3-1 and 3-2

Figure 9 is the third alternative of the detention pond system. This plan calls for three detention ponds (A, B, and C) to control the highlighted area, as shown on the map. Pond A is different in location as compared to Alternatives 1 and 2, and reflects the consideration for an alternate pond site. Ponds B and C are located as an alternate site to minimize the volume requirement at site A. The other pond locations at D, E, F, and G are the same as Alternative 1. Both alternatives are different in concept to the detention requirement. Alternative 3-1 is a retention system where all ponds are to be sized as retention ponds which minimizes the release to the downstream system. Alternative 3-2 is a detention and retention system whereby ponds A, B, C, and F are sized as detention ponds with a 10-year outlet system; and ponds D, E, and G are identified as a retention pond which releases a minimal flow to the downstream system. All drainage collection systems to the detention pond are similar to Alternative 1 with the exception

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REGIONAL DETENTION ALTERNATIVE #3-1&2

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FIG. 9

of storm sewers at Lines 11, 9, 10, 26, and 24.1, which is due to the different pond locations at A, B, and C.

2. Storm Sewer/Security Creek System

Alternative 1 and 2

Figure 10 demonstrates the storm sewer/Security Creek alternative for both Alternatives 1 and 2. Storm sewer Alternative 1 includes the storm sewer improvements along Lines 1A, 1A1, 1A2, 1A3, 1B, 1C, 1D, 1D1, 1D2, 1E, 1G, and 1F. Storm sewer Alternative 2 includes the storm sewer improvements along Lines 2A, 2A1, 2A2, 2A3, 2B, 2C, 2C1, 2-SEC-3, 2D, 2D1, 2D2, 2E, 2G, and 2F. Storm sewer Alternative 1 emphasizes improvements along major streets such as Main Street and Security Boulevard. Storm sewer Alternative 2 routes the pipe through local streets (Lines 2A and 2A1). Both storm sewer systems have been evaluated for a 100-year storm event and the combination of 10- and 100-year storm event. The Security Creek system investigated includes the improvements of the Security Channel based on the various storm sewer system configurations. Alternative 1 shows the total improvement along the channel from Academy Boulevard to Crews Gulch. Alternative 2 calls for the channel improvements between Academy Boulevard and Crawford Drive, and Fountaine Boulevard to Crews Gulch. Both Security Creek alternatives were evaluated for the combination of 10- and 100-year storm events based on the floodplain and damage analysis conducted for Security Creek.

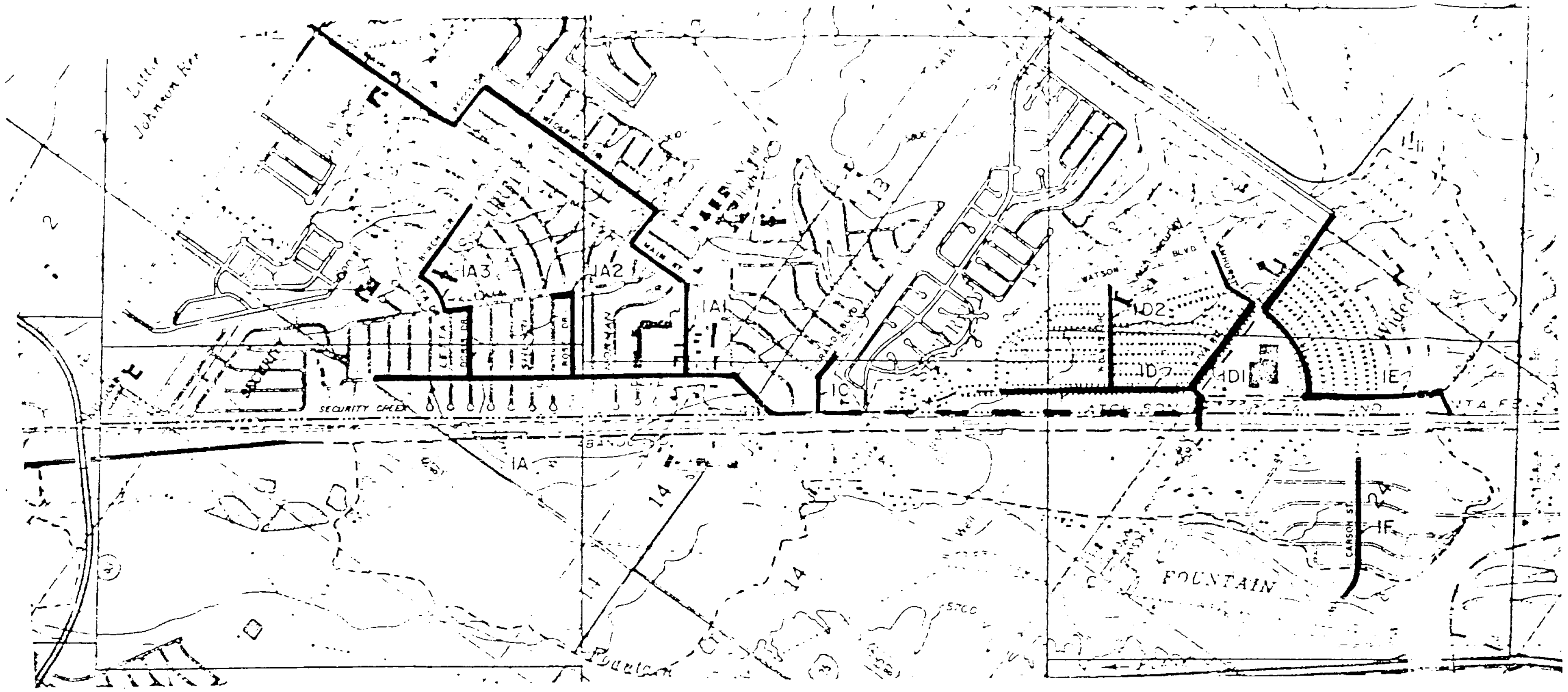
Cost Estimates and Alternative Evaluation

Cost estimates for all the alternatives investigated are based on the unit costs as developed for this study (Table 4). Contingency costs are defined to be 5 percent of the construction cost, and engineering costs are 10 percent of the contingency cost and construction cost. Costs for utility removal and relocation are assumed to be 10 percent of construction cost. Land acquisition cost for the detention pond is $15,600 per acre, and the construction costs for the detention pond which includes earthwork, native grass, outlet structure, and emergency spillway is estimated at $7,000 per acre-foot of storage volume. The land acquisition cost is based upon the parkland reimbursement fee, and has been applied to the land cost of detention ponds in several past and ongoing master drainage plans in the area. This fee

STORM SEWER SYSTEM

ALTERNATIVE 1

SCALE IN FEET

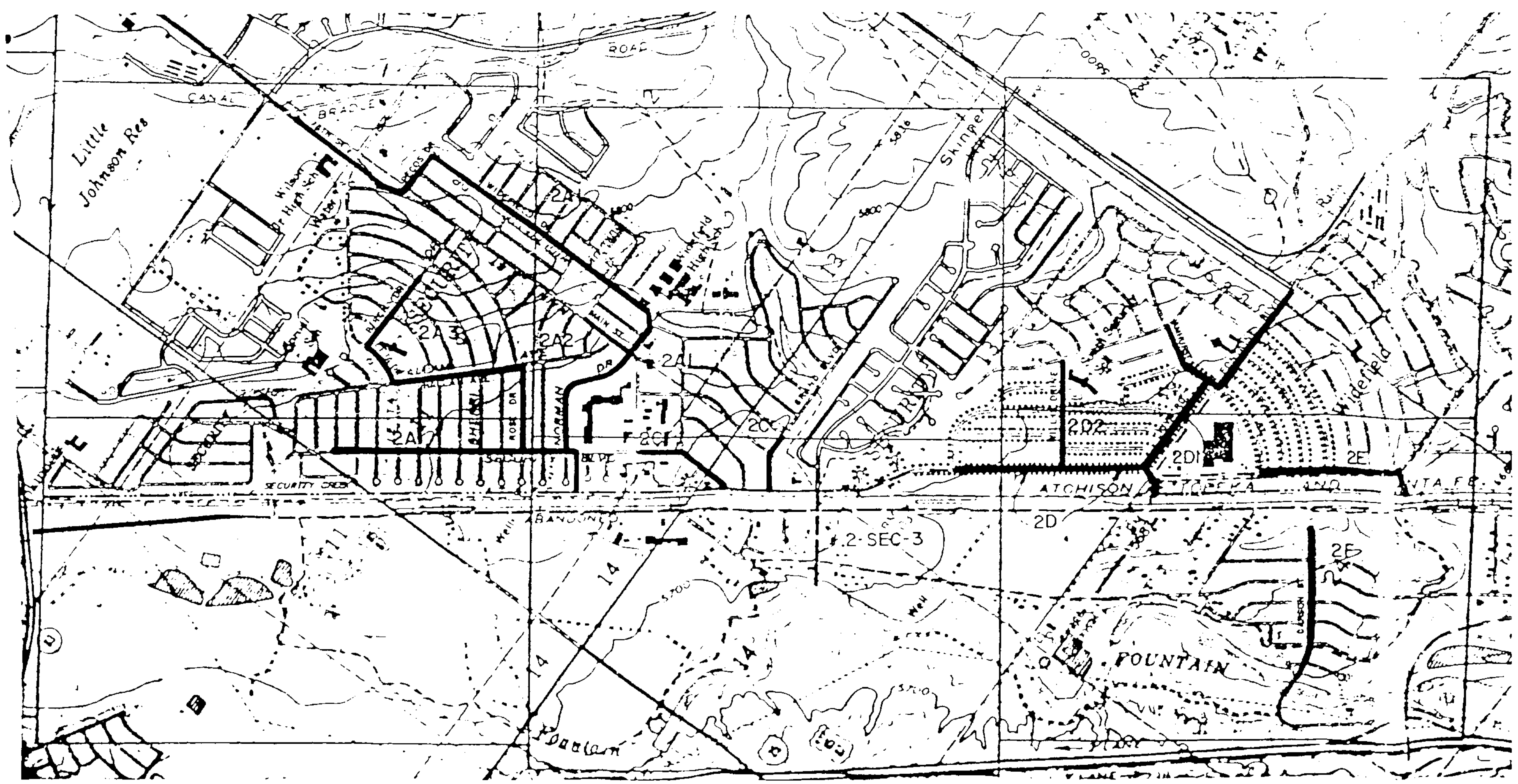


STORM SEWER SYSTEM

ALTERNATIVE 2

0' 1,000' 1,500' 2,000' 2,500' 3,000'

SCALE IN FEET



LEGEND

- STORM SEWER
- OPEN CHANNEL
- CONDUIT

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LITTLE JOHNSON/SECURITY CREEK

DRAINAGE BASIN PLANNING STUDY

STORM SEWER SYSTEM ALTERNATIVES 1 & 2

Project No	[illegible] EPC-01
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Revisions	

FIG 10

Table 4. Unit Construction Costs.

Item Description	Unit	Estimated Unit Price
REINFORCED CONCRETE PIPE		
18-inch	LF	$ 40
24-inch	LF	50
30-inch	LF	60
36-inch	LF	85
42-inch	LF	95
48-inch	LF	110
54-inch	LF	135
60-inch	LF	155
66-inch	LF	175
72-inch	LF	205
78-inch	LF	245
84-inch	LF	300
90-inch	LF	325
96-inch	LF	350
JACKING PIPE AND TUNNELLING		
90-inch	LF	$ 600
96-inch	LF	700
CONCRETE BOX CULVERT		
5 ft. x 7 ft.	LF	$ 300
5 ft. x 8 ft.	LF	325
6 ft. x 8 ft.	LF	350
7 ft. x 10 ft.	LF	450
8 ft. x 10 ft.	LF	500
SECURITY CREEK ROAD CROSSINGS		
5 ft. x 10 ft.	LF	$ 720
8 ft. x 11 ft.	LF	920
2 - 5 ft. x 9 ft.	LF	1,014
6 ft. x 22 ft.	LF	1,814
CURB INLETS		
10 ft.	EA	$ 3,000
15 ft.	EA	3,500

Table 4. Unit Construction Costs (continued).

Item Description	Unit	Estimated Unit Price
MANHOLES		
4 ft. diameter	EA	$ 2,000
5 ft. diameter	EA	2,500
6 ft. diameter	EA	3,500
Box Base	EA	4,500
Junction Structure/Drop Inlet	EA	10,000
SECURITY CREEK CONCRETE CHANNEL (VERTICAL WALLS)		
4 ft. x 10 ft.	LF	$ 424
5 ft. x 14 ft.	LF	656
6 ft. x 22 ft.	LF	824
FLARED END SECTION (REINFORCED CONCRETE)		
24-inch	EA	$ 200
42-inch	EA	550
48-inch	EA	650
72-inch	EA	1,500
OUTLET (90-inches)	EA	$ 20,000
GRASSLINED CHANNELS (INCLUDES EARTHWORK AND NATIVE GRASS)		
B = 8 ft., D = 4 ft., SS = 4:1	LF	$ 50
B = 15 ft., D = 6 ft., SS = 4:1	LF	110
SPILL STRUCTURE	EA	$ 50,000
DROP STRUCTURE		
4 ft.	EA	$ 5,000
DETENTION POND ≥ 20 AF (WITH EARTHWORK, OUTLET AND EMERGENCY OVERFLOW STRUCTURES, AND NATIVE GRASS)	AF	$ 7,000
DETENTION POND ≤ 20 AF (WITH EARTHWORK, OUTLET, OVERFLOW STRUCTURES, AND NATIVE GRASS)	AF	$ 5,000
LAND ACQUISITION	AC	$ 15,600

Table 4. Unit Construction Costs (continued).

Item Description	Unit	Estimated Unit Price
RIPRAP		
18-24 in.	CY	$ 45
SEED/MULCH/FERTILIZER	AC	$ 3,500
CHAIN LINK FENCE	LF	$ 14
48-INCH SIPHON	LS	$ 10,000
REMOVAL AND RELOCATIONS	LS	10% of construction cost
CONTINGENCIES	LS	5% of construction cost
ENGINEERING	LS	10% of contingency and construction cost

is collected at the time of platting the parcel where the pond is to be sited. Grasslined channel cost, as shown in Table 4, includes earthwork and native grass establishment. Other facility costs such as storm sewer costs are based on actual project bid lists and available cost data obtained for the region. A summary of the total cost for all alternatives evaluated is shown on Table 5. A detailed cost breakdown for each alternative is contained in the technical addendum to this report.

Evaluation of alternatives studied includes the comparison of cost, design storm, constructability, operations and maintenance, land use, land acquisition, and impact on existing utilities. A rating of each alternative is shown on the bottom row of Table 5. Alternatives 1-1, 2-1, and 3-1 for a regional detention system were not the most feasible alternatives because of the large detention pond sizes required, and the potential high risk of seepage, debris blockage, and drainage problems. Alternatives 1-2, 2-2, and 3-2 are rated as 2, 3, and 4, based on the consideration of pond locations and sizes. Alternative 1-3 is rated as the most feasible alternative by considering the project cost and pond location. Alternative 2 on Security Creek and Alternative 2-1 of the storm sewer system is selected based primarily from the total cost benefit point of view.

Table [illegible]. Comparison of Alternatives.

Evaluation Criteria	Regional Detention System Alternatives 1-1	1-2	1-3	2-1	2-2	3-1	3-2	Storm Sewer System Alternatives: Security Creek 1	2	Storm Sewer 1-1	2-1	1-2	2-2	
Cost ($)	11,984,000	11,448,000	11,072,000	12,027,000	11,010,000	12,041,000	11,921,000	13,932,000	6,511,000	10,042,000	10,337,000	7,740,000	8,061,000	
Design Storm	100-yr. w/ minimum release	100-yr. w/ 10-yr. release	100-yr. w/ 10-yr. release	100-yr. w/ minimum release	100-yr. w/ 10-yr. release	100-yr. w/ minimum release	100-yr. w/ 10-yr. release	100-yr.	100-yr.	100-yr.	100-yr.	Combination of 10- and 100-year	Combination of 10- and 100-year	Floodplain analysis concludes that storm sewer alternatives 2-1 or 2-2 are more feasible
Constructability	Require mass earth movement for Pond A	Large outlet pipe required under railroad and Highway 85/87	Same as Alt. 1-2		Same as Alt. 1-2		Same as Alt. 1-2	Upgraded channel system required	Large diameter storm sewer required under railroad and Highway 85/87 Larger culvert required under main street	Use larger diameter storm sewer within existing right-of-way	Same as Alt. 1-1	Use smaller diameter storm sewer within existing right-of-way	Same as Alt. 2-1	Storm sewer alternatives 1-2 and 2-2 will have less impact on traffic during construction due to the pipe location
Operations and Maintenance	Less number of ponds to be maintained	Same as Alt. 1-1	Same as Alt. 1-1	More ponds to be maintained than Alt. 1-1	Same as Alt. 2-1	Most number of ponds to be maintained	Same as Alt. 3-1	All channel length to be maintained	Less channel length to be maintained than Alt. 1	Require routine maintenance for all storm sewer	Same as Alt. 1-1	Same as Alt. 1-1	Same as Alt. 1-1	Retention pond may have drainage, seepage, and debris blockage problems during a flood
Land Use	Multiple use potential at Pond site A	Same as Alt. 1-1	Same as Alt. 1-1 Pond E can be planned as part of the future Academy Blvd. Interchange	Same as Alt. 1-1	Same as Alt. 1-1									Detention system Alternatives 1-1, 2-1, and 3-1 require larger surface area for detention pond
Land Acquisition	Acquisition of right-of-way required for all facilities within private property	Same as Alt. 1-1	Same as Alt. 1-1	Same as Alt. 1-1	Same as Alt. 1-1	Same as Alt. 1-1	Same as Alt. 1-1	None	None	None	None	None	None	All storm sewer systems will be located within existing right-of-way
Impact on Existing Utilities	Relocation of existing utilities required at Bradley Rd. and Hancock Expressway	Relocation of existing utilities required at railroad, Highway 85/87, Bradley Rd., and Hancock Expressway	Same as Alt. 1-2	Same as Alt. 1-1	Same as Alt. 1-2	Same as Alt. 1-1	Same as Alt. 1-2	Relocation of existing utilities required at Main St. and Fountaine Blvd.	Relocation of existing utilities required at Main St., railroad, and Highway 85/87	Relocation of existing utilities required	Same as Alt. 1-1	Same as Alt. 1-1	Same as Alt. 1-1	Existing utility locations to be identified for preliminary design
Rating on Alternative Selection	7	2	1	6	3	5	4	2	1	4	3	1	2	

VI. PRELIMINARY DESIGN AND COST ESTIMATE

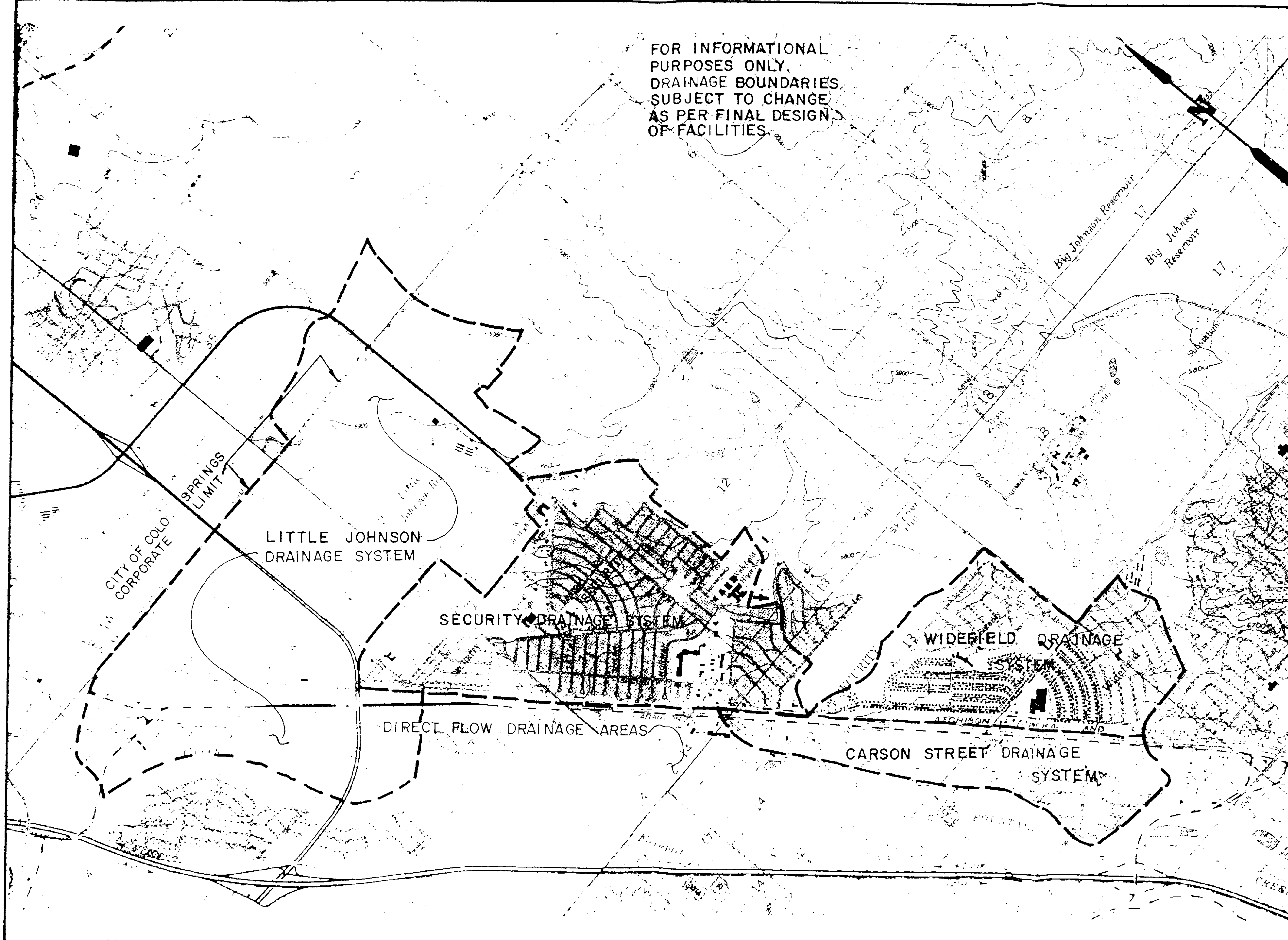
General

As a result of alternative evaluation and the comments obtained from the County and project workshop, the following alternatives were selected for preliminary design, namely; Alternative 1-3 regional detention pond system; Alternative 2-1 for the storm sewer system; and Alternative 2 for the Security Creek system. Each system is presented in the preliminary design plates, and contained in the appendix. Sheets 1 through 10 presents the detailed topography map used in the hydrologic and hydraulic analysis and the inventory of existing drainage facilities. Sheets 11 through 17 includes the preliminary design of a regional detention pond system in a separate plan and profile format. Sheets 18 through 26 contain the plan and profile view of the storm sewer system and Security Creek system. Each system and associated costs are described below. Figure 11 shows the individual drainage basins associated with the storm drainage systems described below.

Little Johnson Basin System

The regional detention pond system consists of eleven sub-systems. Sheets 11 through 13 contains the plan views, and Sheets 14 through 17 are the corresponding profiles for each sub-system. Line 1, as shown in Sheets 11, 13, and 14, is the main outfall system that has the connection to all the other sub-systems. This outfall system is designed from the northeast corner of Drennan Road and Hancock Expressway, to Fountain Creek via Bradley Road. Major improvements for all sub-systems are highlighted below.

Line 1: This sub-system includes: (1) 507 feet of concrete-lined channel along the east side of Hancock Expressway, (2) 1,160 feet of 54-inch RCP between Hancock Expressway and Canal No. 4, (3) a 25 acre-feet detention pond just north of Canal No. 4, (4) 1,460 feet of grasslined channel between Canal No. 4 and Bradley Road, (5) a 36 acre-foot detention pond north of Bradley Road, (6) 4,486 feet of box culvert from Bradley Road to the railroad with a culvert size ranging from eight-feet by nine-feet to seven-feet by ten-feet, (7) 200 feet of 90-inch RCP to be tunnelled under the railroad and Highway



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LITTLE JOHNSON/SECURITY CREEK DRAINAGE BASIN PLANNING STUDY

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Date:	11/87
Design:	RNW
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Revisions:	

FIG. 11

85/87 (8) 820 feet of 90-inch RCP from the west side of the railroad, (9) 1,305 feet of riprap channel between Highway 85/87 and Fountain Creek.

Line 2: This sub-system includes: (1) 1,510 feet of grasslined channel, (2) canal spill structure at northwest side of Canal No. 4 and Bradley Road, and (3) 260 feet of 42-inch RCP between Canal No. 4 and Hancock Expressway. Line 2 is shown on Sheet 11.

Line 3: This sub-system includes 2,033 feet of storm sewer from the south side of Drennan Road to detention pond A-1. The existing inlet and outlet pipes from detention pond just north of Drennan Road are to be connected to this system. Line 3 is shown on Sheet 11. It is recommended that the improvements to the Foxhills Subdivision pond and/or outlet structure be designed to prevent overtopping of Drennan Road in the 100-year event, using the discharges calculated herein.

Line 4: This sub-system includes 863 feet of 54-inch RCP from detention pond A-1 to the intersection of Yucatan Drive and Hancock Expressway. Line 4 is shown on Sheet 11.

Line 5: This sub-system includes 2,125 feet of grasslined channel to be daylighted at detention pond A-2 as shown on Sheet 11.

Line 6: This sub-system includes 3,500 feet of concrete-lined channel to be discharged into the junction structure at Line 1 as shown on Sheets 12 and 13.

Line 7: This sub-system includes 1,960 feet of 42-inch RCP to be connected to the security channel at Line 6 as shown on Sheets 12 and 13.

Line 8: This sub-system includes: (1) 324 feet of 42-inch RCP, (2) a five acre-foot detention pond, and (3) 1,265 feet of 18-inch RCP to be connected to Line 3. The installation of 18-inch outlet pipe will need to be coordinated with property owners. This sub-system is a temporary drainage facility which no cost is to be included in the basin fee calculation. Line 8 is shown on Sheet 11.

Line 9: This sub-system includes: (1) 150 feet of 18-inch RCP to be connected to the existing 24-inch RCP, (2) a 15 acre-foot detention pond with an 18-inch diameter riser pipe, (3) 593 feet of 48-inch RCP, (4) 261 feet of 42-inch RCP to be connected to the existing 42-inch RCP, and (5) 425 feet of 36-inch RCP to be connected to existing 42-inch RCP. Line 9 is shown on Sheet 11.

Pond D Sub-System: This sub-system includes: (1) 3,280 feet of grasslined channel, (2) a 17 acre-foot detention pond. Due to the current open mining operation, only plan view with conceptual design is shown on Sheet 12.

Pond E Sub-System: This sub-system includes: (1) 1,700 feet of grasslined channel, (2) 31 acre-foot detention pond. Due to the current open mining operation, only plan view with conceptual design is shown on Sheet 12.

The total system cost with cost breakdown for each sub-system is shown on Table 6.

Storm Sewer and Security Creek System

1. Storm Sewer System

A storm sewer system was designed to provide drainage outfalls to minimize existing drainage problems and prevent potential damages from a major flood event for unincorporated Widefield and Security. The system contains a total of 33,470 feet of pipe and box culverts ranging in size from 24-inch diameter to 8-foot by 12-foot boxes. The total system contains seven separate outfall systems. The storm sewer system is shown on Sheets 18 through 24. Each individual system is described below:

Security Creek-Security Boulevard Outfall: This system includes storm sewers along Security Boulevard, Rose Drive, Doris Drive, Hallam Avenue, and

Table 6. Preliminary Cost Estimates for the Little Johnson Basin System.

Sub-System No.	Item Description	Unit	Estimated Unit Price	Quantity	Item Cost ($)
1	Riprap Channel (B=30', D=6', SS=2.5:1)	CY	45	10,540	474,300
	90-inch RCP	LF	325	825	268,125
	Tunnelling 90-inch RCP	LF	700	200	140,000
	7'H x 10'W RCB	LF	450	914	411,300
	6'H x 10'W RCB	LF	400	894	357,600
	5'H x 10'W RCB	LF	370	484	179,080
	8'H x 9'W RCB	LF	470	2,194	1,031,180
	Detention Pond (Including Earthwork and Native Grass)	AF	5,000	61	305,000
	Emergency Spillway	LS	50,000	2	100,000
	Grasslined Channel (B=15', D=5', SS=4:1)	LF	125	1,460	182,500
	Canal Siphon Structure	EA	10,000	1	10,000
	54-inch RCP	LF	135	1,235	166,725
	Concrete Lined Channel (B=5', H=5', Vertical)	LF	250	1,285	321,250
	Junction Structure	EA	10,000	13	130,000
	6-ft. Diameter Manhole	EA	3,500	1	3,500
	Concrete Low Flow Channel (B=8', D=1.5')	LF	60	769	46,140
	54-inch RCP Flare End Section	EA	800	1	800
	Drop Structure	EA	5,000	4	20,000
	A. Construction Cost				$4,147,500
	B. Contingency (5% of Construction Cost)				207,375
	C. Engineering (10% of Construction Cost & Contingency)				435,488
	D. Subtotal				$4,790,363
	E. Land Acquisiton - 10 acres @ $15,600/AC				156,000
	F. TOTAL SUB-SYSTEM 1 COST				$4,946,363

Table 6. Preliminary Cost Estimates for the Little Johnson Basin System. (continued)

Sub-System No.	Item Description	Unit	Estimated Unit Price	Quantity	Item Cost ($)
2	Concrete Low Flow Channel (B=8', D=1.5')	LF	60	300	18,000
	Grasslined Channel (B=8', SS=4:1, D=4')	LF	50	1,510	75,500
	42-inch RCP	LF	95	260	24,700
	Canal Spill Structure	EA	50,000	1	50,000
	5-ft. Diameter Manhole	EA	2,500	1	2,500
	42-inch RCP Flare End Section	EA	550	1	550
	A. Construction Cost				$ 171,250
	B. Contingency (5% of Construction Cost)				8,563
	C. Engineering (10% of Construction Cost & Contingency)				17,981
	D. TOTAL SUB-SYSTEM 2 COST				$ 197,794
3	54-inch RCP	LF	135	448	60,480
	60-inch RCP	LF	155	1,585	245,675
	Concrete Low Flow Channel (B=8', D=1.5')	LF	60	580	34,800
	60-inch RCP Flare End Section	EA	1,000	1	1,000
	A. Construction Cost				$ 341,955
	B. Contingency (5% of Construction Cost)				17,098
	C. Engineering (10% of Construction Cost & Contingency)				35,905
	D. TOTAL SUB-SYSTEM 3 COST				$ 394,958
4	Concrete Low Flow Channel (B=8', D=1.5')	LF	60	360	21,600
	54-inch RCP	LF	135	863	116,505
	6-ft. Diameter Manhole	EA	3,500	2	7,000
	A. Construction Cost				$ 145,105
	B. Contingency (5% of Construction Cost)				7,255
	C. Engineering (10% of Construction Cost & Contingency)				15,236
	D. TOTAL SUB-SYSTEM 4 COST				$ 167,596

Table 6. Preliminary Cost Estimates for the Little Johnson Basin System. (continued)

Sub-System No.	Item Description	Unit	Estimated Unit Price	Quantity	Item Cost ($)
5	Grasslined Channel (B=8', SS=4:1, D=4')	LF	50	2,125	106,250
	Concrete Low Flow Channel (B=6', D=1.5')	LF	50	200	10,000
	A. Construction Cost				$ 116,250
	B. Contingency (5% of Construction Cost)				5,813
	C. Engineering (10% of Construction Cost & Contingency)				12,206
	D. TOTAL SUB-SYSTEM 5 COST				**$ 134,269**
6	Concrete Lined Channel (B=6', SS=1.5:1, D=4')	LF	100	3,500	350,000
	Drop Structure	EA	5,000	1	5,000
	A. Construction Cost				$ 355,000
	B. Contingency (5% of Construction Cost)				17,750
	C. Engineering (10% of Construction Cost & Contingency)				37,275
	D. TOTAL SUB-SYSTEM 6 COST				**$ 410,025**
7	42-inch RCP	LF	95	1,960	186,200
	5-ft. Diameter Manhole	EA	2,500	5	12,500
	A. Construction Cost				$ 198,700
	B. Contingency (5% of Construction Cost)				9,935
	C. Engineering (10% of Construction Cost & Contingency)				20,863
	D. TOTAL SUB-SYSTEM 7 COST				**$ 229,498**
8	All facilities associated with Line 8 on the preliminary design plans are considered temporary. Therefore, no costs have been included in the cost estimate or fee calculation.				$ 0