PHOENIX, ARIZONA

I-1Ø INNER LOOP

STORM DRAINAGE SYSTEM

VALUE ENGINEERING STUDY

OCTOBER 5, 1982

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I-10 Inner Loop
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Brainstorming Group
Analytical Phase
SUMMARY

The brainstorming groups concluded that the following ideas should be further developed and evaluated as potential methods of accommodating overland storm drainage flow:

1. EVALUATE DESIGN PARAMETERS

   - Refine Hydrology in Conjunction with Certain Concepts
   - Modify Design Criteria Through Risk Analysis

2. INVESTIGATE CONVEYING ACROSS FREEWAY

   - Cover Freeway
   - Siphons Under Freeway

3. INVESTIGATE STORM WATER STORAGE

   - Upstream Off Site Storage
   - Storage On Site

4. RETAIN PRESENT ALTERNATIVES

   - Investigate Feasibility of Tunneling

5. INVESTIGATE COMBINATIONS OF IDEAS

   - Partial Storage
   - Groundwater Recharge
   - Use of Open Channels Where Practical
   - Use of Pipes or Tunnels for Storage and Conveyance
   - Other Combinations

Phoenix, Arizona
I-1Ø Inner Loop
Storm Drainage System
Value Engineering Study

Brainstorming Group
INFORMATION

PROJECT: I-1Ø Inner Loop

ITEM: Storm Drainage

BASIC FUNCTION: Drain Roadway

DATE: October 5, 1982

DESIGN CRITERIA:

Interstate design criteria requires a drainage system which will accommodate a 5Ø-year design storm. Where conditions exist making this criteria prohibitive from a cost stand point, a lesser design storm may be acceptable if a risk analysis demonstrates that the given design criteria results in prohibitively high costs without compensating benefits to the public. The proposed project must not worsen the existing flooding conditions upstream or downstream of the project area.

HISTORY AND BACKGROUND:

The hydrology for the drainage area and four alternative solutions for the drainage system have been developed in the initial design stage. The alternative solutions each convey both freeway drainage and off site drainage to the Salt River in closed conduits. The attached Appendix includes description and sketches for the proposed design.

TEAM MEMBERS:

The team members were divided into two study groups - Team A and Team B. The work sheets for both groups are included in this report.

TEAM A	TEAM B
John Curtis, Leader	Bob Larget, Leader
Bob Clour	Bob Baumgardner
Howard Boswell	Larry O'Toole
Bill Wakefield	Dave Elack
Tom Schmitt	Dave Johnson
Bob Ward	Les Bond
Dave Burris	Reggie Swartz
Art Beard	Gary Siders
Greg Allen	Pete Jarchow
Ben Muns	Lee Holloway
Stan Mast	Tim Smirnoff
Dick Prosence	Ross Buckett

PHOENIX, ARIZONA

I-1Ø INNER LOOP

STORM DRAINAGE SYSTEM

VALUE ENGINEERING STUDY
BRAINSTORMING GROUP

AGENDA

Monday, October 4, 1982		HNTB I-1Ø Project Management Ofc. 2211 East Highland Avenue Phoenix, Arizona (6Ø2) 957-1931
1:45 P.M.	Initial Briefing of Project Area	
2:ØØ P.M.	Field Tour of Project Area. Transportation Provided	
4:3Ø P.M.	Return to HNTB Open Discussion Refreshments	
Tuesday, October 5, 1982		Ramada Townehouse 1ØØ West Clarendon Avenue Phoenix, Arizona (6Ø2) 279-9811
8:ØØ A.M.	Project Introduction	
9:3Ø A.M.	Break	
9:45 A.M.	First Brainstorming - Speculative Phase - Two Groups	
11:3Ø A.M.	General Discussion - Combined Groups	
12:ØØ Noon	Lunch - (Provided)	
1:ØØ P.M.	Second Brainstorming - Analytical - Two Groups	
2:45 P.M.	Break	
3:ØØ P.M.	General Discussion - Combined Groups	
3:3Ø P.M.	Summary and Consensus - Combined Groups	
4:3Ø P.M.	Adjournment	

PHOENIX, ARIZONA

I-10 INNER LOOP

STORM DRAINAGE SYSTEM

VALUE ENGINEERING STUDY
LIST OF WORK SHEETS

Phoenix, Arizona
I-10 Inner Loop
Storm Drainage System
Value Engineering Study

FUNCTIONAL ANALYSIS

ITEM	FUNCTION			COST	WORTH	COMMENTS
	Verb	Noun	Kind *			
SPAN FREEWAY (50% span)	Convey	Water	B	$\$119\text{x}10^{6}$	$\$85\text{x}10^{6}$	Cost Estimated at: 8500' @ $14,000 / LF
SPAN FREEWAY (10% span)	Convey	Water	B	$\$25\text{x}10^{6}$		Based on cost of E-W coll. modified to convey to bridges and redistribute.
(In Freeway trench) STORAGE IN EXCESS pf 2-Yr. STORM	Store	Water	B	36-Hr. Pumpout & Cleaning Cost		Total Hydrograph 1500 Ac-Ft 4-Hr. Base = 430 Ac-Ft. Store 1100 Ac-Ft. Depressed Fwy = 1890 Ac-Ft.
STORAGE UPSTREAM (Surface Retention)	Retain	Water	B			Cost to include R/W, Excavation, and 36-Hr. Pumping
STORAGE - UNDER FWY	Dispose	Water	B	Bridge in Trench less Cost of Reg. Pavement		(Recharge)

* B = Basic
S = Secondary

Brainstorming Group
Speculative Phase
FUNCTIONAL ANALYSIS
Work Sheet 1
TEAM A

Phoenix, Arizona
I-10 Inner Loop
Storm Drainage System
Value Engineering Study

Brainstorming Group
Speculative Phase
CREATIVE IDEA LISTING
Work Sheet 2
TEAM A

NOTE: List all Ideas -- Evaluate Later.

1	Collect Water with sponge
2	Retention Basin - Offsite & Upstream
3	Span Fwy - Extend Existing Streets Across as Hydraulic Structures
4	Improve Grand Canal - Westerly Flow
5	Elevate Freeway
6	No Action
7	Encourage On-Site Retention
8	Inverted Siphons/Capacity of Existing Sewers and Capacity of Exist.Streets
9	French Drains
10	Alternative I per Arthur Beard Engineers, Inc.
11	Alternative II per Arthur Beard Engineers, Inc.
12	Alternative III per Arthur Beard Engineers, Inc.
13	Alternative IV per Arthur Beard Engineers, Inc.
14	Convey to N-S Leg; Open Channel to River
15	Joint Use - City and Freeway Systems
16	Open Channel on E-W Leg w/closed conduit along I-17
17	Open Channel on E-W Leg w/Open channel along I-17
18	Pressure Siphon at Each City Street
19	Freeway and Retention Basin
20	Retention Basin - Offsite & Downstream; Use Fwy. Spans w/o Dispersion Sys.
21	Improve Grand Canal - Reverse Flow

Phoenix, Arizona
I-10 Inner Loop
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Value Engineering Study

Brainstorming Group
Speculative Phase
CREATIVE IDEA LISTING
Work Sheet 2

TEAM A
Sheet 2 of 2

NOTE: List all Ideas -- Evaluate Later.

22	Isolate Central Ave. Corridor out of East-West Collector Sewer
23	Span Fwy - (10%) w/Collection and Dispersion System
24	Storage Under Freeway
25	Revise Hydrologic Analysis
26	Revise Design Criteria
27	Create a Man-made Lake
28	Encourage Porous Pavement
29	Recharge Wells
30	Recharge Trenches

Phoenix, Arizona
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Brainstorming Group
Speculative Phase
CREATIVE IDEA LISTING
Work Sheet 2

TEAM A
SURVIVORS

1	Retention Basin - Offsite
2	Span Freeway and Existing City Streets
3	Inverted Siphons at City Streets
4	Alternative I per Arthur Beard Engineers, Inc.
5	Alternative II per Arthur Beard Engineers, Inc.
6	Alternative III per Arthur Beard Engineers, Inc.
7	Alternative IV per Arthur Beard Engineers, Inc.
8	Pressure Siphons
9	Freeway as Retention Basin
10	Improve Grand Canal
11	Isolate Central Ave. Corridor
12	Span Freeway with 10% Coverage
13	Storage Under Freeway
14	Reduce Design Criteria

Phoenix, Arizona
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Value Engineering Study

Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3

TEAM A

Sheet 1 of 4

SPANNING OF FREEWAY IDEAS:

IDEA	ADVANTAGES	DISADVANTAGES	IDEA RATING*
Approximately 10% of Freeway Spanned Cut and Cover Section Plus four (4) Streets	• Utilize Proposed Facilities • Reduced Capital Outlay • No Outfalls to Salt River • Reduced Utility Conflicts • No Additional R/W	• Concentration of Flows • Traffic Interference • Potential For Upstream or Down-Stream Liabilities • Potential EIS Modification • Reliability • Loadings Difficult to Predict	5
Approximately 20% of Freeway Spanned Cut and Cover Section Plus All City Streets	• Better Access - N/S • No Outfalls to Salt River • Reduced Utility Conflicts • No Additional R/W	• Lesser When Compared to the Above • Higher Cost Outlay	8
Isolate Central Ave. Corridor (Common to the above and other alts.)			

* 10 = MOST DESIRABLE, 1 = LEAST DESIRABLE

Phoenix, Arizona
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Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3

TEAM A

SIPHON IDEAS:

IDEA	ADVANTAGES	DISADVANTAGES	IDEA* RATING
Inverted Siphons at all Drainage Crossings	• Lesser Cost than Bridge Costs • No Salt River Outfalls • No Utility Conflicts	• More Upstream Flooding • Concentration and Dispersion • Maintenance	5
Pressure Siphons	• Less Upstream Flooding • Smaller Pipe • No Utility Conflicts • No Salt River Outfalls	• Increased Concentration/Dispersion Problems • Higher Maintenance • Energy • Reliability	3

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Phoenix, Arizona
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Value Engineering Study

Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3

TEAM A

Sheet 3 of 4

RETENTION IDEAS:

IDEA	ADVANTAGES	DISADVANTAGES	IDEA RATING*
Retention Basin -Offsite-	• Multi-Use Potential • Reduce Overall System Cost	• Requires Lane • Collector System Required • Must Be Drained • Pumping Possible • Potential EIS Modification--LAND!	7
Freeway as Retention Basin	• Combine With Other Systems	• Disruptive to Traffic • Maintenance Cost • Human Life Danger • Potential EIS Modification-	1
Storage Under Freeway	• Multi-Use of Facilities • Potential for Recharge	• Net Increase in Cost • Pumping • Potential For Contamination of Groundwater • Potential EIS Modification	8

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Phoenix, Arizona
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Value Engineering Study

Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3
TEAM A

CONVEYANCE IDEAS:

Sheet 4 of 4

IDEA	ADVANTAGES	DISADVANTAGES	IDEA RATING*
ALTERNATE III	AS PRESENTED IN BACKGROUND INFORMATION	AS PRESENTED IN BACKGROUND INFORMATION	8
ALTERNATE IV			8
ALTERNATE I			3
ALTERNATE II			3

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Phoenix, Arizona
I-10 Inner Loop
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Value Engineering Study

Brainstorming Group
Analytical Phase
ALTERNATIVE EVALUATION
Work Sheet 4

TEAM A

NOTES:

H = High Impact
M = Medium Impact
L = Low Impact

	FACTORS									
IDEAS	CAPITAL COST	O & M COST	PUBLIC ACCEPTANCE	ENVIRONMENTAL IMPACT	LIABILITY	TRAFFIC SERVICE	UTILITY DISRUPTIONS	R/W		
Cut & Cover with All City Streets Over (20% Covered)	L	L	L	L	M	L	L	L		
Storage Under Freeway	H	M	L	L	L	L	L	L		
Alternate III	H	M	L	L	M	L	M	L		
Alternate IV	H	M	L	L	M	L	M	L		
Off-Site Retention	L	L	M	H	L	M	M	H		
Cut & Cover with 4 City Streets Over (10% Covered)	L	L	M	M	M	L	L	L		
Inverted Siphons	M	H	M	M	M	L	L	L		
Pressure Siphons	M	H	M	M	M	L	L	L		
Alternate I	H	L	H	L	L	H	H	L		
Alternate II	H	L	H	L	L	H	H	L		
Freeway as Retention Basin	L	H	H	H	H	H	L	L		

FUNCTIONAL ANALYSIS

ITEM	FUNCTION			COST	WORTH	COMMENTS
	Verb	Noun	Kind *			
HIGHWAY DRAINAGE	Drain	Roadway	B		$2.0M	I-10 Roadway, Say, Cost $12.0M
ACCOMMODATE OVERLAND FLOW	Maintain	Traffic	B		0	From City Streets and Adjacent Land, Say, Cost $73.0M
ACCOMMODATE OVERLAND FLOW	Minimize	Liability	S		0	
EAST-WEST COLLECTOR SYSTEM	Collect	Water	B	$29.6M	$18.0M	
EAST-WEST COLLECTOR SYSTEM	Move	Water	S		0	

* B = Basic
S = Secondary

Brainstorming Group
Speculative Phase
FUNCTIONAL ANALYSIS
Work Sheet 1
TEAM B
Sheet 1 of 2

Phoenix, Arizona
I-10 Inner Loop
Storm Drainage System
Value Engineering Study

FUNCTIONAL ANALYSIS

ITEM	FUNCTION			COST	WORTH	COMMENTS
	Verb	Noun	Kind *			
OUTFALL	Convey	Water	S	$55.6	0	Outfall is $8.0 - 9.0M Basic Cost
				$85.0M	$20.0M	Cost / Worth 4.25

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S = Secondary

Brainstorming Group
Speculative Phase
FUNCTIONAL ANALYSIS
Work Sheet 1

TEAM B
Sheet 2 of 2

Phoenix, Arizona
I-10 Inner Loop
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Value Engineering Study

Brainstorming Group
Speculative Phase
CREATIVE IDEA LISTING
Work Sheet 2

TEAM B

NOTE: List all Ideas -- Evaluate Later.

Sheet 1 of 2

1	Cover Freeway
2	Siphons Under Freeway
3	Design for 2-Year Flow
4	Some Siphons and Bridge
5	Bridge Thru Streets
6	Widen Grand Canal
7	Minimize Flow Into Area
8	Hydrology Refinement
9	Store Under Freeway
10	Recharge
11	Store Upstream
12	Tunnel Extension
13	Freeway Parallel Storage
14	New Watershed Storage
15	Retain and Carry West
16	Let Flood
17	Flood Easement
18	Shut Down Freeway
19	Divert to Black Canyon
20	Green Belt to River
21	Restore Cave Creek Wash

Phoenix, Arizona
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Brainstorming Group
Speculative Phase
CREATIVE IDEA LISTING
Work Sheet 2
TEAM B

NOTE: List all Ideas -- Evaluate Later.

Sheet 2 of 2

1	Open Channel
2	Pressurize Flow
3	Elevated Storm Sewer
4	Elevated Freeway
5	At-Grade Freeway
6	Alternate I per Arthur Beard Engineers, Inc.
7	Alternate II per Arthur Beard Engineers, Inc.
8	Alternate III per Arthur Beard Engineers, Inc.
9	Alternate IV per Arthur Beard Engineers, Inc.
10	All - Flow East & N-S Leg
11	Improve "n" Value
12	Partial Retain and Convey
13	Dry Well In Every Property
14	Zoning Modification
15	Store in City Streets
16	Store Under or Alongside City Property
17	Store in Encanto Lagoon
18	Use On-Site Material For Construction
19	Drainage Structure Over Freeway
20	Close Half Freeway
21	Diversion Canal at Grand Canal

Phoenix, Arizona
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Brainstorming Group
Speculative Phase
CREATIVE IDEA LISTING
Work Sheet 2
TEAM B
SURVIVORS
Sheet 1 of 3

STORAGE OPTION IDEAS

1	Under Freeway	Keep
2	Upstream	Keep
3	Use Half Freeway	?
4	Street ROW	Out
5	Flood Easement	Out
6	Shut Down Freeway	Out
7	Parallel to Freeway	Keep
8	Zoning Modification	Out
9	Giant Sponge	Out
10	Downstream Storage	Combine
11	Porous Pavement	Out
12	Recharge	Combine

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Speculative Phase
CREATIVE IDEA LISTING
Work Sheet 2

TEAM B
SURVIVORS
Sheet 2 of 3

CONVEYANCE OPTION IDEAS

1	Covered Freeway	Combine
2	Siphon Under Freeway	Out
3	Siphon for 2-year Flow	Combine
4	Bridge the Thru Streets	Combine
5	Tunnel Extension	Out
6	Alternative I per Arthur Beard Engineers, Inc.	Keep
7	Alternative II per Arthur Beard Engineers, Inc.	Keep
8	Alternative III per Arthur Beard Engineers, Inc.	Keep
9	Alternative IV per Arthur Beard Engineers, Inc.	Keep
10	Flumes	Out
11	Open Channels	Keep
12	Diversion to Black Canyon	Out
13	Pressure System	Out
14	Aquaduct	Out
15	Reverse Flow in Grand Canal	Out
16	Improve Grand Canal	Out
17	Modified Alternative II to West	Out
18	Improve "N" Value	Out
19	Cave Creek Green Belt	Out

Phoenix, Arizona
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Brainstorming Group
Speculative Phase
CREATIVE IDEA LISTING
Work Sheet 2

TEAM B
SURVIVORS
Sheet 3 of 3

CHANGE CONCEPT OR CRITERIA IDEAS:

Out	1	At-Grade Freeway	Out
Out	2	Elevated Freeway	Out
Keep	3	Refine Hydrology (Combine w/All)	Keep
Keep	4	Revise Design Criteria (Combine w/All)	Keep
Out	5	No Freeway	Out

Phoenix, Arizona
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Storm Drainage System
Value Engineering Study

Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3

TEAM B

Sheet 1 of 5

SPANNING IDEAS:

IDEA	ADVANTAGES	DISADVANTAGES	IDEA RATING*
Cover Freeway	1. Does not change present condition 2. Help the environment (parks, etc.) 3. May need only lid at cross streets 4. Lid is already provided at major flow areas 5. 6300 cfs is already lidded	1. May be high cost 2. Need to make lid watertight 3. Refinement of hydraulic model is needed to insure direction of flow 4. May need large factor of safety to insure workability 5. Lack of reliability 6. Difficult to predict loading conditions	10

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Phoenix, Arizona
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Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3

TEAM B

CONVEYANCE IDEAS:

Sheet 2 of 5

IDEA	ADVANTAGES	DISADVANTAGES	IDEA RATING*
Existing Alternatives	1. Alternative III is best for traffic control.	1. Need to pump or leave wet or recharge.	8

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Phoenix, Arizona
I-10 Inner Loop
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Value Engineering Study

Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3
TEAM B

STORAGE IDEAS:

IDEA	ADVANTAGES	DISADVANTAGES	IDEA RATING*
Upstream Storage Site	1. May be available for public use. 2. Reduces amount of water at site.	1. Convey to Site 2. Feds may not participate. 3. Cost high if ROW is purchased. 4. Agency cooperation is difficult to obtain. 5. May violate EIS.	5

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Phoenix, Arizona
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Value Engineering Study

Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3

TEAM B

STORAGE IDEAS:

Sheet 4 of 5

IDEA	ADVANTAGES	DISADVANTAGES	IDEA* RATING
Store Under Freeway	1. Have land and in construction area. 2. Build in sandy material. 3. Could be located to west - decrease outfall cost.	1. May need more storage for more than one event. 2. Salt River may fill storage. 3. Increased cost of roadway. 4. For Advantage 3 pump may be needed.	7

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Phoenix, Arizona
I-10 Inner Loop
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Value Engineering Study

Brainstorming Group
Analytical Phase
IDEA EVALUATION
Work Sheet 3

TEAM B

STORAGE IDEAS:

IDEA	ADVANTAGES	DISADVANTAGES	IDEA RATING*
Storage Parallel to Freeway	1. Use for Partial Storage. 2. Cost may be very small.	1. Does not solve entire problem.	7

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Phoenix, Arizona
I-1Ø Inner Loop
Storm Drainage System
Value Engineering Study

Brainstorming Group
Evaluation Phase
GROUP EVALUATION CRITERIA
TEAMS A & B

IMPACT*	CRITERIA
H	Capital Cost
H	Operation and Maintenance Cost
H	Liability/Risk
M	Public Acceptance
L	Compliance with Environmental Impact Statement
L	Right of Way
L	Utilities
M	Traffic
L	Implementation Time
L	Construction Problems
H	Funding
M	Public Benefits

*Notations:

H - High Impact

M - Medium Impact

L - Low Impact

RESULTS OF VALUE ENGINEERING STUDY

The following items were recommended for further evaluation:

1. EVALUATE DESIGN PARAMETERS
2. INVESTIGATE CONVEYING ACROSS FREEWAY
3. INVESTIGATE STORM WATER STORAGE
4. RETAIN PRESENT ALTERNATIVES
5. INVESTIGATE COMBINATIONS OF IDEAS

1. EVALUATE DESIGN PARAMETERS

A. Refine Hydrology in Conjunction with Certain Concepts

It is recognized that the hydrology as per the original Scope of Services for the Arthur Beard Engineers study has been completed. However, certain of the concepts developed through the Value Engineering study process will require more detailed analysis as to the actual locations or spacial distributions of the flows. For example, for the conveyance over the freeway concept involving covering portions of the depressed freeway, flow quantities at each through street will be necessary for design, rather than the total flows assoicated with each of the major streets that were the result of the original analysis. A sensitivity analysis of the TR-20 hydrology model parameters indicated the relative variation inflow associated with changes in parameter values. While flow is quite sensitive to variation and some parameters, the potential for parameter variation is often minimal. The parameters investigated and their potential for variation are as follows.

- o Hydrologic Soil Cover Complex (Cn's) - minimal potential for variation.
- o Times of Concentration (Tc's) - minimal potential for variation.
- o Routing Coefficients (C's for pipe flow velocities) - minimal potential for variation.
- o Rating Curve Modifications (overland flow velocities) - potential for variation.
- o Rainfall Distribution - minimal potential for variation.
- o Possible Existing Storage Above Banks of Grand Canal - minimal potential for variation.

Of the parameters addressed by the sensitivity analysis, only modifications to the overland flow assumptions merit further consideration within this context.

There are two methods which have potential for refining the original flow distribution to the accuracy required for study of conveyance on a street by street basis.

- o Modelling subareas used for the TR-20 hydrology model to apply the original model methodology to subareas within the subarea on a block by block basis if program limitations permit. One subarea might establish a valid pattern.

- o Using an alternative hydrology modelling method specifically developed for urban areas, such as SWMM, for all or part of the contributing area. This may require the acquisition of further input data.

B. Modify Design Criteria Through Risk Analysis

- o Risk Analysis of Inundation of Roadway or adjacent lands during Design Storm Peak is necessary to determine whether design criteria can or should be reduced. An analysis should be performed comparing incremental costs of full protection of roadway during design storm versus real and potential costs (cleanup, repair and intangibles) of flooding roadway for range of durations during storm peak. The results of this analysis could effect the reduction of the design storm for <u>full</u> protection.

2. INVESTIGATE CONVEYING ACROSS FREEWAY

A. Introduction

This concept provides for conveyance of storm run-off which originates outside the I-10 corridor across the depressed section of the I-10 Inner Loop. The end product is to not alter existing runoff conditions on either side of the corridor. Conveyance is to be accomplished by either of two methods:

- o Covering portions of the freeway;
- o Installing siphons at existing run-off points.

The following discussions described these methods.

B. Covered Freeway

This method proposes that the depressed section of the freeway be covered to various degrees to permit surface run-off to flow over the freeway. Three alternatives are included in this method:

- o Proposed General Plan Crossings - Bridges at 7th Avenue, 7th, 10th, 12th and 16th Streets and the covered deck section between 3rd Avenue and 3rd Street. Runoff will be directed towards these crossings, bridges designed to provide hydraulic capacity and dispersion systems installed on the south (downstream) side of the crossings.
- o All City Streets - At all points where vertical clearance is possible, existing city streets are to be continued across the depressed section as hydraulic structures or roadway structures modified to provide hydraulic capacity. The covered deck section between 3rd Avenue and 3rd Street is included in this alternative. Runoff will be collected and dispersed as noted above.
- o Cut-and-Cover Section - Where vertical clearance is possible, the depressed section will be covered similar to that proposed between 3rd Avenue and 3rd Street. It is estimated that approximately 50 percent of the depressed section may be covered in this manner. Runoff will be collected and dispersed as noted above.

Each of these alternatives can be used in combination with other concepts to minimize project construction costs.

C. Siphons

Siphons, either inverted or pressurized, may be utilized to convey surface runoff and flows in storm sewers under or over the depressed section.

- o Inverted Siphons - Siphons constructed at each intersection of existing (and proposed) city storm sewers.

- o Pressure Siphons - Collection, conveyance, pumping, siphons and distribution systems for surface runoff and/or flows in storm sewers. Siphons may be located under or above the depressed section.

Siphons may also be utilized in combination with other concepts to minimize project construction costs. Dispersal on the downstream must be carefully designed to insure an unchange condition.

3. INVESTIGATE STORM WATER STORAGE

These alternatives will accommodate all or part of the 50-year event runoff volume thereby eliminating or reducing the need to convey the associated peak flow rate via conveyance facilities.

- Upstream (Offsite) Storage - Utilization of retention basins within the tributary drainage area in addition to existing areas identified as non-contributing to runoff.

- Onsite Storage - Utilization of right-of-way corridor for storage facilities for intercepted runoff and direct rainfall. Storage would be provided in either or both of the following means:

  - Beneath the roadway, requiring a viaduct type construction;

  - Paralleling the roadway using depressed median strip and retention basins within right-of-way. This may be enhanced by selected widening of the right-of-way to increase usable area.

4. RETAIN PRESENT ALTERNATIVES

A. Introduction

The concepts of conveyance to the Salt River are taken from three of the four alternatives developed by Arthur Beard Engineers, Inc., under their present scope of work for the Arizona Department of Transportation. Storm run-off which originates upstream of the I-10 corridor is collected along the north side of the depressed section of the I-10 Inner Loop and released at points along the Salt River. Minimal amounts of surface runoff would cross the corridor--3rd Avenue to 3rd Street being an example. Conveyance concepts are categorized by their method of construction, tunnels and cut and cover. Each of these methods is discussed below.

B. Tunnels

Tunnel alternatives require an east-west collection system cut and cover which intercepts surface runoff and existing (and proposed) city storm sewers and conveys the flow to outfall tunnel(s). The outfall tunnel(s) is anticipated to be below the grade of the Salt River in order to avoid utility conflicts, and will act as a siphon during runoff events. Pumping will be required to empty the tunnel after an event. Descriptions of tunnel alternatives are taken from data derived by Arthur Beard Engineers and provided to the Value Engineering study group.

- Alternative Concept III - A 30-foot diameter tunnel under 15th Avenue to conduct all off site flows to the Salt River.
- Alternative Concept IV - Two 20-foot diameter tunnels, one under 15th Avenue and the other under Central Avenue, for discharges to the Salt River.

In order to determine if tunnels are implementable, tunneling feasibility studies must be conducted.

C. Cut and Cover Sewers

A system composed entirely of cut and cover sewer construction is included in the event tunneling is not feasible. A cut and cover system would not intercept existing or proposed storm sewers as these sewers will be conveyed via siphons across the depressed section of the freeway. The Arthur Beard Engineers' Alternative I is an cut and cover concept to be considered which utilizes box culvert outfalls installed under the following streets:

- o I-17 Northbound Frontage Road;
- o 1st Avenue;
- o 11th Street.

It must be determined if these outfall sewers are to function as gravity sewers or act as siphons (with pumping) as discussed under tunnels.

5. INVESTIGATE COMBINATIONS OF IDEAS

The optimal drainage system which will result in the most desirable and effective solution may be a combination of the "pure-bred" alternatives which meets the design needs, does not increase existing sheet flow impacts, and is implementable at a cost less than other options. The combination system considered worthy of further evaluation include:

- Recharge - Drainage of storage facilities, siphons and/or tunnels via seepage ports into porous strata thereby eliminating other dewatering facilities. Dewatering of open storage will be enhanced by evaporation.

- Storage - Use storage to reduce peak conveyance requirements associated with infrequent events thus reducing highway collector drainage and outfall sewer sizes. Optimal storage volume dependent upon combined total cost of conveyance and storage facilities for alternative design frequencies for conveyance facilities with remaining differential volume for the 5Ø-year event stored.

- Tunnel - Use tunnel for collector system if feasible and cost effective. Tunnel size may be reduced in combination with storing excess volumes associated with infrequent events. Design should recognize volume provided within outfall and collector systems as decreasing total storage requirement.

- Pipes - Used for siphon construction on existing storm sewers intercepted by roadway to decrease collector needs and pass flows under corridor. Where feasible use for highway drainage, collector system and outfall sewers. In selective areas, pipes may be an economical form of providing storage.

- Open Channels - In lieu of pipes for highway drainage, use of drainage ditches may be viable, providing drainage as required, decreasing flow velocities and peaks and providing on-site storage within median strips and off shoulders within corridor.

- Change Design Parameters - Evaluate potential cost reductions for total drainage systems if design parameters are changed. An associated risk analysis would be required to determine the impact resulting from such changes, i.e., potential duration of closure, limited lane closure or limited inundation, etc.

- Covered Freeway and Thru Streets - Convey all or part of existing surface flow associated with areas upstream of proposed covered sections of highway and through streets thereby minimizing intercepted flow requiring conveyance and/or storage.

- Recycle - Stored water may be used for spray irrigation within the right-of-way should green belt strips be incorporated for aesthetics.

APPENDIX

A. BACKGROUND INFORMATION

B. SENSITIVITY ANALYSIS

APPENDIX A

PHOENIX, ARIZONA

I-10 INNER LOOP

STORM DRAINAGE

VALUE ENGINEERING STUDY

BACKGROUND INFORMATION

OCTOBER 5, 1982

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

A. PURPOSE OF REPORT

THE PURPOSE OF THIS REPORT IS TO PRESENT THE RESULTS OF STUDIES RELATIVE TO STORM DRAINAGE ALONG THE I-10 INNER LOOP IN PHOENIX. THE STUDY IS COMPRISED OF TWO ELEMENTS:

1. COMPUTE THE HYDROLOGY OF THE DRAINAGE AREA CONTRIBUTING STORMWATER FLOW ALONG THE INNER LOOP'S EAST-WEST CORRIDOR, LOCATED APPROXIMATELY 0.25 MILE SOUTH OF MCDOWELL ROAD, FROM ITS INTERSECTION WITH I-17 TO THE END OF THE CORRIDOR AT APPROXIMATELY 21ST STREET.

2. DEVELOP AND EVALUATE ALTERNATIVE CONCEPTS WHICH SAFELY CONDUCT STORMWATER AWAY FROM THE PROPOSED FREEWAY FOR STORMS EQUAL TO AND LESS THAN THE 50-YEAR FREQUENCY STORM EVENT, WITHOUT INUNDATION OF THE FREEWAY.

THE FINAL PRODUCT OF THIS REPORT IS A RECOMMENDED ALTERNATIVE DESIGN FOR THE OFF-SITE FREEWAY STORM DRAIN SYSTEM.

B. SUMMARY OF HYDROLOGY

1. DRAINAGE AREA CHARACTERISTICS

THE DRAINAGE AREA ESTABLISHED FOR THE I-10 INNER LOOP'S EAST-WEST CORRIDOR IS SHOWN ON FIGURE 1. AN INDEX MAP FOR PHOENIX, ARIZONA IS SHOWN ON FIGURE 8 ON PAGE 16. THE ARIZONA CANAL DIVERSION CHANNEL (ACDC), WHICH IS A MAJOR CORPS OF ENGINEERS FLOOD CONTROL PROJECT, IS ASSUMED TO BE IN PLACE FOR THE PURPOSES OF THIS REPORT, AND THEREFORE PROVIDES PROTECTION OF THE DRAINAGE AREA FROM FLOWS ORIGINATING NORTH OF THE ARIZONA CANAL.

THE WESTERN PORTION OF THE DRAINAGE AREA INCLUDES CAVE CREEK WASH, A FLOOD PLAIN WHICH HAS BEEN ALMOST COMPLETELY DEVELOPED AS AN URBAN AREA.

THE INNER LOOP DRAINAGE AREA INCLUDES APPROXIMATELY 24 SQUARE MILES IN NORTH-CENTRAL AND NORTH-EAST PHOENIX.

THE AREA HAS BEEN ALMOST COMPLETELY URBANIZED WITH A COMBINATION OF COMMERCIAL AND RESIDENTIAL LAND USE. WITHIN THE CENTRAL AVENUE CORRIDOR, CURRENT AND FUTURE ZONING ALLOWS FOR THE REDEVELOPMENT OF THE CORRIDOR INTO A HIGHRISE COMMERCIAL, OFFICE AND RESIDENTIAL DISTRICT.

STORM DRAINAGE IN THE INNER LOOP DRAINAGE AREA IS CURRENTLY PROVIDED BY EXISTING CITY OF PHOENIX STORM DRAINS AND BY SURFACE FLOWS WHICH GENERALLY FOLLOW THE MAJOR STREET PATTERN IN PHOENIX. FUTURE STORM DRAINS BEING PLANNED BY THE CITY WILL AUGMENT THE EXISTING DRAINS TO PROVIDE FOR THE TWO-YEAR FREQUENCY STORM.

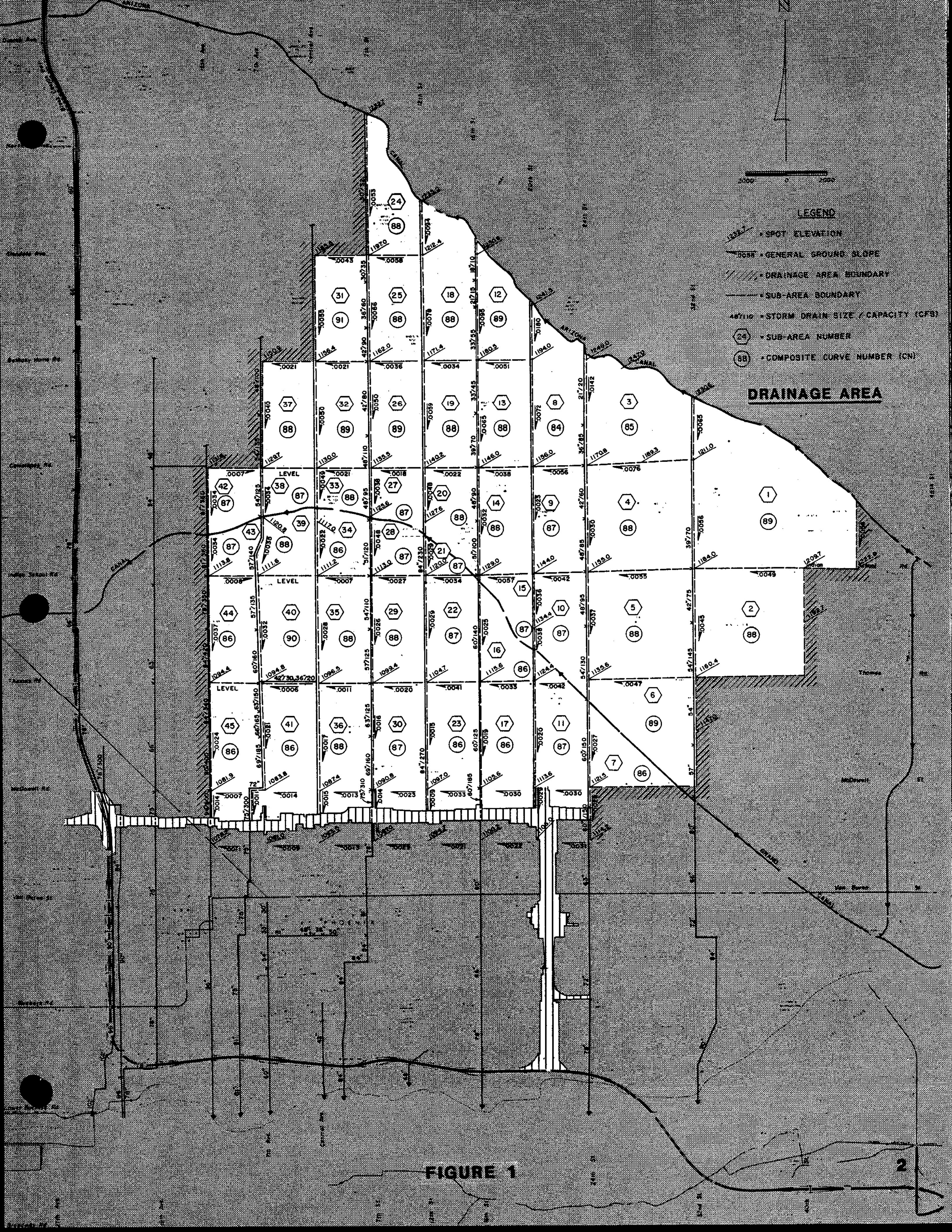
LEGEND
= SPOT ELEVATION
= GENERAL GROUND SLOPE
= DRAINAGE AREA BOUNDARY
= SUB-AREA BOUNDARY
= STORM DRAIN SIZE / CAPACITY (CFS)
= SUB-AREA NUMBER
= COMPOSITE CURVE NUMBER (CN)
DRAINAGE AREA
N

FIGURE 1

STORM DRAINAGE IS REDUCED WITHIN THE DRAINAGE AREA BY THE ON-SITE RETENTION OF STORM WATER ON LARGE COMMERCIAL PROPERTIES AND BY RESIDENCES WHICH ARE FLOOD IRRIGATED.

FUTURE DEVELOPMENT WITHIN THE DRAINAGE AREA WILL CONSIST OF FILLING IN THE REMAINING UNDEVELOPED PARCELS SCATTERED THROUGHOUT THE AREA, AND THE REDEVELOPMENT OF THE CENTRAL AVENUE CORRIDOR INTO AN UPTOWN BUSINESS DISTRICT.

2. METHOD OF COMPUTING HYDROLOGY

THE METHOD OF ANALYSIS USED FOR THE DETERMINATION OF HYDROLOGY ON THE INNER LOOP DRAINAGE AREA IS THE SOIL CONSERVATION SERVICE TR-20 COMPUTER PROGRAM. THE PROGRAM'S FLEXIBILITY AND CAPABILITIES ALLOW ITS USE IN COMPLEX URBAN DRAINAGE PROJECTS, AS IS THE CASE FOR THE I-10 INNER LOOP.

THE RAINFALL INTENSITY AND DISTRIBUTION FOR 50- AND 100-YEAR FREQUENCY STORMS WHICH WERE USED IN THE COMPUTATION OF HYDROLOGY ARE IN ACCORDANCE WITH NATIONAL WEATHER SERVICE VALUES FOR TOTAL PRECIPITATION, WITH RAINFALL DISTRIBUTION MADE IN ACCORDANCE WITH THE 24-HOUR RAINFALL DISTRIBUTION CURRENTLY USED BY THE CITY OF PHOENIX. AREAL REDUCTION OF THE RAINFALL INTENSITY BASED ON THE SIZE OF THE DRAINAGE AREA WAS NOT RECOMMENDED.

USING THE ABOVE RAINFALL PATTERN, AND THE DRAINAGE AREA CHARACTERISTICS, THE HYDROLOGY OF THE INNER LOOP DRAINAGE AREA WAS COMPUTED BY THE TR-20 PROGRAM. RESULTS OF THE PROGRAM ARE SUMMARIZED IN FIGURE 2 FOR THE 50-YEAR STORM, AND IN FIGURE 3 FOR 100-YEAR STORM.

3. ESTIMATED FLOWS AT THE DURANGO CURVE

FLOWS IN CAVE CREEK WASH AT THE DURANGO CURVE OF I-17 WERE ESTIMATED BY UTILIZING THE CAVE CREEK HYDROLOGY DEVELOPED BY THE CORPS OF ENGINEERS IN CONJUNCTION WITH THE ARIZONA CANAL DIVERSION CHANNEL, AND THE RESULTS OF THE HYDROLOGY FOR THE I-10 INNER LOOP AS DESCRIBED ABOVE.

USING THIS DATA, THE 50-YEAR FLOW IN CAVE CREEK AT THE DURANGO CURVE WAS ESTIMATED TO BE 5771 CUBIC FEET PER SECOND (CFS).

C. HYDRAULIC DESIGN CONCEPTS

USING THE HYDROLOGY AS DESCRIBED ABOVE, CONCEPTS FOR COLLECTING THESE FLOWS ALONG THE I-10 INNER LOOP AND FOR DISCHARGING INTO THE SALT RIVER WERE EVALUATED FOR FEASIBILITY.

1. PRELIMINARY CONCEPTS

TWO CONCEPTS WERE IDENTIFIED IN THE SCOPE OF WORK:

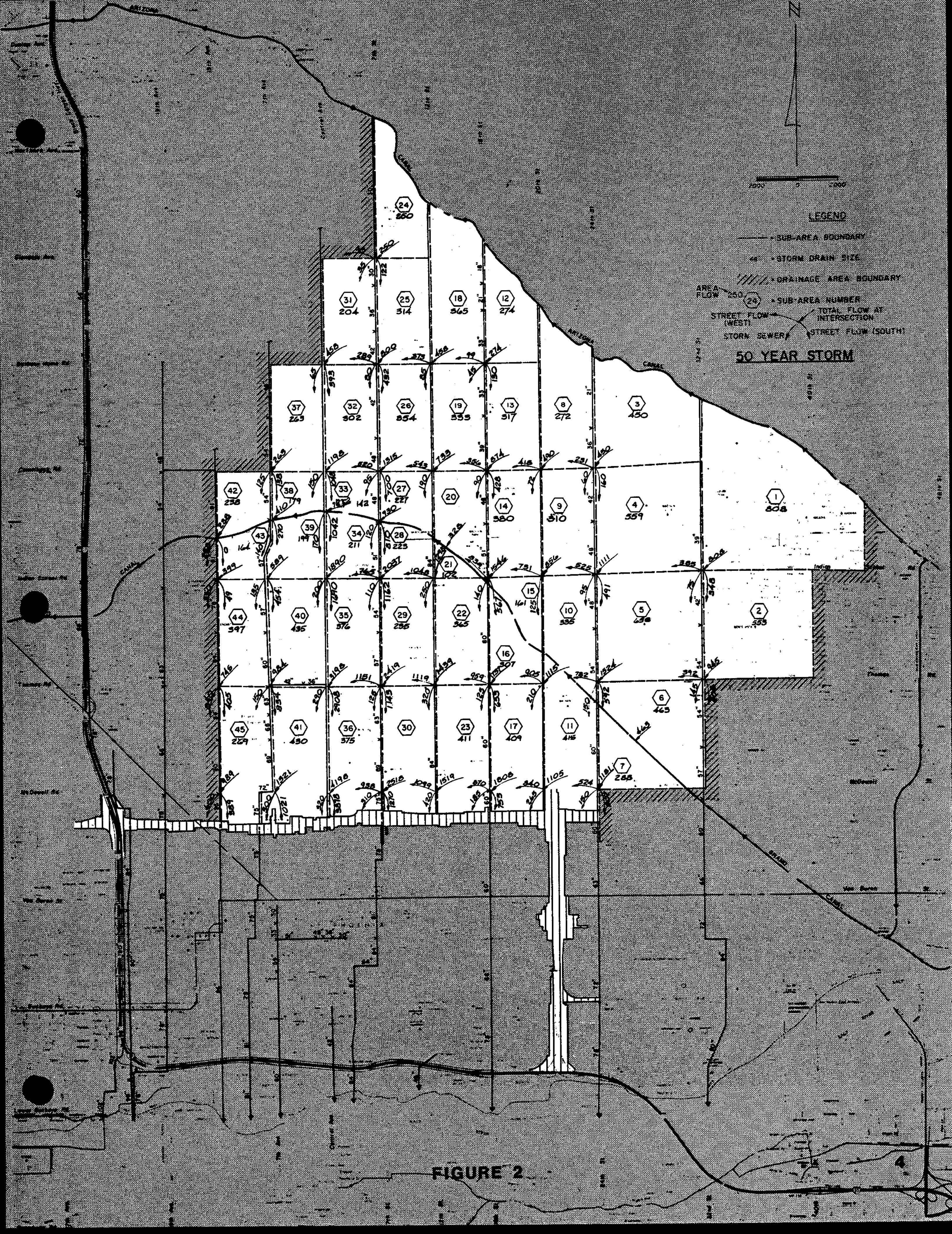
LEGEND
SUB-AREA BOUNDARY
STORM DRAIN SIZE
DRAINAGE AREA BOUNDARY
AREA
FLOW
SUB-AREA NUMBER
STREET FLOW (WEST)
TOTAL FLOW AT INTERSECTION
STORM SEWER
STREET FLOW (SOUTH)
50 YEAR STORM

FIGURE 2

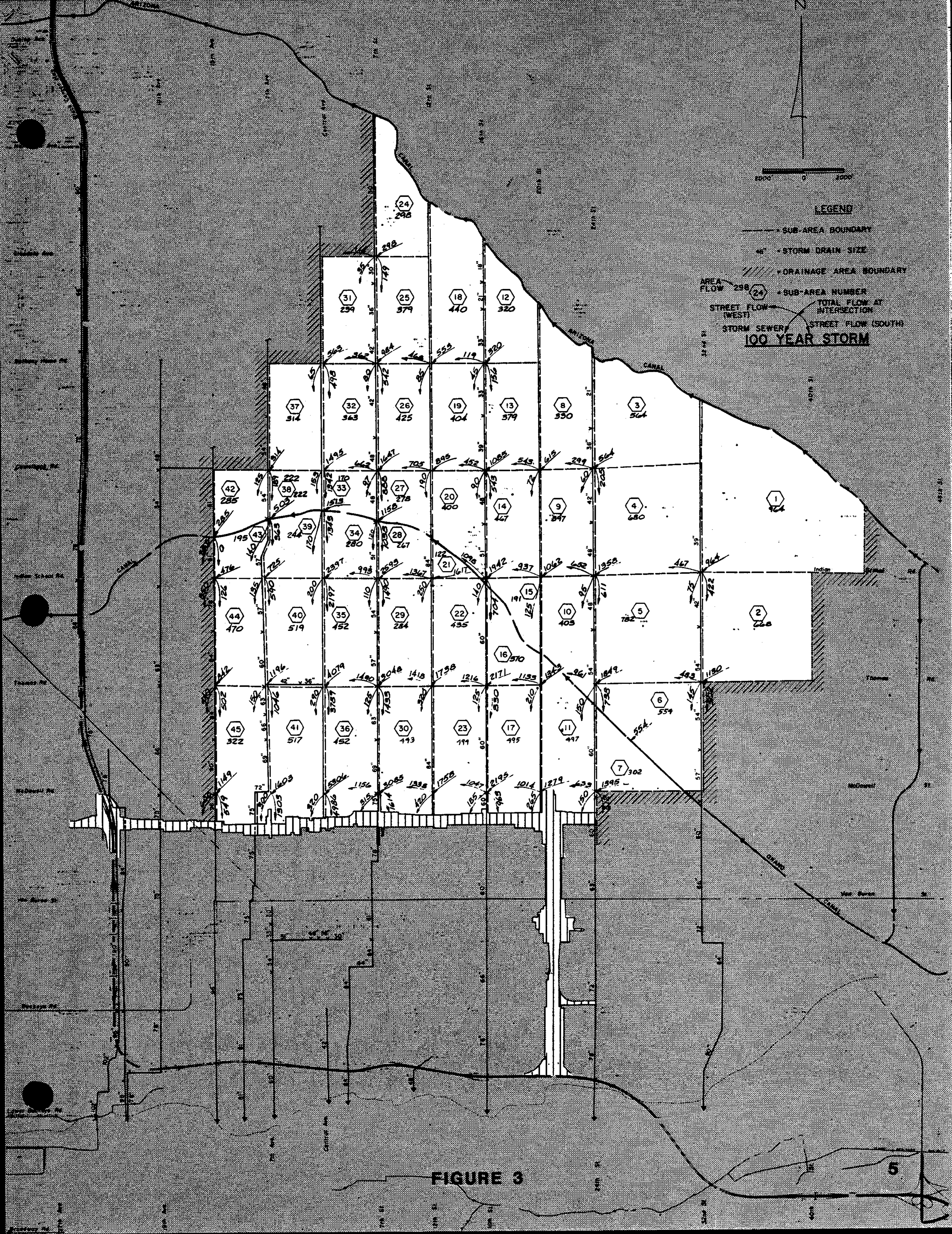
LEGEND
SUB-AREA BOUNDARY
48" = STORM DRAIN SIZE
= DRAINAGE AREA BOUNDARY
AREA FLOW 298 24 = SUB-AREA NUMBER
STREET FLOW (WEST)
TOTAL FLOW AT INTERSECTION
STORM SEWER
STREET FLOW (SOUTH)
100 YEAR STORM
ARIZONA CANAL
2000 0 2000

FIGURE 3

PRELIMINARY CONCEPT I: COLLECT ALL STORMWATER ALONG THE I-10 INNER LOOP, EAST OF APPROXIMATELY 15TH AVENUE, FOR DISCHARGE TO THE SALT RIVER, INCLUDING PORTIONS OF CAVE CREEK FLOWS AT BOTH THE I-10 ALIGNMENT AND AT THE DURANGO CURVE.

PRELIMINARY CONCEPT II: COLLECT ALL STORMWATER ALONG THE I-10 INNER LOOP, INCLUDING ALL OF THE CAVE CREEK FLOW, FOR DISCHARGE TO THE SALT RIVER.

BASED ON EVALUATION OF CONSTRUCTION COSTS AND RIGHT-OF-WAY REQUIRED, PRELIMINARY CONCEPT II WAS ELIMINATED FROM FURTHER CONSIDERATION.

THE FOLLOWING ADDITIONAL CONCEPTS WERE ALSO EVALUATED FOR FEASIBILITY IN CONDUCTING INNER LOOP STORM WATER FLOWS TO THE RIVER:

- USE OF EXISTING AND FUTURE STORM DRAINS
- USE OF BRIDGES AS HYDRAULIC STRUCTURES
- PEAK DISCHARGE REDUCTION BY STORMWATER RETENTION
- INTERCEPT FLOWS ABOVE INNER LOOP ALIGNMENT
- OUTFALL TUNNELS TO THE RIVER
- OPEN CHANNELS
- JOINT-USE FACILITIES

AFTER DISCUSSION OF EACH OF THE ABOVE, IT WAS CONCLUDED THAT ONLY THE ADDITIONAL CONCEPTS INVOLVING THE USE OF EXISTING STORM DRAINS, OUTFALL TUNNELS, AND JOINT-USE FACILITIES SHOULD BE CONSIDERED ANY FURTHER.

2. ALTERNATE CONCEPT FORMULATION

USING THE GENERAL CONCEPTS NOTED ABOVE, FOUR ALTERNATIVES WERE FORMULATED FOR ADDITIONAL EVALUATION. EACH OF THE ALTERNATIVES UTILIZE BOX CULVERTS AND/OR CONCRETE PIPE TO COLLECT THE 50-YEAR STORM RUNOFF ALONG THE INNER LOOP, AND THE OUTFALLS IN EACH ALTERNATIVE ARE CAPABLE OF DISCHARGING THIS 50-YEAR FLOW INTO THE SALT RIVER, WITH THE RIVER FLOWING AT ITS 10-YEAR LEVEL.

ALTERNATIVE I UTILIZES BOX CULVERT OUTFALLS INSTALLED UNDER THE FOLLOWING STREETS:

- I-17 NORTHBOUND FRONTAGE ROAD
- 1ST AVENUE
- 11TH STREET

FIGURE 4 SHOWS A GENERAL LAYOUT OF ALTERNATIVE I.

ALTERNATIVE II ALSO UTILIZES BOX CULVERT OUTFALLS, AT THE FOLLOWING LOCATIONS:

- I-17 NORTHBOUND FRONTAGE ROAD
- 1ST AVENUE
- 11TH STREET
- 20TH STREET (NORTH-SOUTH LEG OF I-10)

FIGURE 5 SHOWS THE GENERAL LAYOUT OF ALTERNATIVE II, WHICH IS SIMILAR TO ALTERNATIVE I EXCEPT THAT FLOWS ALONG THE I-10 ALIGNMENT EAST OF 16TH STREET ARE TAKEN TO THE SALT RIVER BY AN OUTFALL LOCATED ALONG THE NORTH-SOUTH LEG OF I-10.

ALTERNATIVE III UTILIZES A 30-FOOT DIAMETER TUNNEL UNDER 15TH AVENUE TO CONDUCT ALL FLOWS TO THE SALT RIVER FROM THE I-10 ALIGNMENT. FIGURE 6 SHOWS THE LAYOUT OF ALTERNATIVE III.

ALTERNATIVE IV UTILIZES TWO 20-FOOT DIAMETER TUNNELS, ONE UNDER 15TH AVENUE AND THE OTHER UNDER CENTRAL AVENUE, FOR DISCHARGES TO THE RIVER. FIGURE 7 SHOWS THE LAYOUT OF ALTERNATIVE IV.

3. EVALUATION OF ALTERNATIVES

THE FOUR ALTERNATIVES DESCRIBED ABOVE WERE THEN EVALUATED ON THE BASIS OF THE FOLLOWING PARAMETERS:

- CONSTRUCTION COSTS
- OPERATION AND MAINTENANCE COSTS
- RIGHT-OF-WAY REQUIREMENTS
- TIME OF COMPLETION/TRAFFIC CONTROL
- DISPOSAL OF EXCESS MATERIALS
- ENVIRONMENTAL EFFECTS
- POSSIBLE JOINT USE OF FACILITIES

EACH ALTERNATIVE WAS THEN EVALUATED AND RANKED FOR EACH OF THE PARAMETERS LISTED ABOVE, AND A COMPOSITE RANKING MADE, AS SHOWN BELOW. A RANKING OF 1 INDICATES THE MOST FAVORABLE.

SUMMARY OF RANKINGS

	ALTERNATIVES			
ELEMENTS	I	II	III	IV
INSTALLED COSTS	3	4	1	2
OPERATION AND MAINTENANCE COSTS	1	1	3	2
RIGHT-OF-WAY REQUIREMENTS	3	4	1	2
TIME OF COMPLETION/TRAFFIC CONTROL	3	4	1	2
DISPOSAL OF MATERIALS	3	4	1	2
UTILITY CONFLICTS	3	4	2	1
ENVIRONMENTAL EFFECTS	3	4	1	2
JOINT-USE POTENTIAL	2	1	4	3

GENERAL GEOLOGY

A. GENERAL

THE CITY OF PHOENIX IS LOCATED IN THE SALT RIVER VALLEY WHICH IS IN THE INTERMONTANE PHOENIX BASIN OF THE LOWLAND OR SONORAN DESERT SECTION OF THE BASIN AND RANGE PHYSIOGRAPHIC PROVINCE. THE BASIN AND RANGE PROVINCE IS SEPARATED FROM THE COLORADO PLATEAU PROVINCE BY THE MOGOLLON RIM LOCATED IN CENTRAL ARIZONA. THIS ESCARPMENT MARKS THE SOURCE OF THE SALT RIVER AND THE SOUTHERN MARGIN OF THE GENTLY TILTED SEDIMENTARY ROCKS OF THE COLORADO PLATEAU.

THE SALT RIVER VALLEY IS AN ALLUVIAL PLAIN LOCATED SOUTHWEST OF THE COLORADO PLATEAU. THE RIVER EMERGES FROM A NARROW CANYON EAST OF PHOENIX INTO THE BROAD VALLEY CONTAINING COARSE GRANULAR DEPOSITS AND FINER ALLUVIAL FAN DEPOSITS. THE AGUA FRIA, GILA, AND THE NEW RIVERS AND THE CAVE, SKUNK, AND QUEEN CREEKS HAVE CREATED SIMILAR, BUT LESS EXTENSIVE DEPOSITS.

IN THE VALLEY NEAR PHOENIX, ISOLATED MOUNTAIN PEAKS PARTIALLY BURIED BY VALLEY FILL PROTRUDE ABOVE THE PLAIN, RESULTING IN AN ABRUPT TRANSITION FROM PLAIN TO MOUNTAIN. THE TOPOGRAPHY OF THE VALLEY IS GENERALLY FLAT TO GENTLY SLOPING. THE VALLEY FLOOR, SLOPING TO THE SOUTHWEST AT ABOUT 30-FT. PER MILE, IS PUNCTUATED WITH ISOLATED MOUNTAIN TIPS, WHICH REACH HEIGHTS OF 1,200 TO 3,000 FT. ABOVE THE PLAIN.

B. GEOLOGIC HISTORY

THE PRE-CAMBRIAN FORMATIONS REMAINING IN EVIDENCE IN THE PHOENIX AREA CONSIST OF REMNANTS OF GNEISSES, GRANITE, AND QUARTZITE.

THROUGH MUCH OF GEOLOGIC TIME (AT LEAST SINCE THE CAMBRIAN PERIOD) THERE HAS BEEN A STRUCTURAL TROUGH IN THE SOUTHWEST CORNER OF ARIZONA. SEDIMENTATION WAS OCCURRING IN THE VALLEY DURING THE PALEOZOIC TIME, AND THE SEDIMENTARY ROCKS WERE DISPLACED DURING THE LATE TRIASSIC PERIOD AND TILTED BY NORMAL FAULTING. THE RESULTS WERE THE UP-FAULTED MOUNTAINS AND DOWN-FAULTED BASINS WHICH FORM THE BASINS AND RANGES OF THIS PHYSIOGRAPHIC PROVINCE. THE FAULT AXES GENERALLY TREND NORTHWEST-SOUTHEAST AND THE MOUNTAIN BLOCKS, BASINS, AND DRAINAGE REFLECT THIS ORIENTATION. THE PHOENIX AREA DRAINAGE HAS BEEN TO THE SOUTHWEST SINCE LATE TRIASSIC TIMES, WHEN CENTRAL ARIZONA WAS UPLIFTED.

THE TRIASSIC OROGENY WAS FOLLOWED BY A PERIOD OF EROSION AND SEDIMENTATION WHICH FILLED THE INTERMONTANE BASINS WITH SEVERAL THOUSAND FEET OF SEDIMENTS. THE COLORADO PLATEAU NORTH OF THE MOGOLLON RIM WAS ELEVATED NEAR THE END OF THE CRETACEOUS PERIOD, AFTER WHICH LATE PLIOCENE VOLCANISM DEPOSITED SEVERAL THOUSAND FEET OF VOLCANIC ROCK THAT CAPPED THE MOUNTAINS AND INTRUDED THE SEDIMENTS.

COARSE GRANULAR AND ALLUVIAL FAN MATERIALS WERE DEPOSITED DURING THE TERTIARY AND QUATERNARY PERIODS. THIS WAS CAUSED BY UPLIFT OF THE HIGH PLATEAU COUNTRY NORTH OF THE MOGOLLON RIM WHICH BEGAN IN THE CRETACEOUS PERIOD AND INVOLVED A CORRESPONDING SUBSIDENCE OF THE AREA TO THE SOUTH AND WEST. THESE OROGENIC MOVEMENTS RESULTED IN DEEP EROSION OF THE HIGHLAND COUNTRY AND RAPID FILLING OF THE VALLEY AREAS.

A MORE RECENT EROSIONAL PHASE OF THE SALT RIVER, ASSOCIATED WITH A PERIOD OF DRIER CLIMATE IS EVIDENCED IN THE MESA AREA BY TERRACES OF COARSE GRANULAR MATERIAL LOCATED ABOUT 50 FT. ABOVE THE PRESENT CHANNEL. THESE TERRACE LEVELS ARE OBSCURED IN THE PHOENIX AREA BY ALLUVIAL FAN DEPOSITS.

C. STRATIGRAPHY AND LITHOLOGY OF THE PHOENIX BASIN DEPOSITS

THE STRATIGRAPHY OF THE PHOENIX BASIN IS CHARACTERISTIC OF AN INTERMONTANE BASIN. STREAMS FLOWING FROM THE NORTH AND EAST DEPOSIT COARSE GRAINED SEDIMENTS IN STREAM CHANNELS THAT CROSS THE SUBSIDING BASIN. ALONG THE MARGINS OF THE MOUNTAINS, THE STEAM-TRANSPORTED COARSE-GRAINED MATERIAL SPREAD TOWARD THE BASIN AS ALLUVIAL FANS.

IN AREAS OUTSIDE THE NORMAL STREAM CHANNELS, WHERE OVERFLOW CIRCULATION WAS RESTRICTED, THE FINE-GRAIN SEDIMENTS WERE DEPOSITED BY SHEET FLOODS AND INTERMITTENT FLOWS FROM SMALL DRAINAGES. THE FINE SEDIMENTS CONSIST OF SILTY SANDS, SILTY AND SANDY CLAYS WITH LESSER AMOUNTS OF HIGHLY PLASTIC CLAYS, AND OCCASIONALLY CLEAN SANDS. LOCALLY, EVAPORITES OCCUR IN THE UPPER PORTIONS OF THE VALLEY FILL AND CONSIST MAINLY OF GYPSUM WHILE HALITE IS TYPICAL IN THE LOWER DEPTHS.

THE SOURCE ROCKS COMPRISING THE VALLEY FILL IN THE PHOENIX BASIN ARE OF VARIED LITHOLOGY.

MAJOR CONTRIBUTING AREAS AND THEIR PRINCIPAL ROCK TYPES ARE AS FOLLOWS. THE PHOENIX MOUNTAINS, EIGHT MILES NORTH OF THE CITY, CONSIST OF QUARTZITES. CAMELBACK MOUNTAIN, LOCATED NEAR THE NORTHEAST CORNER OF PHOENIX, CONSISTS OF SANDSTONE BRECCIA AND A COARSE CONGLOMERATE OVERLYING A GRANITE AND GNEISS SURFACE. SOUTHEAST OF PHOENIX, NEAR TEMPE, A COARSE GRAINED GRANITE INTERSPERSED WITH BASALT DIKES CAN BE FOUND AS WELL AS A SEDIMENTARY SERIES CONSISTING OF SANDSTONE, BRECCIA, AND CONGLOMERATE CAPPED BY SHALE AND ANDESITE. THE SALT RIVER MOUNTAINS, SOUTH OF THE AREA, CONSIST OF A FINE-GRAINED BIOTITE GRANITE. THE MCDOWELL, GOLDFIELD, AND SUPERSTITION MOUNTAINS (ALL ABOUT 30 MILES EAST TO NORTHEAST OF PHOENIX, AND DRAINED BY THE SALT RIVER) ARE COMPOSED CHIEFLY OF RHYOLITE AND QUARTZ LATITE. THE MAJORITY OF THESE ROCKS ARE DURABLE, WITH HIGH CRUSHING STRENGTH, SWELLING CLAYS. SOME OF THE IGNEOUS ROCKS, HOWEVER, WEATHER INTO UNSTABLE, SWELLING CLAYS. THE RELATIVE OCCURRENCE OF THE VARIOUS ROCK TYPES IN THE ALLUVIUM IS DESCRIBED IN CHAPTER IV.

THE COARSE SAND AND GRAVEL DEPOSITS ARE KNOWN TO BE SEVERAL HUNDRED FEET THICK AT MANY LOCATIONS IN THE PHOENIX AREA. A DEEP WELL IN THE AREA, FOR EXAMPLE, WAS DRILLED TO A DEPTH OF 2,784 FT. WITHOUT REACHING BEDROCK. WELL LOGS IN THE AREA INDICATE THAT THE COARSE SAND AND GRAVEL AVERAGES FROM 100 TO 300 FT. THICK AND OVERLIES ABOUT 600 FT. OF CLAY AND SILT WHICH MAY BE OF LACUSTRINE ORIGIN.

D. DRAINAGE, GROUNDWATER, AND AREAL SUBSIDENCE

THE SALT RIVER DRAINAGE AREA IS ABOUT 13,700 SQ. MI. THE SOURCE OF THE SALT RIVER IS NEAR THE MOGOLLON RIM AND IT FLOWS ABOUT 1.5 MILES SOUTH OF THE PROJECT LOCATION IN A WEST-SOUTH-WESTERLY DIRECTION TOWARD ITS CONFLUENCE WITH THE GILA RIVER. THE REGION RECEIVES ITS 1- TO 10-INCH ANNUAL RAINFALL IN HEAVY CONCENTRATION, WITH FLASH FLOODING BEING COMMON. THE ARID CLIMATE OF THE PHOENIX IS TYPIFIED BY LONG HOT SUMMERS AND SHORT MILD WINTERS. BECAUSE EVAPORATION EXCEEDS 60 INCHES, WATER BECOMES A PRIME COMMODITY.

THE VALLEY FILL IS A LARGE STORAGE RESERVOIR AND AN IMPORTANT SOURCE OF WATER NECESSARY TO THE REGIONAL ECONOMY. IN THE AGRICULTURAL AREAS DEEP WELLS HAVE PENETRATED THE SEDIMENTS AND HAVE CAUSED THE WATER TABLE TO DECLINE 150 FT. BETWEEN 1941 AND 1961. THE U. S. GEOLOGICAL SURVEY STATES THAT THE WATER TABLE IN THE DOWNTOWN AREA HAS NOT DROPPED IN THE LAST TEN YEARS. THE WATER LEVELS MAY VARY LOCALLY, HOWEVER, WITH WATER "PERCHED" ON IMPERMEABLE LAYERS. THIS WATER MAY ORIGINATE FROM RAINFALL, IRRIGATION LOSSES, RIVER SEEPAGE, OR RESIDUAL WATER THAT IS TEMPORARILY TRAPPED AS THE WATER TABLE DECLINES. NO GROUNDWATER WAS ENCOUNTERED DURING THE SUBSURFACE INVESTIGATION FOR THIS PROJECT.

CONSOLIDATION OF THE LOOSE SEDIMENTS, AS WELL AS THE SEMI-CONSOLIDATED ROCKS, MAY OCCUR BECUASE OF THE INCREASED EFFECTIVE STRESSES WHEN THE GROUNDWATER IS LOWERED. THE RESULTING SUBSIDENCE IS ACCOMPANIED BY VERTICAL, AND SOMETIMES HORIZONTAL, SOIL DISPLACEMENT WHICH IS ASSOCIATED WITH CRACKS APPEARING ON THE EARTH SURFACE.

THE FOLLOWING LOCATIONS IN THE PHOENIX REGION HAVE EARTH CRACKS. IN THE BLACK CANYON AREA ABOUT 45 MILES NORTH OF PHOENIX THERE IS A FISSURE OCCURRING IN BASALT AND SEMI-CONSOLIDATED SEDIMENTARY ROCKS. A 10- TO 15-FT. VERTICAL DISPLACEMENT IS ASSOCIATED WITH A NORMAL FAULT. THERE IS NO SIGNIFICANT HORIZONTAL MOVEMENT.[1] IN THE CHANDLER HEIGHTS AREA ABOUT 30 MILES SOUTHEAST OF PHOENIX, FISSURES PARALLEL THE EXPOSED SEGMENT OF THE SANTAN MOUNTAINS. THE EARTH MATERIAL HAS ALSO PULLED APART BUT THERE IS NO DIFFERENTIAL HORIZONTAL OR VERTICAL MOVEMENT.(2) AT LUKE AFB, ABOUT 15 MILES NORTHWEST OF PHOENIX AN EARTH FISSURE ABOUT ONE MILE IN LENGTH HAS BEEN CAUSED BY GROUND WATER WITHDRAWAL.(3,4) IN PINAL COUNTY, ALONG THE WEST SIDE OF THE PICACHO MOUNTAINS EAST OF ELOY, INTERSTATE 10 AND A PARALLELING RAILROAD TRACK REQUIRE PERIODIC MAINTENANCE WHERE THEY CROSS A FRACTURE.

MEASUREMENTS INDICATE AS MUCH AS 7 FT. OF SUBSIDENCE AT THIS LOCATION.(5,6) FACTORS OTHER THAN GROUND WATER WITHDRAWAL, SUCH AS DEEP-SEATED STRUCTURAL MOVEMENTS, MAY HAVE BEEN AFFECTING THE EARTH MOVEMENTS IN SOME OF THE CITED CASES.

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(1) ROBINSON, G. M. AND D. E. PETERSON: "NOTES ON EARTH FISSURES IN SOUTHERN ARIZONA," USGS CIRCULAR 446, 1962.

(2) IBID.

(3) IBID.

(4) STULIK, R. S. AND F. R. TWENTER: "GEOLOGY AND GROUNDWATER OF THE LUKE AREA, MARICOPA COUNTY, ARIZONA," USGS WATER SUPPLY PAPER 1779-P, 1964.

(5) ROBINSON, G. M. AND D. E. PETERSON: "NOTES ON EARTH FISSURES IN SOUTHERN ARIZONA," USGS CIRCULAR 446, 1962.

(6) FIELDNOTES, ARIZONA BUREAU OF MINES, VOL. 2, NO. 3, SEPT. 1972.

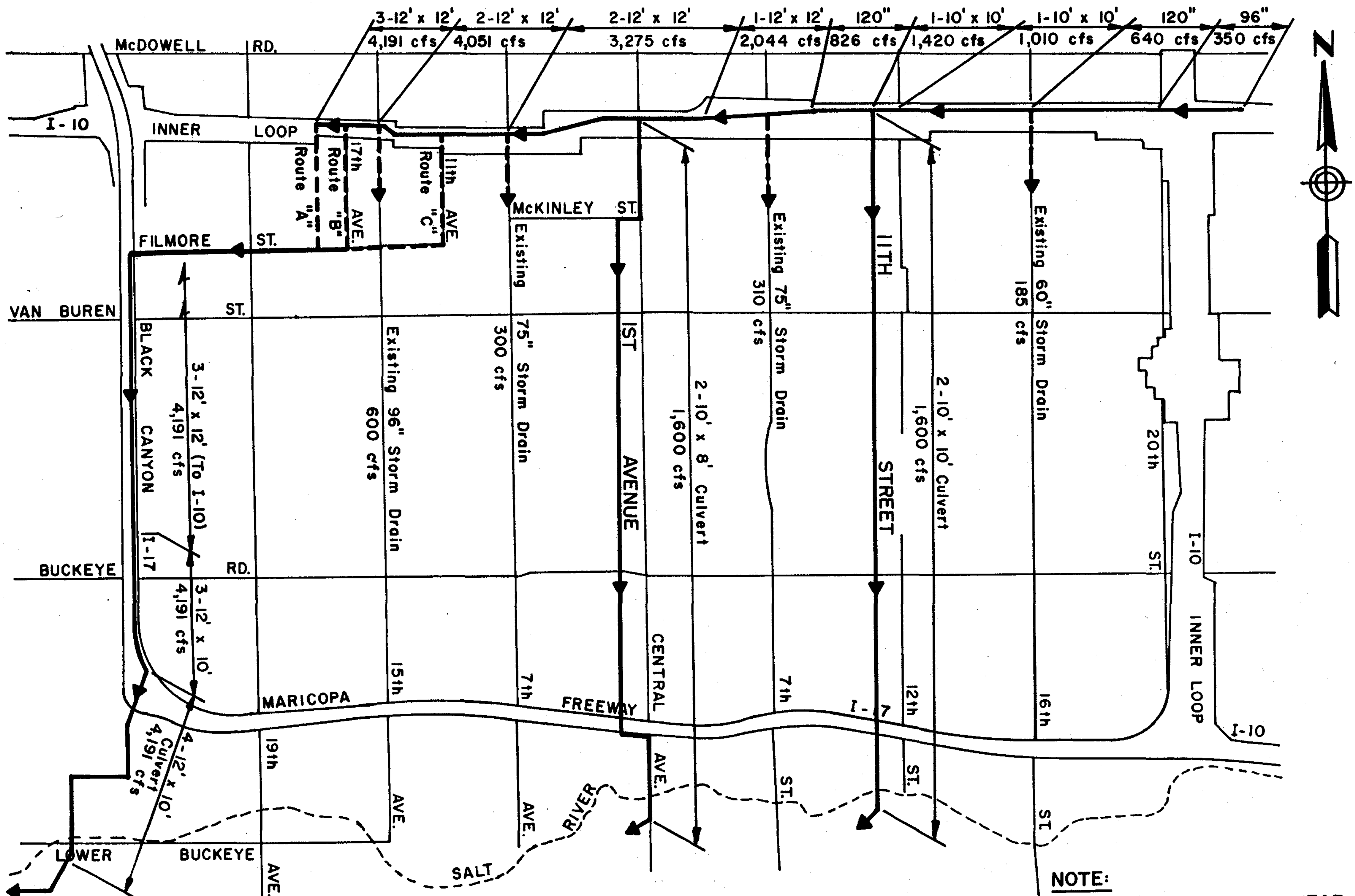

FIGURE 4

NOTE:
DESIGN BASIS IS FOR 50-YEAR FREQUENCY STORM.

ALTERNATE CONCEPT I
GENERAL PLAN AND FLOW SCHEMATIC

Sept., 1982

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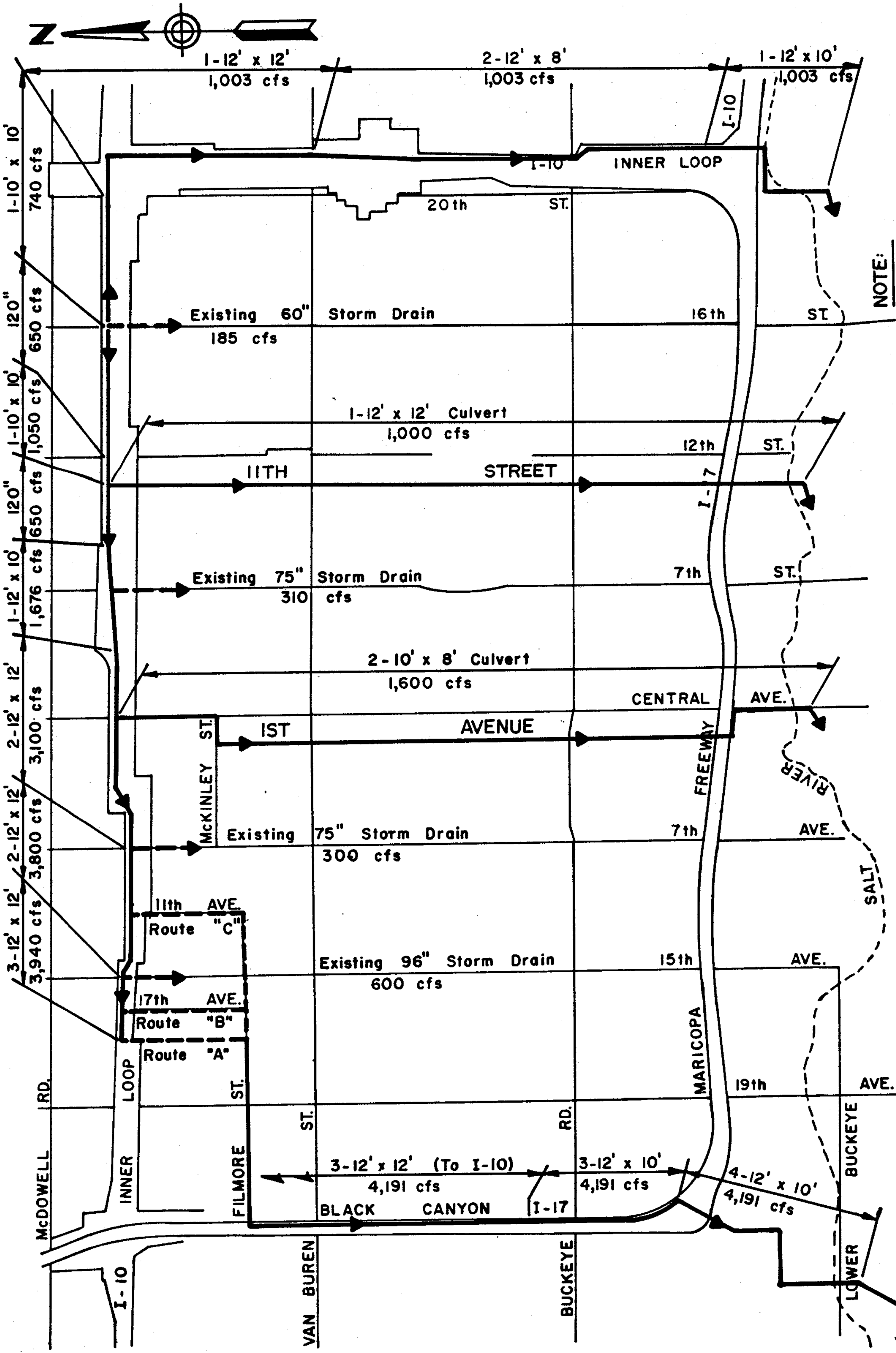

NOTE:
DESIGN BASIS IS FOR 50-YEAR FREQUENCY STORM.

ALTERNATE CONCEPT II
GENERAL PLAN AND FLOW SCHEMATIC

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FIGURE 5

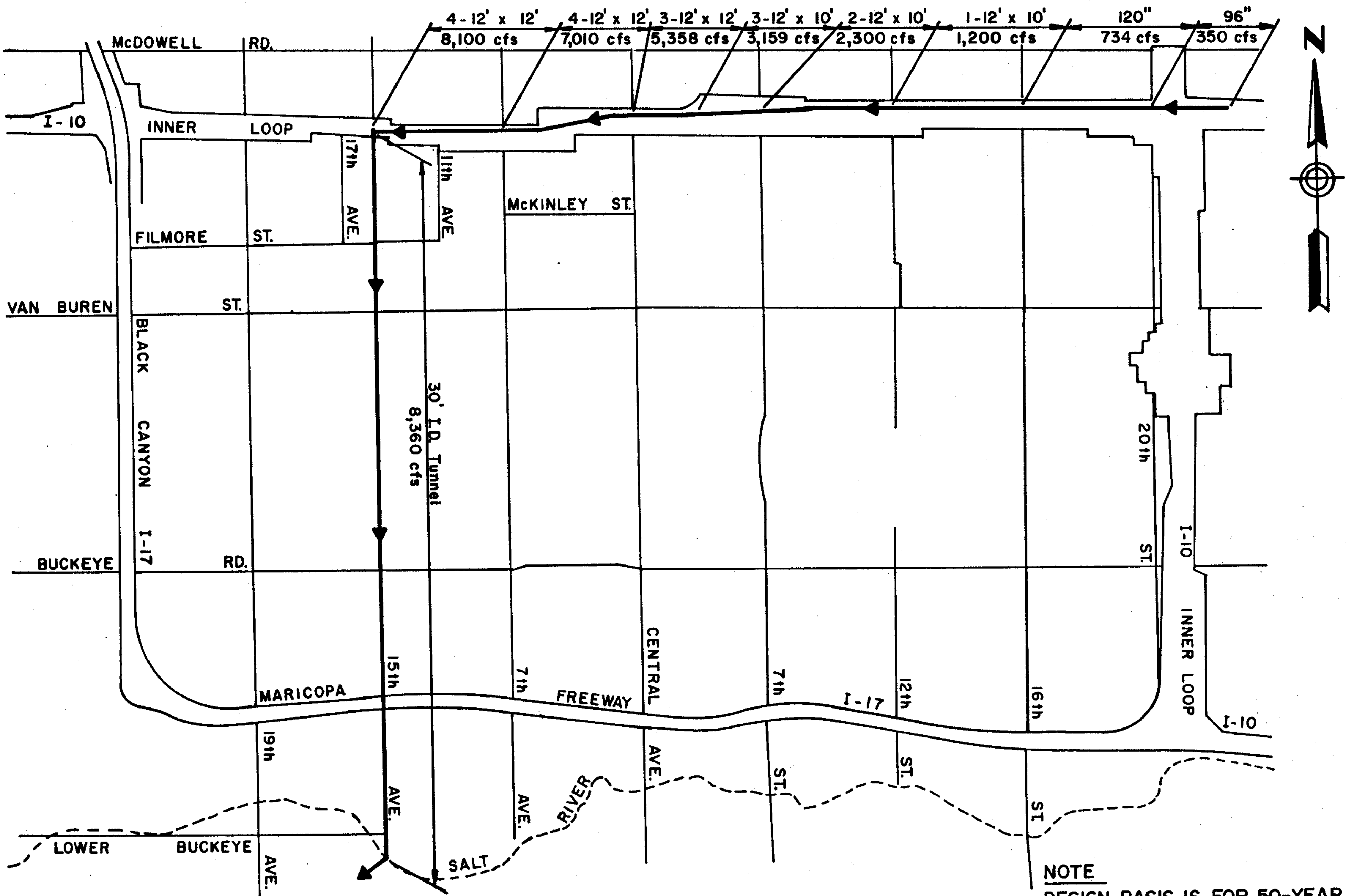

FIGURE 6

NOTE
DESIGN BASIS IS FOR 50-YEAR FREQUENCY STORM.

ALTERNATE CONCEPT III
GENERAL PLAN AND FLOW SCHEMATIC

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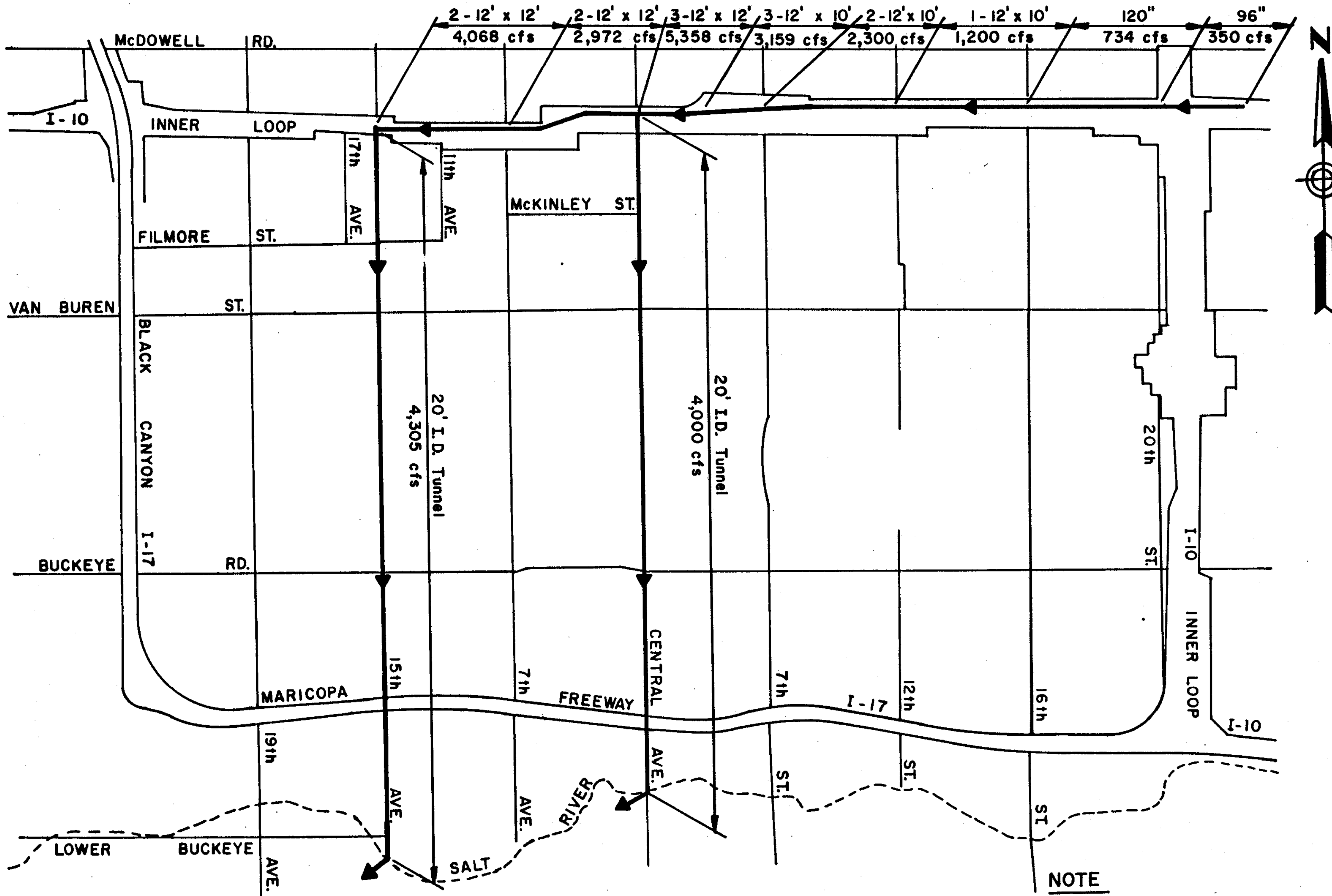
FIGURE 7



NOTE

DESIGN BASIS IS FOR 50-YEAR FREQUENCY STORM.

ALTERNATE CONCEPT IV
GENERAL PLAN AND FLOW SCHEMATIC

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Sept., 1982

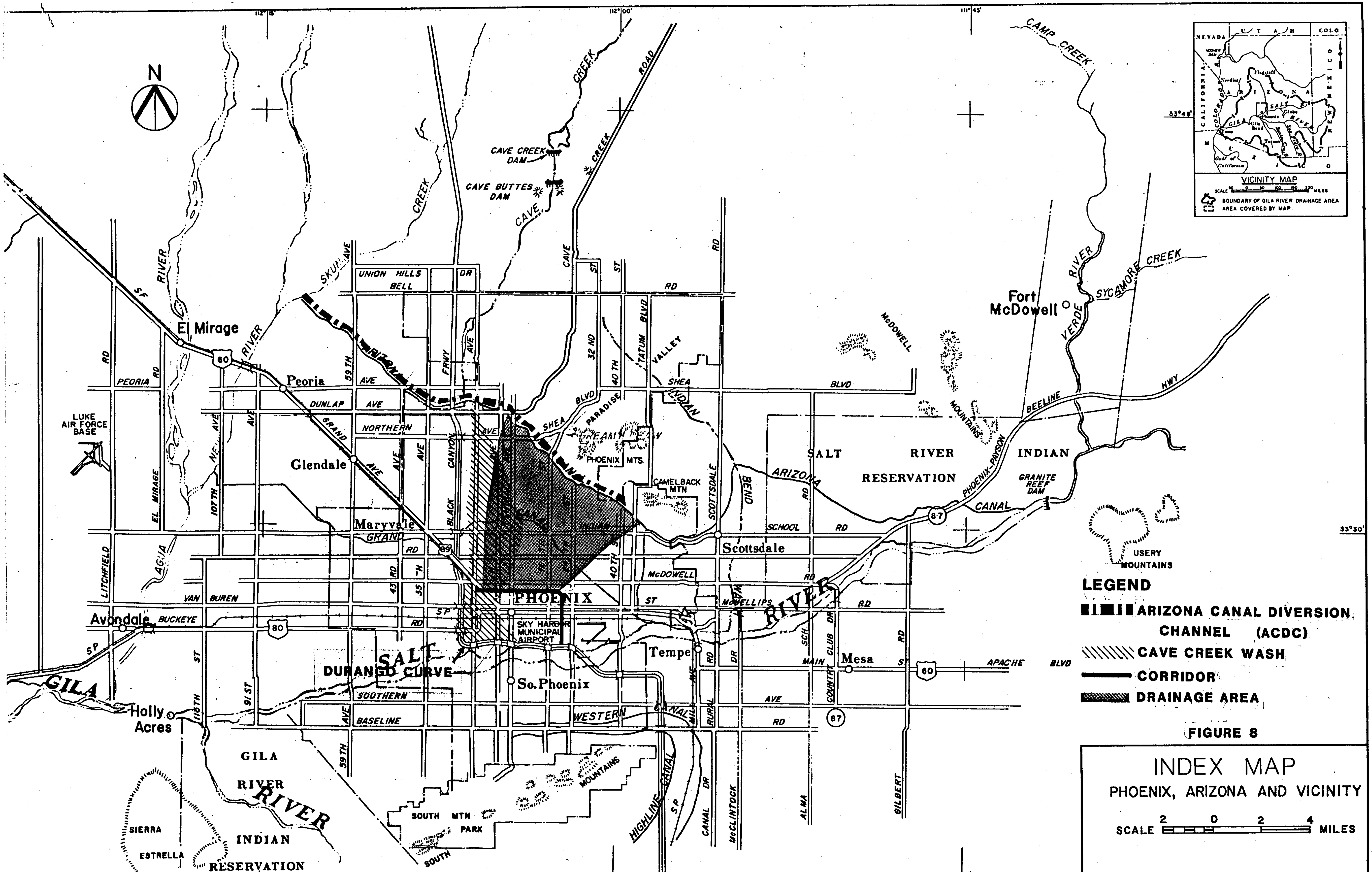


FIGURE 8

INDEX MAP
PHOENIX, ARIZONA AND VICINITY

FIGURE 1
PROPOSED I-10 LOCATION AND RIGHT-OF-WAY, EAST-WEST SEGMENT

APPENDIX B

PHOENIX, ARIZONA

I-10 INNER LOOP

STORM DRAINAGE

SENSITIVITY ANALYSIS FOR HYDROLOGY STUDY

BACKGROUND INFORMATION

OCTOBER 5, 1982

SENSITIVITY ANALYSIS FOR HYDROLOGY STUDY

GENERAL

THE PURPOSE OF THIS ANALYSIS IS TO DETERMINE THE SENSITIVITY OF THE TR-20 HYDROLOGY MODEL TO VARIATIONS IN CERTAIN PARAMETERS. VARIABLES ADJUSTED INCREMENTALLY WERE: CURVE NUMBER, TIME OF CONCENTRATION, RUNOFF COEFFICIENT, AND VELOCITY (FOR RATING CURVES USED IN ROUTINGS AND DIVERSION). THE RAINFALL DISTRIBUTION USED WAS COMPARED TO THE STANDARD TR-20 DISTRIBUTION AND THE TYPE II DISTRIBUTION. ALSO, BASED ON FLOODING LIMITS INDICATED ON THE PHOENIX FIS, STORAGE NORTH OF THE GRAND CANAL WAS INCLUDED IN ONE ANALYSIS.

PROCEDURE

THE HYDROLOGY MODEL FOR 7TH STREET TO 16TH STREET WAS INPUT AND RUN ON THE HNTB VAX COMPUTER SYSTEM. THIS WAS DONE TO DETERMINE ANY DIFFERENCES IN RESULTS DUE TO DIFFERENT COMPUTER SYSTEMS OR VERSIONS OF THE TR-20 PROGRAM. THIS COMPARISON INDICATED AGREEMENT WITHIN ONE PERCENT.

WHILE THE PEAK DISCHARGES ARE NOT IDENTICAL THEY ARE VERY SIMILAR UP TO A DIVERT ROUTINE AT CROSS-SECTION 34. THE RATING CURVE TO BE USED IN THE DIVERSION WAS NOT CONTAINED IN THE HYDROLOGY MODEL AND THE HNTB PROGRAM DEFAULTED. THE FILE WAS ADJUSTED TO ELIMINATE INFLOW FROM ADJACENT SUBWATERSHEDS AND ALL MODIFICATIONS WERE PERFORMED ON THIS FILE. ALL RESULTS ARE COMPARED TO THE DISCHARGES PRODUCED BY THIS FILE.

SCS CURVE NUMBER

A MULTIPLIER WAS APPLIED TO EACH CN VALUE IN THE FILE. THE FILE WAS THEN RUN AND RESULTS PRINTED. MULTIPLIERS USED RANGED FROM 0.85 TO 1.15 BY INCREMENTS OF 0.05.

FIGURE 1 IS A PLOT OF THE RESULTS OF THIS ANALYSIS.

TIME OF CONCENTRATION

MULTIPLIERS USED IN THIS ANALYSIS RANGED FROM 0.7 TO 1.3 BY INCREMENTS OF 0.1. FIGURE 2 GRAPHICALLY PRESENTS THE RESULTS OF THIS ANALYSIS.

ROUTING COEFFICIENTS

ROUTING COEFFICIENTS WERE VARIED BY A RANGE OF MULTIPLIERS FROM 0.5 TO 1.5 BY INCREMENTS OF 0.2. FIGURE 3 IS A PLOT OF THESE RESULTS.

RATING CURVE VELOCITY

THE VELOCITY DATA USED IN DEVELOPING THE CROSS-SECTION

RATING CURVES WERE VARIED BY MULTIPLIERS OF 0.3 TO 1.5 (0.2 INCREMENTS). FIGURE 4 IS A PLOT OF THE RESULTS.

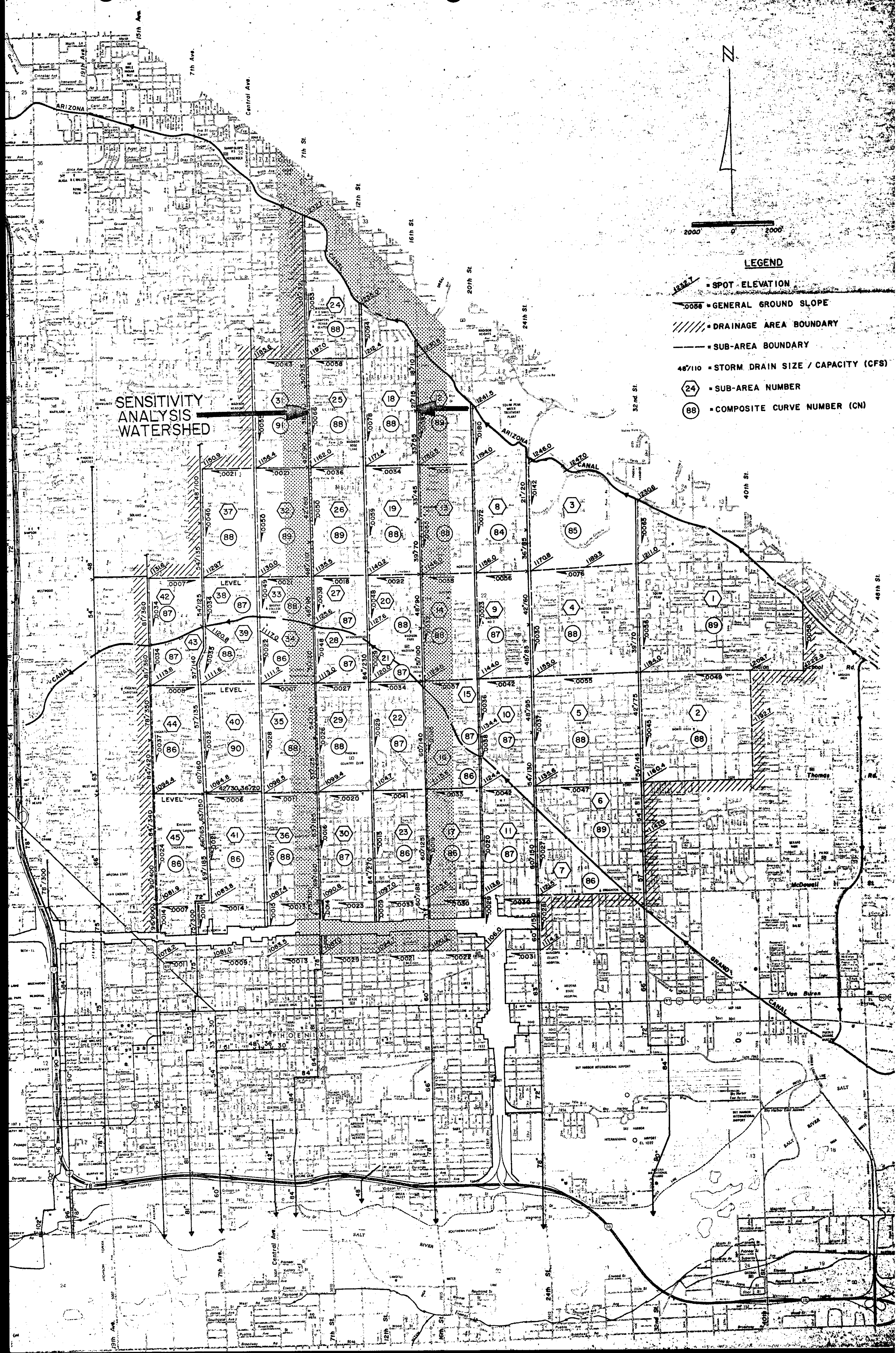
RAINFALL DISTRIBUTION

DUE TO THE SEVERITY OF THE RAINFALL DISTRIBUTION USED IN THE HYDROLOGY MODEL, TWO MORE CONVENTIONAL DISTRIBUTIONS WERE APPLIED TO THE MODEL. THE FIRST WAS THE TR-20 DISTRIBUTION AS PUBLISHED IN THE USERS MANUAL. THE SECOND WAS THE SCS TYPE II DISTRIBUTION. THESE RESULTS ARE SHOWN IN FIGURE 5.

STORAGE

THE PHOENIX FIS INDICATES THAT THE SOUTH LEVEE OF THE GRAND CANAL IS EFFECTIVE IN CONTAINING THE 100-YEAR DISCHARGE FOR THE DRAINAGE FEATURE. BECAUSE THIS IS AN APPROXIMATE STUDY (ZONE A) THERE COULD BE SOME QUESTION AS TO THE CONTINUITY OF THE LEVEE, BUT AVAILABLE DATA INDICATES THAT SOME STORAGE CAPACITY DOES EXIST NORTH OF THE CANAL. THE AVERAGE STREET GRADES AND FLOOD BOUNDARY WIDTH INDICATE A POTENTIAL STORAGE CAPACITY OF APPROXIMATELY 272 ACRE-FEET PER MILE OF CANAL.

THE MODEL USED IN THIS ANALYSIS ASSUMES THE AVAILABILITY OF 136 ACRE-FEET PER ONE-HALF MILE. WHILE THIS QUANTITY OF STORAGE MAY NOT ACTUALLY BE AVAILABLE THIS FIGURE WAS USED TO DETERMINE WHETHER FURTHER INVESTIGATION OF STORAGE POTENTIAL WOULD BE WARRANTED. THE RESULTS OF THIS INVESTIGATION ARE SHOWN IN FIGURE 6.

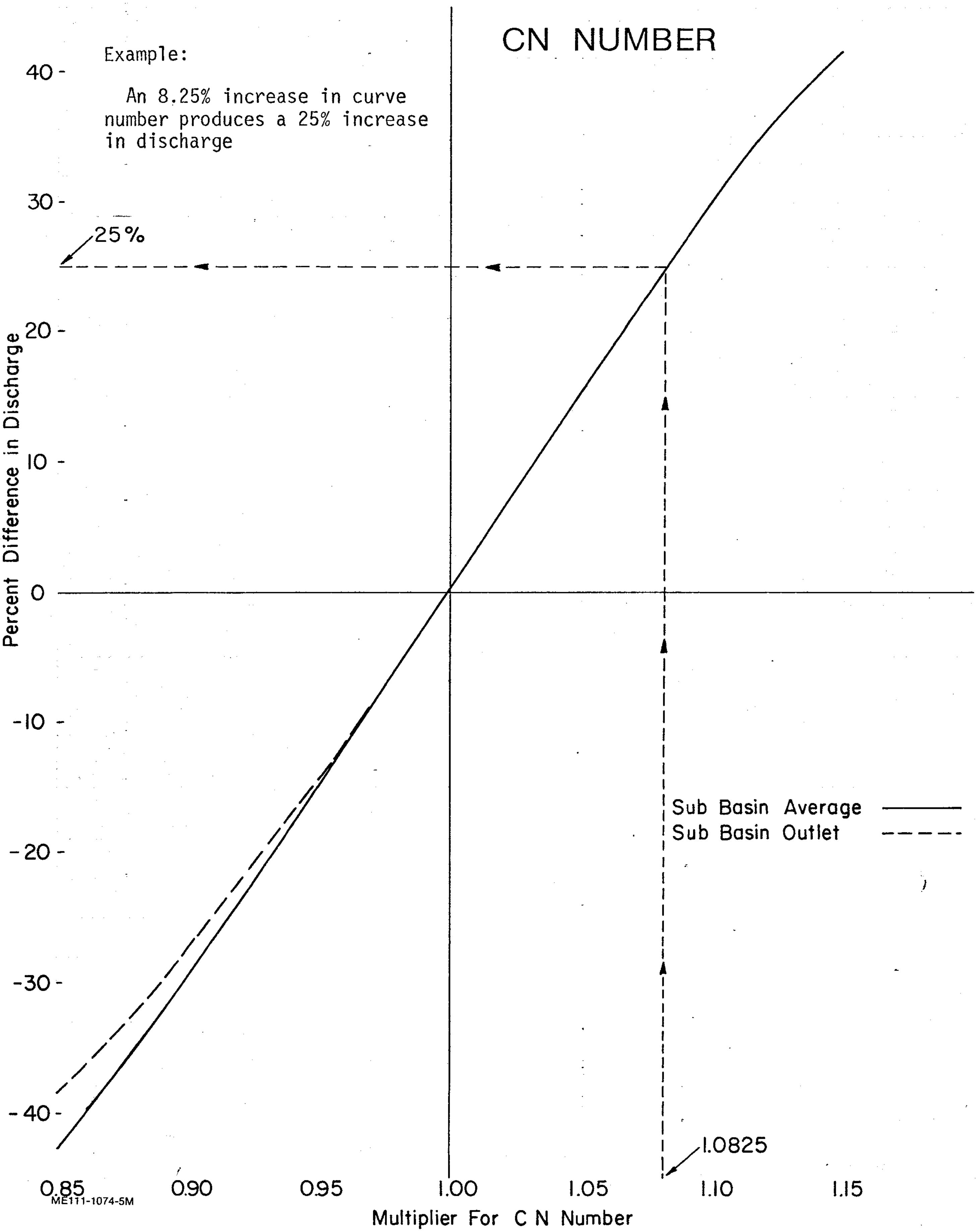


SENSITIVITY ANALYSIS WATERSHED
LEGEND
1232.7 = SPOT ELEVATION
.0058 = GENERAL GROUND SLOPE
= DRAINAGE AREA BOUNDARY
= SUB-AREA BOUNDARY
48"/110 = STORM DRAIN SIZE / CAPACITY (CFS)
24 = SUB-AREA NUMBER
88 = COMPOSITE CURVE NUMBER (CN)
N
2000' 0 2000'
ARIZONA CANAL
GRAND CANAL
SALT RIVER
Central Ave.
7th Ave.
7th St.
12th St.
16th St.
20th St.
24th St.
32 nd. St.
40th St.
48th St.
Thomas Rd.
McDowell
Van Buren St.
PHOENIX
SKY HARBOR INTERNATIONAL AIRPORT

HNTB
HOWARD NEEDLES TAMMEN & BERGENDOFF

Made by WMS	Date 9/24/82	Job No. 7101-21-10
Checked by	Date	Sheet No.

Calculations For



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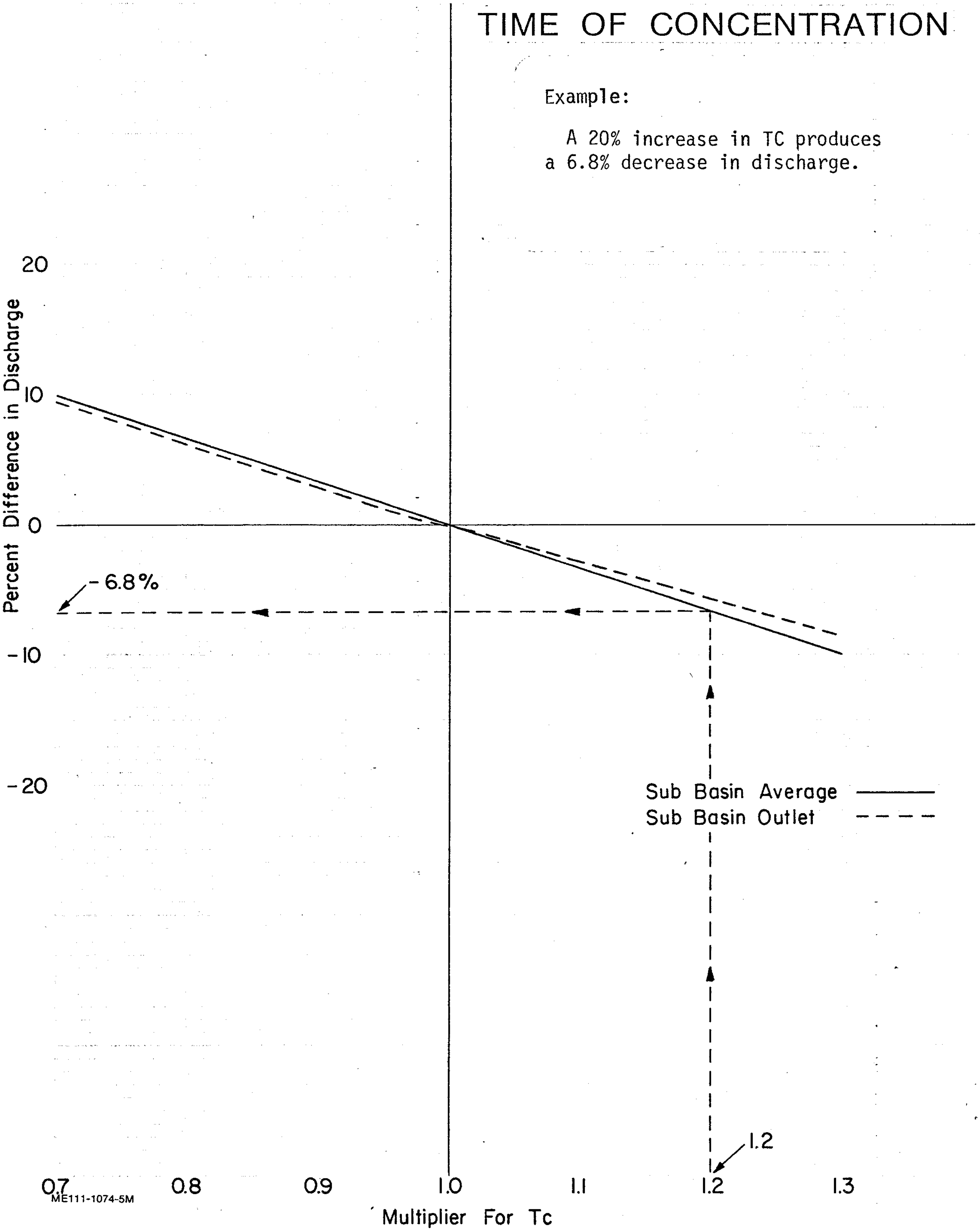
	Checked by	Date	Sheet No.
Calculations For			

TIME OF CONCENTRATION

Example:

A 20% increase in TC produces a 6.8% decrease in discharge.



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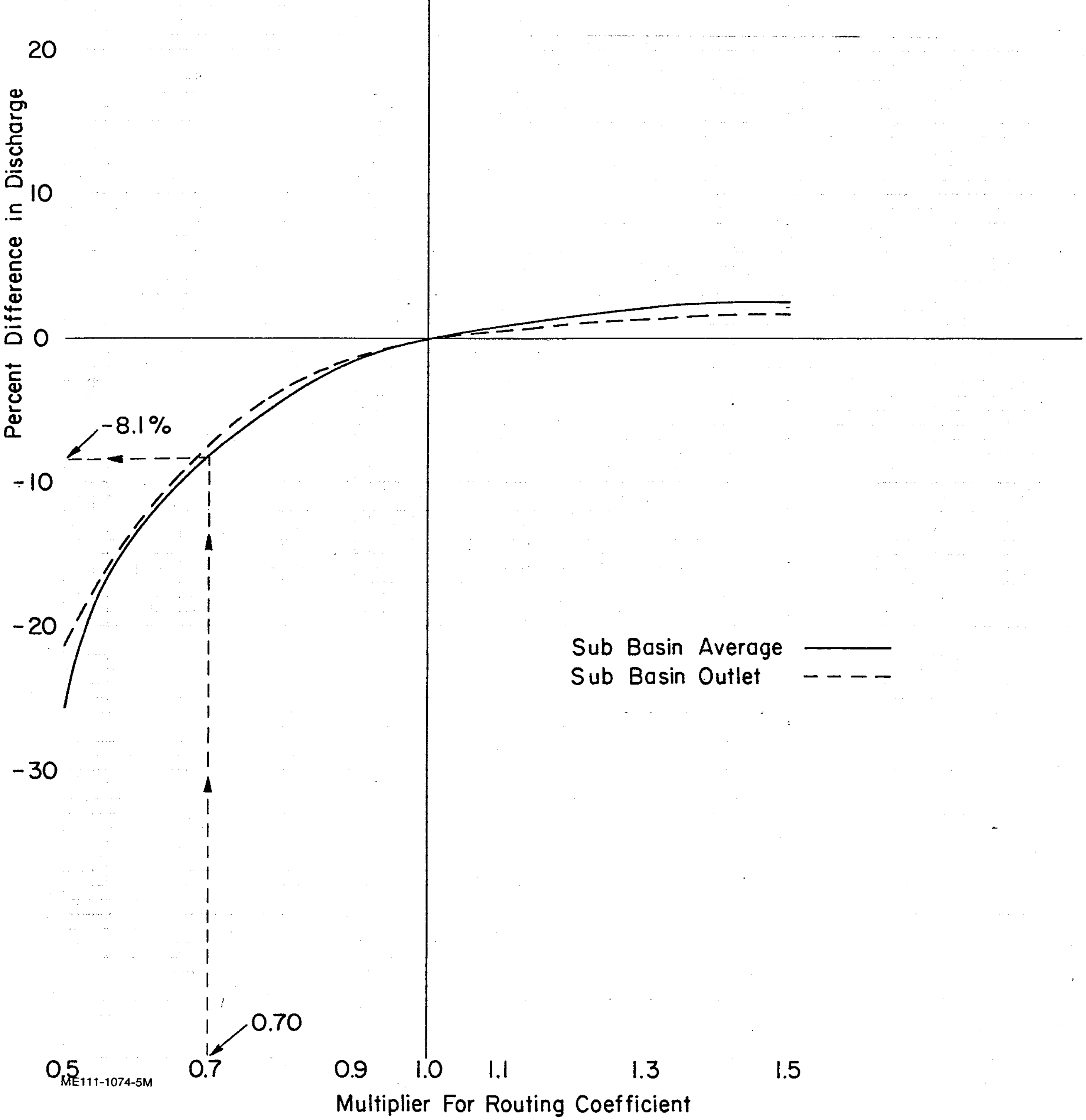
	Checked by	Date	Sheet No.
Calculations For			

ROUTING COEFFICIENT

Example:

A 30% reduction in Routing Coefficient results in an 8.1% decrease in discharge.



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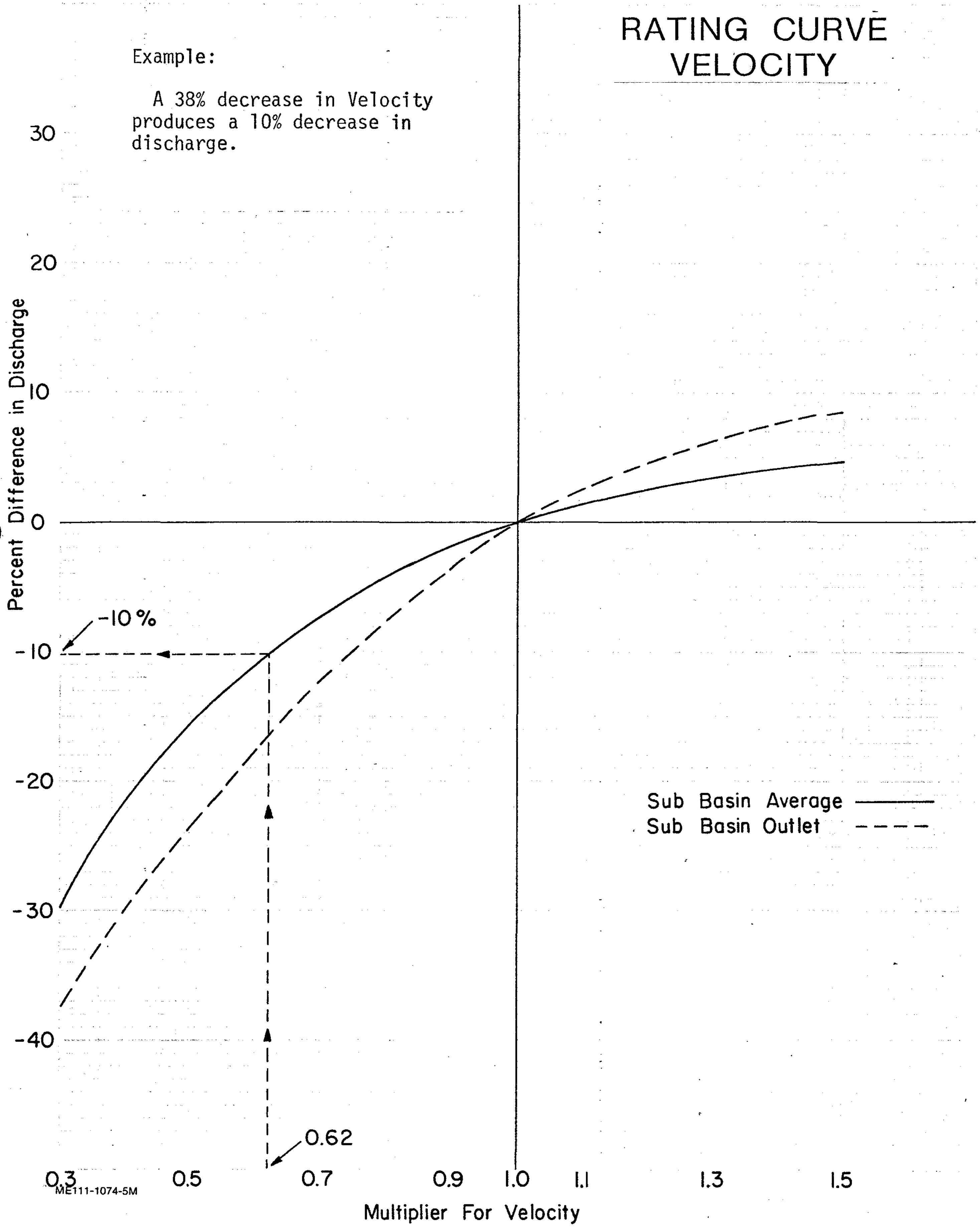
	Checked by	Date	Sheet No.
Calculations For			

RATING CURVE VELOCITY

Example:

A 38% decrease in Velocity produces a 10% decrease in discharge.



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Date

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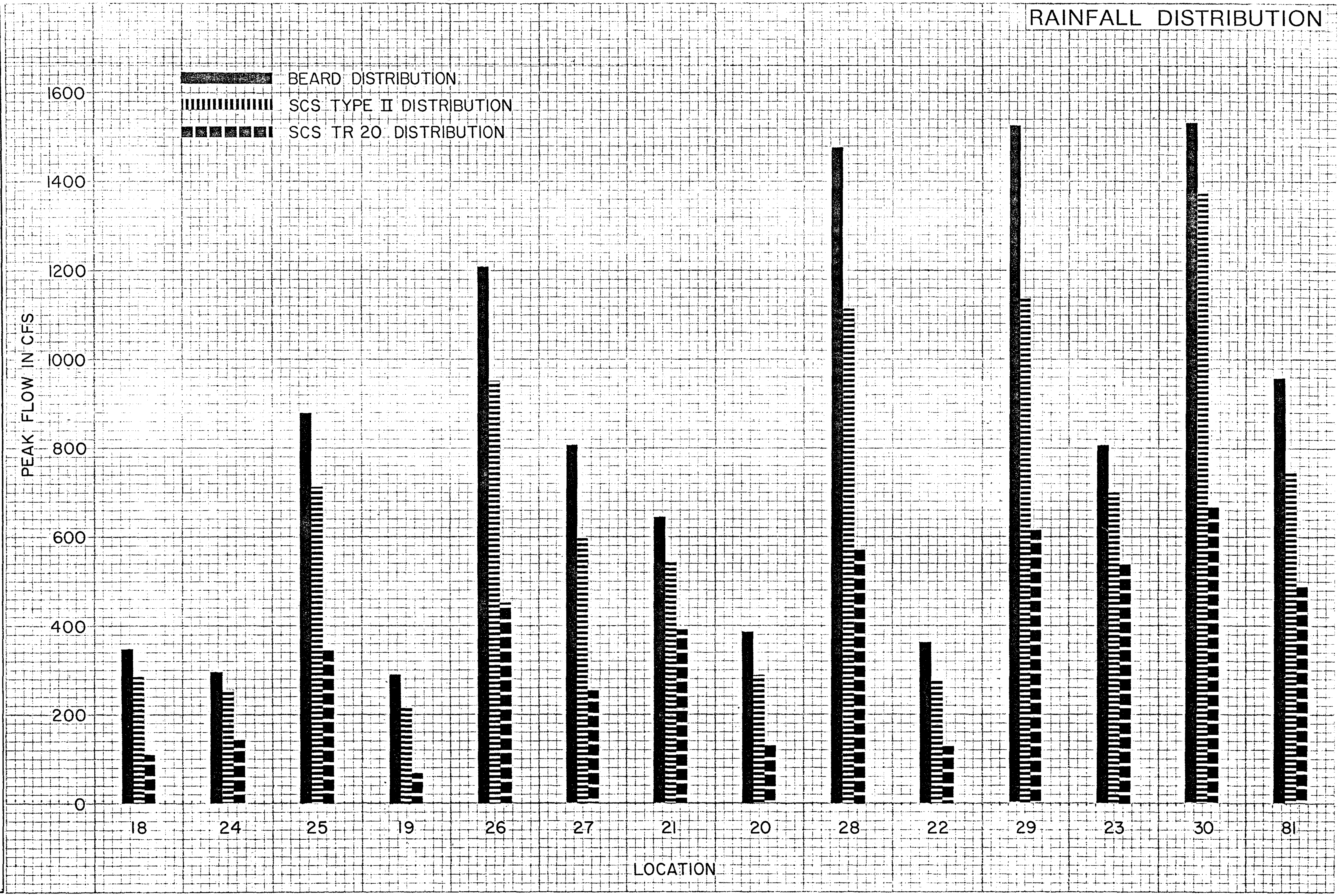

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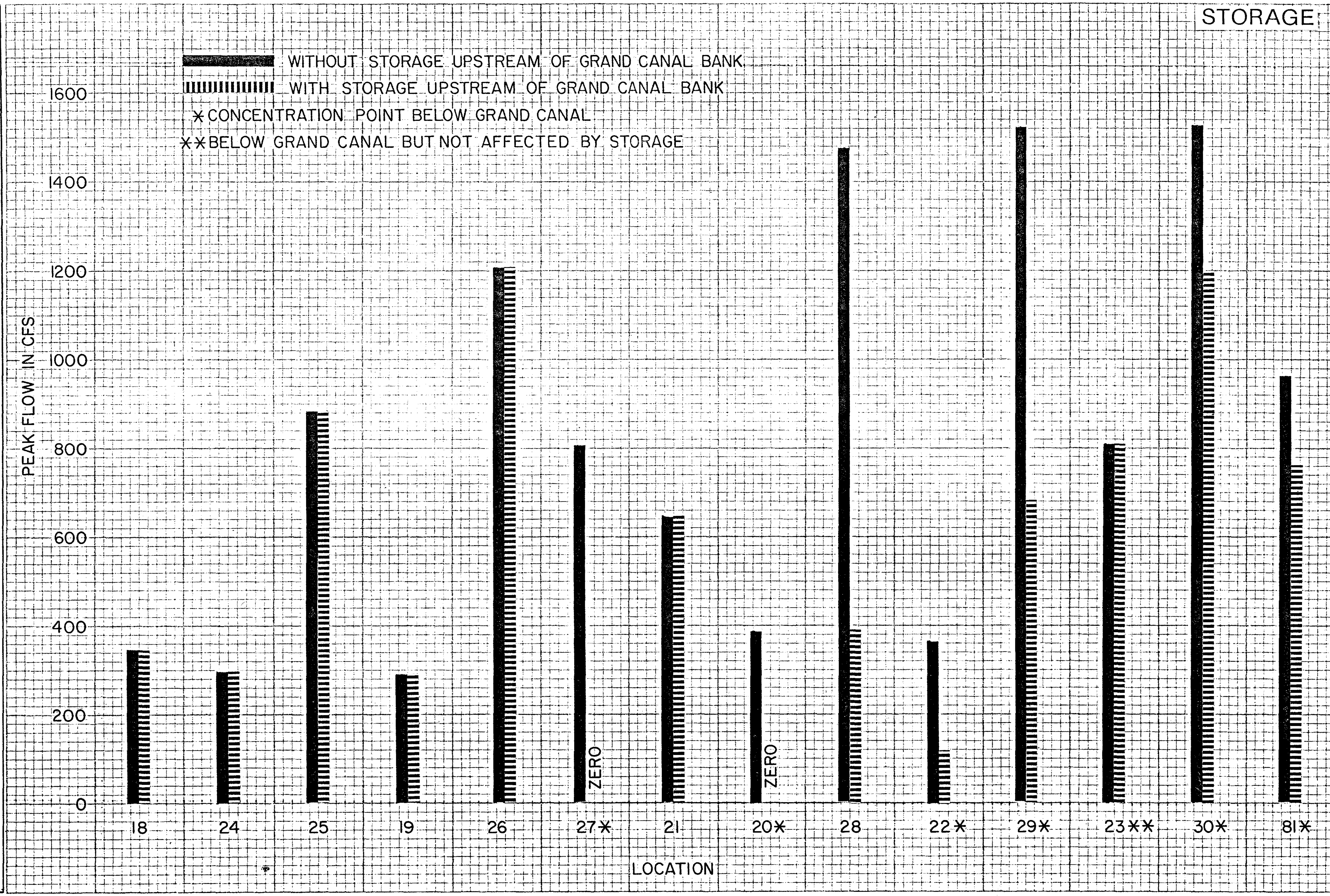

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HOWARD NEEDLES TAMMEN & BERGENDOFF

3	CHENG	1	HYDRO
2	ASST		LMgt
	ADMIN		SUSP
	C & O		FILE
	ENGR		DESTROY
	FINANCE	4	D.J
REMARKS			

October 12, 1982

Mr. Dave Johnson
Flood Control District
of Maricopa County
3335 West Durango
Phoenix, Arizona 85009

Dear Mr. Johnson:

I am enclosing a copy of our report for the first phases of the Value Engineering Study for the I-10 Inner Loop Storm Drainage System. This report presents the results of the October 5, 1982 brainstorming session in which you were a participant. This report is for your information and file. We trust that you will find it to reasonably represent the consensus of the brainstorming groups.

We appreciate your contribution to this effort. We believe the ideas developed by the groups and recommended for further development and evaluation will prove to be of benefit to the community and to the Arizona Department of Transportation on this project.

We will endeavor to keep you informed as to the results of later phases of the Value Engineering Study. Again, thank you for your time and effort.

Sincerely,

HOWARD NEEDLES TAMMEN & BERGENDOFF

Robert D. Miller

Robert D. Miller

RDM:jp
Enclosure

Architects Engineers Planners

2211 East Highland Street, Suite 100, Phoenix, Arizona 85016, 602 957-1931