KEB

NORTHEAST AREA MASTER STORM DRAINAGE STUDY

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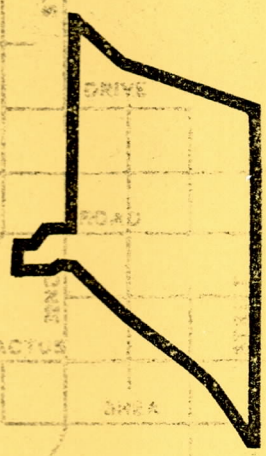

PROJECT NO. ST-78328.00

1979

southwest computing
inc. phoenix, arizona

G. E. Kmetty, P.E.
G. L. Allen, P.E.

December 5, 1979

Mr. Reginald Swartz
Engineering Supervisor
City of Phoenix
251 W. Washington
Phoenix, Arizona 85003

Re: Northeast Area Master
Storm Drainage Study
Project: ST-78328.00

Dear Sir:

Transmitted with this letter is our report on storm drainage for the northeast area of Phoenix, and in accordance with our contract dated February 9, 1979.

The two selected alternates are presented in Volume I. Volume II contains the eight alternative concepts that were evaluated and additional backup information on the hydrology, hydraulics and cost estimation.

We wish to acknowledge and express our appreciation for the assistance given to us by the City of Phoenix staff, particularly Dwayne Williams, during the preparation of this report.

Respectfully submitted,
SOUTHWEST COMPUTING, INC.

Gregory L Allen

Gregory L. Allen, P.E.
Vice President

Registered Professional Engineer (Civil)
CERTIFICATE NO. for the
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ARIZONA, U.S.A.

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CHAPTER 1
SYNOPSIS

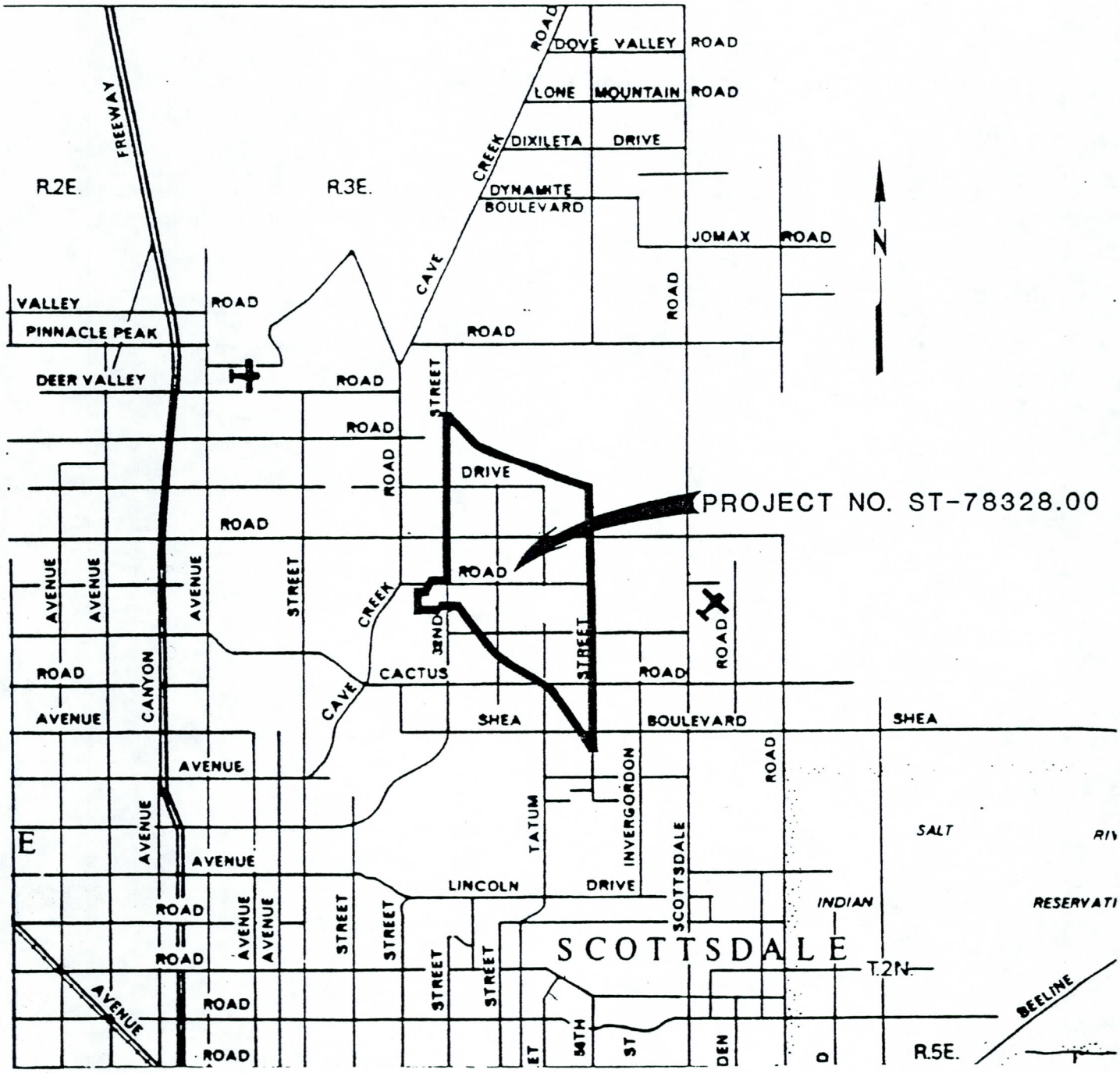
SYNOPSIS

The Northeast Storm Drainage Study is a two volume report which contains the hydrology, hydraulics and estimated costs of several alternative concepts for handling the runoff in this study area. Volume I contains the assumptions, design considerations, hydrology, hydraulics, cost analysis and two selected alternative concepts. Volume II contains the eight alternative concepts that were evaluated and additional backup information on the hydrology, hydraulics and cost estimation.

A set of plans is submitted with these two volumes. The plans contain typical sections, schematics and profiles of each alternate. The plans also contain schematics showing the study area boundary and individual drainage area boundaries. The profiles contain slope and length of pipes or waterways, and the hydraulic grade lines for the 2 year frequency design storm.

The hydrology was computed using the Soil Conservation Service computer program TR20 for the 1, 2, 5 and 10 year frequency storms. These computer printouts are bound and will be part of the final submittal.

A set of quartersection maps have been prepared with hydrologic base data and the selected master storm drainage system will be superimposed on them for the final submittal.



VICINITY MAP OF THE NORTHEAST
STORM DRAINAGE STUDY AREA

FIG. 1

CHAPTER 2
SUMMARY

SUMMARY

The Northeast Drainage Study Area consists of approximately 14 square miles, bound by the Central Arizona Project Canal (CAP) on the north, 56th Street on the east, the Indian Bend Wash (IBW) on the south, and 32nd Street on the west (Figure 1).

Two alternative concepts have been selected by the City of Phoenix staff for presentation in Volume I. Alternate 1 (Plate 1) is primarily an underground storm drain system on half mile intervals, while Alternate 6 (Plate 2) is primarily a surface waterway system in combination with detention basins. Of the eight alternate concepts that were evaluated, Alternate 1 and Alternate 6 were selected as the optimum design solutions for the area, representing underground stormdrain systems and surface waterway systems respectively.

The estimated construction costs for the selected two alternates (2 year design storm) are as follows:

Alternate	Description	Waterway channel Lining	Total Cost (X$1000)
1	Primarily underground storm drain system	Earth	$ 14,359
		Grass	14,476
		Soil Cement Treatment	$ 14,428
6	Primarily above ground waterway system	Earth	$ 9,780
		Grass	$ 11,255
		Soil Cement Treatment	$ 11,020

The above estimated costs include materials, construction, right of way, engineering design, and contingencies. The cost estimates do not include maintenance costs. Estimates for maintenance cost will be furnished as a supplemental report by the City of Phoenix staff.

CHAPTER 3
INTRODUCTION

INTRODUCTION

Purpose

The purpose of this study was to provide an optimized solution for storm drainage for the Northeast Area of Phoenix. Eight storm drainage alternatives have been developed and evaluated for this area.

Objectives

The objective of this study was to prepare a Storm Drainage Planning Report for the City Engineer and his staff. The Report was to include:

1. Data or information used to compute storm runoff.
2. Drainage patterns and subdivisions of the study area into various hydrologic and hydraulic systems.
3. Description of various storm drainage alternatives and cost estimates for each.
4. Plan and profile of the stormdrain with hydraulic gradeline, and location of outfalls.
5. Information for the city staff to select an optimum storm drainage solution.
6. Engineering data needed for future detailed storm drainage designs in the study area.

The contents of this report (volumes I and II) contain the above listed information.

Study Area

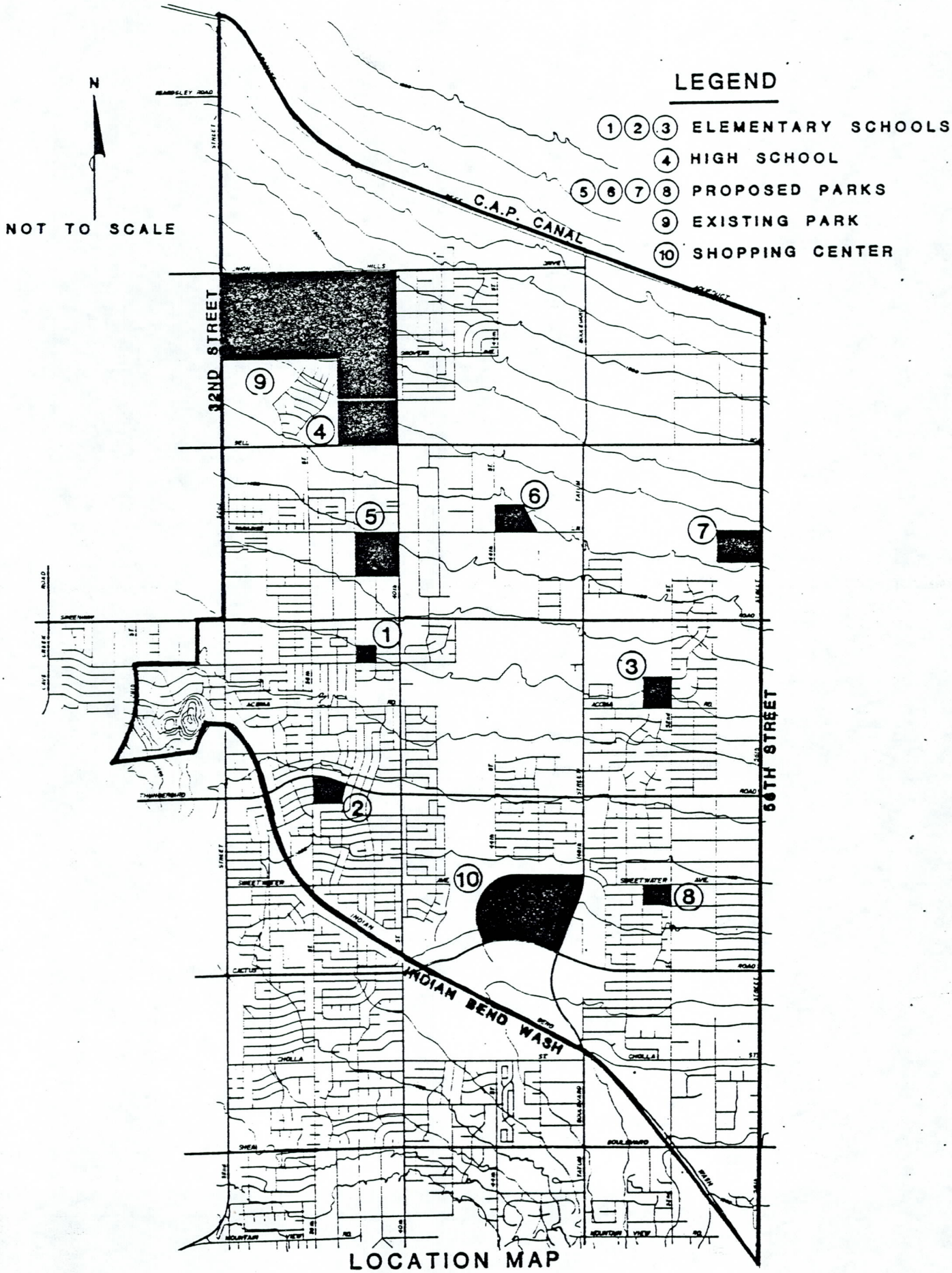
The Northeast Storm Drainage Study Area consists of approximately 14 square miles, bound by the Central Arizona

Project (CAP) aqueduct on the north, 56th Street on the east, the Indian Bend Wash (IBW) on the south and 32nd Street on the west (Figure 2).

The Northeast Area is one of the most rapidly growing areas of the Phoenix area. Staff members of the City of Phoenix and Maricopa Association of Governments planning departments have estimated the current population of the Northeast Area to be 20,000 persons. The entire area is projected to be fully developed by the year 2000. The projected population for the study area for the year 2000 is approximately 80,000 persons.

The study area is primarily zoned residential, with scattered commercial and industrial zonings along major streets. Currently the only major shopping center in the area is the recently (1978) developed Paradise Valley Mall (Site 10 on fig. 2). The Maricopa County Parks Department has a 0.75 square mile regional park located between Bell Road and Union Hills and 32nd Street and 40th Street (Site 9 on fig. 2). The park presently contains a golf course, a rodeo arena, and a picnic area. There are also three elementary schools (Site 1, 2 & 3 on fig. 2) and one high school (Site 4 on fig. 2) located within the study area.

NORTHEAST STORM DRAINAGE STUDY



LOCATION MAP

FIG. 2

CHAPTER 4
SELECTED ALTERNATES

SELECTED ALTERNATES

The two alternates presented in this report were chosen from a total of eight solutions, presented in Volume II, that resulted from this master study of the northeast drainage area. These alternatives were selected by the City staff for presentation because they represent the two alternate conceptual solutions that most dramatically reflect the difference between methods for solving the storm water problems in the area. The discussion presented below provides the descriptive details of the storm drainage system for Alternatives 1 and 6.

Alternate 1

Alternate 1 is primarily an underground storm drain system, on half mile intervals. The general configuration of this system requires that the mains be laid out along streets in the north to south flow direction. The mains for the storm drain pipe systems are located in the following streets: 32nd, 36th, 40th, 44th, 48th, and 52nd. With the exception of 44th Street, each of these street storm drain systems conveys the runoff directly to the outfall channel in the Indian Bend Wash.

The 44th Street storm drain system delivers pipe flow to a constructed waterway whose headwater is located at Greenway Road and 44th Street. The collected runoff is then carried by the existing waterway to the outfall channel in the IBW near the Paradise Valley Shopping Center.

The typical length of the storm drain laterals is one-quarter mile. The laterals located in major east-west streets of the study area are Bell Road, Greenway Road, Thunderbird Road, Cactus Road and Shea Boulevard. Additional laterals, in collector streets, are also located as follows: Grovers Avenue, Paradise Lane, Acoma Road, Sweetwater Avenue, Willow Road, and Cholla Streets. The flow in these laterals is east to west in direction.

Collectively the mains and laterals of the storm drain system represent more than 146,000 feet of storm drain pipes.

The proposed waterways that are part of Alternate 1 were included because of the adverse conditions for the use of storm drain pipes. The proposed waterways can be graded to properly convey the flows into the existing waterways. The total waterway systems length is slightly over 9,400 feet.

Four minor waterways exist in the study area. The waterways are located as follows: on Union Hills Drive between 42nd Street and 40th Street, on Greenway Road between 46th Street and 43rd Street, on Acoma Road, between 46th and 43rd Streets, and on Thunderbird Road between 46th and 43rd Streets.

The storm drainage for the Paradise Valley Shopping Center is collected and conveyed by an existing waterway directly to the IBW outfall channel.

Alternate 6

Alternate 6 is significantly different in concept from Alternate 1. This alternate represents a surface solution

to the storm drainage problem. The surface solution includes waterways, three detention basins and some minor storm drains.

The surface runoff in Alternate 6 is collected by five (5) major waterway systems. These storm drainage waterway systems are located along 32nd, 38th, 44th, 48th and 52nd Streets. Each of these streets will carry the runoff in the proposed waterways with the exception of the 38th and 52nd Street systems which are underground storm drains.

The 38th and 44th Street storm drainage systems take advantage of the existing waterways to convey runoff. The existing waterway in the 38th Street system starts south of Union Hills Drive and 40th Street. The flow from this waterway is eventually conveyed to it's outfall at Bell Road and 36th Street. An existing waterway starting near Greenway Road and 44th Street is used to collect and convey runoff to the Indian Bend Wash. The existing waterway around the Paradise Valley Shopping Center conveys the runoff from the 52nd Street system, and continues until it terminates in the Indian Bend Wash. A minor existing waterway collects runoff from the local area below Cactus Road and 48th Street.

Three detention basins are used to reduce the peak discharge in the 32nd, 38th and 44th Street Systems. The first detention basin, 32nd Street System, is 5 acres in size and is located near the northeast corner of Grovers Avenue and 32nd Street. The second basin, 38th Street system, requires 15 acres. The site

is located near Acoma Road and 40th Street. A third detention basin, 44th Street system, is 6 acres in size. This basin is located near Acoma Road and 44th Street. The detention basins have been located at city park sites, when possible.

In Alternate 6, the length of waterway is approximately 96,500 feet, and the length of storm drains is approximately 36,000 feet.

All collected runoff of Alternate 6 is eventually discharged into the Indian Bend Wash.

Cost of Alternates

The total costs of Alternates 1 and 6 are described separately as to the cost of storm drain, waterways, and/or detention basins. The total waterway cost is further categorized into the type of construction materials used to construct the waterway. The construction material alternatives for waterways are: earth lining, grass lined with concrete low flow channel and soil cement lined channels.

Table 1 contains the cost summarizations for Alternates 1 and 6.

TABLE 1

TOTAL COST SUMMARIZATION

FOR

ALTERNATES 1 & 6

ALT. NO.	LININGS	WATERWAY (X $1000)	STORM DRAIN (X $1000)	DETENTION BASIN (X $1000)	TOTAL (X $1000)
1	Earth	898	13,461	0	14,359
	*Grass	1,015	13,461	0	14,476
	Soil Cement	967	13,461	0	14,428
6	Earth	5,981	3,062	736	9,779
	*Grass	7,457	3,062	736	11,255
	Soil Cement	7,222	3,062	736	11,020

* Grass lining includes sprinkler system and concrete low flow channel costs

CHAPTER 5
COST ESTIMATING

COST ESTIMATING

General

The total estimated project cost prepared for each alternative is the summation of the installed storm drain and waterway costs, including right of-ways and incidental costs.

The total installed pipe cost includes materials, excavation, miscellaneous, engineering, inflation, and contingency costs. The total waterway cost includes excavation, land acquisition, street crossings, engineering, inflation and contingency costs.

The City of Phoenix supplied cost data for storm drain installation, right of way frontage and detention basins. We have utilized the Arizona Department of Transportation bid tabulations for channel excavation and culvert costs. For channel stabilization and landscaping costs, we have utilized data from the Arizona Soil Stabilization contractors and Colin Beals and Son, Concrete Ditching contractor. A complete discussion of cost data sources are presented below.

An estimated escalation factor of 12% per year was included in the total estimated cost for all pipe and waterway systems. The factor was applied as a fixed percentage to the estimated installed costs of stormdrains.

The fixed percentage factor for engineering and contingency cost of 15%, was based on data supplied by the City of Phoenix. This cost percentage is directly applied to the installed, miscellaneous, and inflation costs in order to arrive at an estimate of the expected engineering and contingency cost for each alternative project.

Stormdrain Costs

The unit cost of installation for main line pipe storm drains were provided by the City of Phoenix. The given cost data contained the numerical relationship of the installed cost of storm drain, pipe diameter and depth of trenching to subgrade. The installed costs of storm drains used were taken from those issued March, 1979 (Table 2).

The miscellaneous costs associated with storm drain construction was estimated to be 35% of the installed pipe cost. This miscellaneous cost was given by the City of Phoenix and was based on previous bid tabulations estimating the cost for replacing street pavements, installing catch basins, and other drainage appurtenances.

Waterway Costs

The cost of constructing waterways includes costs for right of way acquisition, channel excavation and grading, and alternative channel linings e.g., earth, grass and soil cement. In checking with realtors in the Paradise Valley area, it was determined that the average land acquisition cost for the Northeast area would be approximately $20,000 per acre. This value was used to estimate land acquisition cost for detention basins. Waterway costs (strip easements) were estimated to cost $3.00 per square foot as per data supplied by the City of Phoenix.

The cost for clearing, excavating and final grading of the channel was taken from a publication entitled Construction Costs 1978 and Quantities and Costs of Material, Arizona Department of Transportation, Highways Division, Contracts and

TABLE 2

STORM DRAIN PIPE COSTS*
per lin. ft

March 9, 1979

Pipe Size In	Depth to Subgrade - Feet								Pipe Size In
	6	7	8	9	10	11	12	14	
12	22.75	23.62	24.06	24.94	25.38	25.81	26.25	27.12	12
15	23.62	24.06	24.50	25.38	26.25	26.69	27.12	28.00	15
18	24.50	24.94	25.38	26.25	27.12	27.56	28.44	29.31	18
21	25.38	25.81	26.69	27.56	28.00	28.44	29.75	31.06	21
24	26.69	27.12	28.00	28.44	28.88	29.75	31.06	32.81	24
27	28.00	28.44	29.31	30.19	30.62	31.50	32.38	34.56	27
30	30.19	30.62	31.50	31.94	32.81	34.12	35.44	37.62	30
33	32.38	33.25	34.12	35.00	35.88	38.06	38.94	41.12	33
36	35.44	36.31	37.62	38.50	39.38	40.69	41.56	44.19	36
39	39.38	40.25	41.56	42.44	43.31	44.62	49.94	48.12	39
42	43.31	44.19	45.50	46.38	47.69	49.00	50.31	52.94	42
45	47.25	48.12	49.44	50.31	51.62	52.94	54.69	57.31	45
48	51.19	52.06	53.38	54.69	56.00	57.31	59.06	61.69	48
51	55.12	56.44	57.75	59.06	60.38	61.69	63.44	66.06	51
54	59.06	60.38	62.12	63.44	64.75	66.06	67.81	70.88	54
57	63.00	64.31	66.06	67.38	69.12	70.44	72.19	75.25	57
60	67.38	69.12	70.88	72.19	73.94	75.25	76.56	80.06	60
63		73.50	75.25	77.00	78.75	80.50	82.25	85.31	63
66		77.88	80.06	81.81	83.56	85.31	87.06	90.12	66
69		84.00	86.19	88.38	90.12	91.44	93.19	95.81	69
72			90.12	91.88	94.06	95.81	97.56	101.06	72
75			95.38	97.12	99.31	101.06	103.25	106.74	75
78			101.06	102.81	105.00	107.19	109.38	113.31	78
81			107.19	108.94	111.12	113.31	115.94	120.31	81

* Source: City of Phoenix Engineering Department, Design Division

Specification Services. The average unit price for drainage excavation was determined to be $2.45 per cubic yard. This is the base price used to estimate the excavation costs for the channels. Additional lining alternatives considered were grassed waterways with a concrete low flow channel, and soil cement lining. The City of Scottsdale, Parks Department, provided the basic cost data for these lining alternatives.

The grass channel costs were composed of grassing costs and construction costs for a concrete lined low flow channel. The channel bed grassing costs were found to be $0.05/ft^2. Side slope grassing costs were increased to $0.07/ft^2 due to the application of hydromulch. The hydromulch is used to reduce erosional conditions on the side slopes of the channel. Sprinkler systems were included in the estimate to sustain grass growth in the grassed waterways. The City of Scottsdale, Parks Department, uses a unit cost figure for an installed sprinkler system of $5,000 per acre. This cost was used to determine the cost of a sprinkler system for each alternative.

Colin Beals and Son Concrete Ditching Contractors provided an estimate for the unit cost for placing the concrete in the low flow channel. The price of $8.50/lin.ft. was developed for a V-type channel, with 4" thickness of concrete; 7.3 ft^2/LF of surface area; and 3000 psi concrete.

A local contracting firm, Arizona Soils Stabilization Contractors, indicated that a probable cost range for preparing and placing a 6" lift of soil cement material with 8% cement would be $0.30 - $0.35 per square foot. The unit cost for soil

cement used in the project cost estimate was $0.35/ft^2.

Detention Basin Costs

The estimated project cost computed for each detention basin is comprised of land acquisition and excavation and grading cost. The land acquisition cost is the same as previously noted i.e., $20,000 per acre. The excavation and grading cost for the detention basin is the same as previously used for drainage channel excavation i.e., $2.45/yd^3.

CHAPTER 6
EXISTING CONDITIONS

EXISTING CONDITIONS

Drainage Area Characteristics

The land in the Northeast Study Area is relatively flat with moderately well drained soils. The only major relief in the area is Shadow Mountain, which lies near the southwesterly boundary of the study area. The elevation of this mountain is approximately 1928 feet. The elevation of the majority of the area varies from 1350 to 1520 feet.

The slope of the land surfaces in the Northeast Area is generally in the south-southwesterly direction. The slope of the area is approximately 0.25% in the westerly and 0.75% in the southerly direction. The surface drainage in the area is generally overland flow. The overland flow subsequently concentrates in natural and artifical waterways and gutters or inverted crown street sections.

The Indian Bend Wash channel originates in the Northeast Study Area at 32nd Street. The wash traverses completely along the southerly boundary of the study area. The natural drainage of the area flows southwesterly into the Indian Bend Wash. Presently the runoff is removed from the area by the IBW to the Salt River.

The existing density of development varies from the completely developed residential areas south of Thunderbird Road, to the sparsely developed areas along the northern boundaries of the study area. There is considerable evidence of scattered

developments in the northern two-thirds of the study area, with large portions of undeveloped lands between densely developed residential subdivisions.

The Northeast Study Area was subdivided into 111 drainage areas (See Plate 3). These drainage areas vary in size from the smallest of 0.020 square miles to the largest of 0.263 square miles.

A 0.25 square mile contributing area is located to the west of 32nd Street (part of Shadow Mountain), and is tributary to the 32nd Street storm drainage system.

The Hallcraft Homes Sunburst Farms Subdivision, located between Cactus Road and Thunderbird Road at 52nd Street, has bermed lots. The lots are bermed to confine irrigation waters. A field survey indicates that most of these homes have berms both in the front and in the back. Through a house count of this area, the percentage of lots bermed was obtained and the curve numbers were modified to reflect the effects of retention.

A 0.02 square mile area within the study area is considered to be non-contributing to the Northeast Drainage Systems, and is located near the intersection of Shea Boulevard and 56th Street. With the above exception, the rest of the drainage area of the Northeast Study is considered to be confined within the previously defined study area.

Existing Drainage System

Several natural drainage systems exist in the Northeast Study Area. The general direction of flow in the area is predominantly south-southwesterly. The natural overland drainage

is conveyed as sheet flow collected in straight or braided shallow channels. There are no major erosion or sedimentation problems in the area.

There are several man made waterways in the Northeast Study Area. The northern most existing waterway lies between Union Hills Drive and Bell Road, and it is originating south of the intersection of 40th Street and Union Hills Drive. The channel is a combination of natural and artificial waterways. The alignment of the channel is generally southwesterly. It is about one mile in length and has an estimated slope of about 0.7%, and the waterway conveys its flows to Bell Road. Located further south, the second man made waterway tends to bisect the Northeast Study Area in a north-south direction. The waterway alignment generally follows along 42nd Street, starting at Greenway Road and outlets into the Indian Bend Wash. The waterway is slightly over two miles in length and has an estimated slope of 0.5%. Moving to the east, a channel has been constructed to divert surface drainage around the Paradise Valley Mall shopping center. This channel originates at the northeast corner of the shopping center at Tatum Boulevard and flows westerly and then southerly along the Paradise Valley Mall shopping center ring road, into Indian Bend Wash. The waterway length is approximately one mile and the estimated slope is about 0.3%. The most easterly artifical waterways in the Northeast Study Area are located along Tatum Boulevard and Cactus Road, and their combined flows are routed southerly into the Indian Bend Wash. Flow from two points along Cactus Road are carried to a common juncture near

the projected intersection of Tatum Boulevard and Paradise Drive, where it combines with the Tatum Boulevard channel. The main stem of the drainage along Tatum is nearly 0.6 miles, the lateral tributary to the main stream is nearly 0.45 miles in length. The estimated slope of the Tatum waterway is 0.5% and the lateral tributary is 0.2%.

The Indian Bend Wash (IBW) is the southern boundary of this study. The IBW extends from 32nd Street on the west to 56th Street on the east. The IBW is being developed by private developers between 40th Street and 50th Street. A golf course has been developed in this area of the wash, which has been designed to carry the 100 year storm.

Schools and Parks

The Northeast Study Area has three elementary schools, one high school, and four proposed parks. The location of the following sites are shown on Figure 2, (page 6).

Site	Type	Location
1	Elementary School	Blanche Drive and 38th Street
2	Elementary School	Thunderbird and 36th Street
3	Elementary School	Acoma and 52nd Street
4	High School	Bell Road and 48th Street
5	Proposed Parks	Paradise Lane and 38th Street
6	Proposed Parks	Paradise Lane and 44th Street
7	Proposed Parks	Paradise Lane and 54th Street
8	Proposed Parks	Sweetwater Avenue and 52nd Street
9	Existing Park	Union Hills between 32nd & 40th Street

CHAPTER 7
DESIGN ASSUMPTIONS

DESIGN ASSUMPTIONS

Design Frequency

A two year precipitation return period was selected by the City of Phoenix for preparation of the hydrologic and hydraulic designs of the alternate collection systems. Additional hydrologic analysis was developed for 1, 2, 5 and 10 year return periods.

Development

The northeast area of Phoenix is one of the most rapidly developing areas of the valley. The runoff from this area is based on full development of all land within the study area. Land development densities are based on existing zoning.

On-Site Retention

The current City of Phoenix drainage requirements require new development to retain on-site the 10 year - 2 hour runoff. Since future maintenance of on-site retention is difficult to enforce in single family residential areas, only partial credit is given to retention in developing the hydrology for this area.

Existing Utilities

The City of Phoenix staff has instructed that the existing utilities and their locations need not be considered for the purposes of this study.

During the final engineering design of the storm drainage facilities, the utility locations must be determined and conflicts resolved.

Stormdrains

In the design of the storm drains, it was assumed that the tailwater elevations at the outfall of pipes into the Indian Bend Wash are at the top of the pipes. Entrance and exit losses were neglected through maintenance manholes, but included at junctions of trunk and lateral lines. Mannings "n" value for the storm drain was assumed to be 0.012.

Waterways

There are several miles of natural and man made waterways in the Northeast Study Area. Each alternative uses these existing waterways to the fullest extent possible. Most of the existing waterways outfall into the Indian Bend Wash. The one exception is the existing channel between Union Hills Drive and Bell Road. This system conveys flow onto Bell Road.

In this study all new proposed waterways were considered to be located in newly proposed right of ways rather than within existing right of ways.

An approved final design for the Indian Bend Wash channel has not been selected as of this date (8/79). However, the Yost and Gardner channel flowlines have been considered and found to be generally consistent with this studys assumed outfall elevations. The waterways were assumed to have a minimum top width of 15 feet. The side slopes of the channels were designed at a 3:1 maximum. If the established flow could not be carried by the minimum 15' channel, with 2 foot maximum depth, then the top width of the waterway was increased by increments of

5 feet until the flow could be conveyed within the waterway. Mannings "n" value for planning purposes was assumed to be 0.025. A typical section for the waterway is shown in Figure 3.

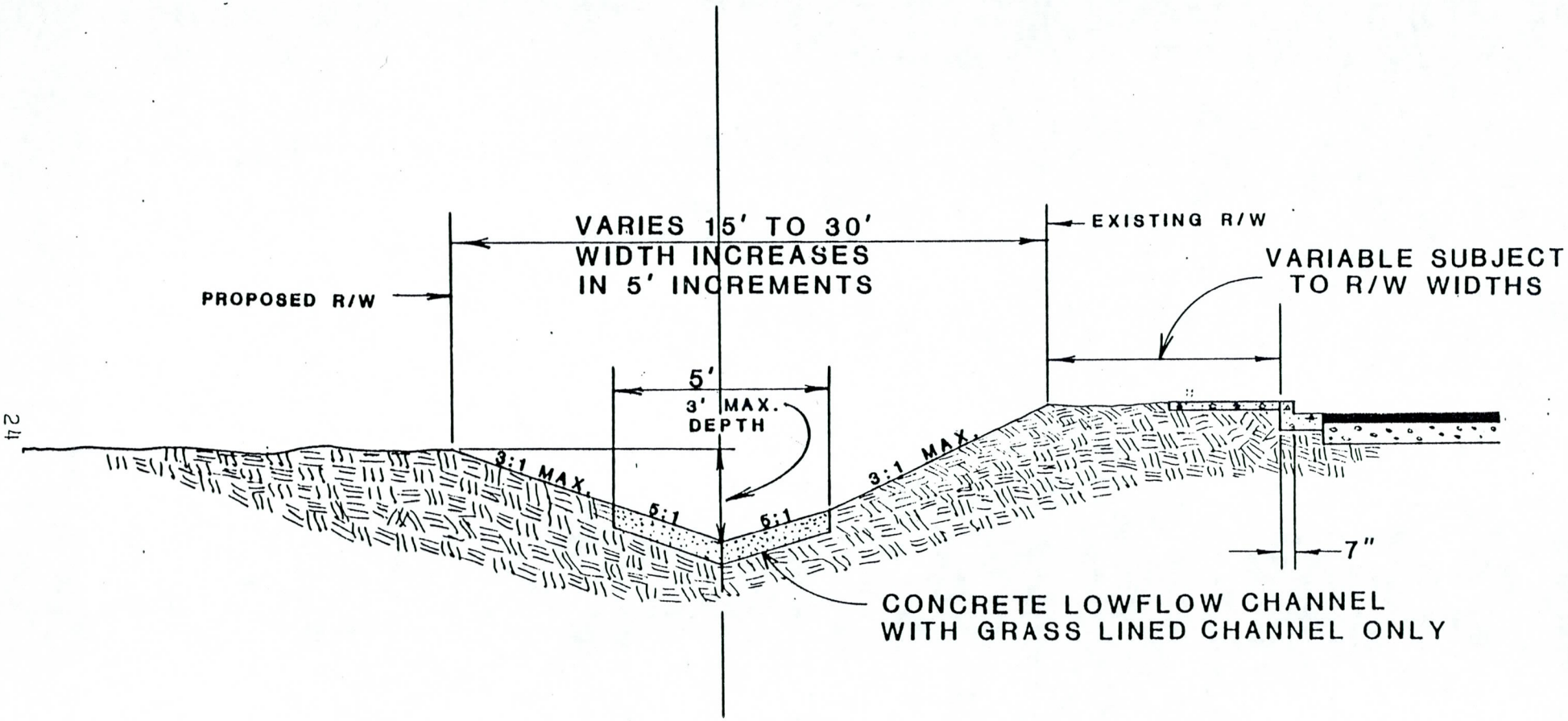
Detention Basins

There are no existing detention basins in this study area, but several proposed parks and some schools were considered for joint use as a recreational area and detention basin.

The design concept on the detention basins visualized an average depth of 2 feet, draining within 48 hours. The minimum surface area used for detention basins was five acres. The detention basin was enlarged by 5 acre increments until the flow was properly managed by the detention basin. A typical section of the detention is shown in Figure 4.

Design Materials

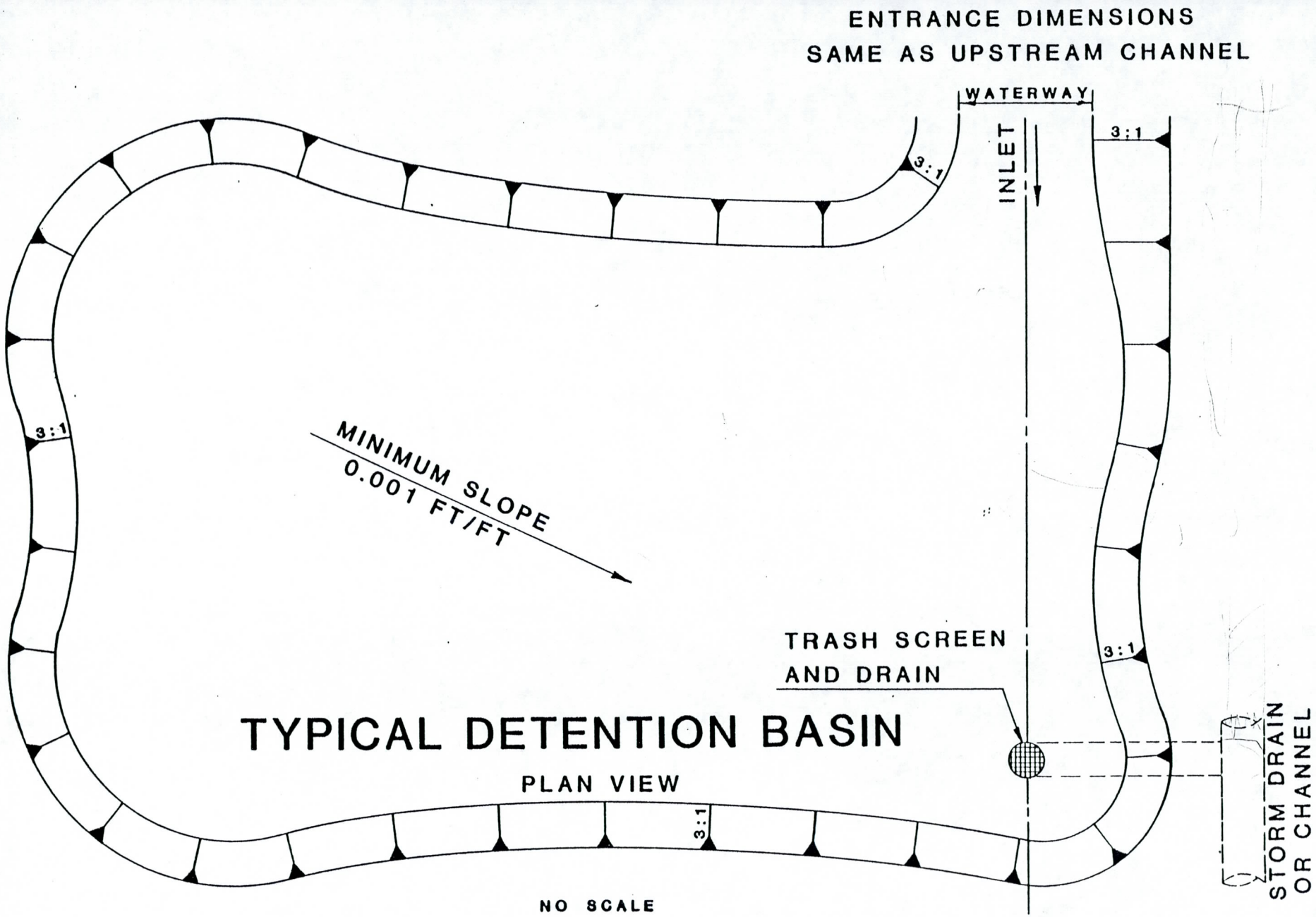
Construction materials for the study were chosen for their relative availability and economy. For storm drains, only pre-cast concrete pipes were considered. For waterways a larger selection of construction materials were considered. Each waterway construction was assumed to start from the basic cross section shaping of the existing ground. Following the initial shaping, there were three possible lining alternatives considered. The three lining alternatives were as follows: graded earth lining; grass lining with concrete low flow channel and soil cement lining.



TYPICAL WATERWAY SECTION

NO SCALE

FIG. 3


ENTRANCE DIMENSIONS
SAME AS UPSTREAM CHANNEL
WATERWAY
INLET
3:1
3:1
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3:1
MINIMUM SLOPE
0.001 FT/FT
TRASH SCREEN
AND DRAIN
TYPICAL DETENTION BASIN
PLAN VIEW
NO SCALE
STORM DRAIN
OR CHANNEL

FIG. 4

CHAPTER 8
HYDROLOGY

HYDROLOGY

Methodology

The Soil Conservation Services computer program TR20 was used in determining the hydrology for the 1, 2, 5 and 10 year frequency storm. The SCS - TR20 program was developed as an evaluation tool for watershed project planning. Because of its capabilities, ease of application and updating, the TR20 program is a time saving tool in master planning drainage systems.

The program can compute surface runoff for any synthetic or natural rainstorm. It takes into account conditions affecting runoff through the input data furnished by the engineer; the size of the drainage area in square miles, time of concentration, and curve number. From this data, hydrographs are developed for all drainage areas at collection points. These hydrographs are then routed through the system and combined with other hydrographs to develop composite hydrographs. The peak discharges are then tabulated in summary tables for ease in reading the computer printouts.

The SCS method of estimating direct runoff from storm rainfall is based on methods developed by SCS hydrologists at their small watershed research sites scattered throughout the United States.

For determining the hydrology of a watershed the following rainfall data is required:

1. Depth of rain for the various frequency and duration of storms.
2. Distribution of the rainfall vs. time.

Drainage Areas

The study area was divided into drainage areas based on existing topographic data, field observations and aerial photography (Plate 3). The maximum drainage area or contributing area of the watershed was assumed to be equal to one-quarter (1/4) section of land. Smaller contributing areas were designated when hydrologic and hydraulic situations evidenced the need for the evaluation of the affects of smaller drainage areas. The drainage areas on this project vary in size from the smallest of .020 square miles to the largest of .263 square miles.

Precipitation Data

The precipitation values for the various design frequencies were furnished by the City of Phoenix. These rainfall amounts are shown in Table 3.

TABLE 3

24 HOUR PRECIPITATION

Design Period (Years)	24 Hour Precipitation (Inches)
1	1.02
2	1.44
5	2.10
10	2.53

Rainfall Distribution

The TR20 program has the capability of varying the precipitation intensities with time. The rainfall distribution input to the program, when plotted on a graph, has the form

of an S-curve. The distribution furnished by the City of Phoenix, shown in Table 4, indicates the percent rainfall versus time.

Soil Classification

On-site reconnaissance and a review of SCS soil maps for the area indicates that the hydrologic group for the Northeast Study Area is generally Type B. Type B soil is defined by the SCS as those soils which have moderate infiltration rate when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Curve Numbers

The SCS hydrologic proceedure, as in TR20, combines the soil type, land use and type of cover into a hydrologic soil-cover complex or curve number. In an urban area, the predominant factor in determining runoff is the percentage of impervious surfaces. The impervious area's percentage varies with the zoning and types of development. The City of Phoenix furnished a table of curve numbers representing the ultimate development based on existing zoning, and the type of soil. The City of Phoenix curve numbers are presented in Table 5.

Time of Concentration

The SCS hydrologic proceedure defines the time of concentration as the time it takes for runoff to travel from the hydraulically most distant part of the watershed to the watershed outlet or

TABLE 4

24 HOUR RAINFALL DISTRIBUTION

TIME HOUR	% TOTAL RAINFALL	TIME HOUR	% TOTAL RAINFALL
0	.000	12.5	.83
.5	.004	13.0	.86
1.0	.008	13.5	.88
1.5	.013	14.0	.893
2.0	.018	14.5	.907
2.5	.022	15.0	.92
3.0	.026	15.5	.924
3.5	.031	16.0	.928
4.0	.035	16.5	.933
4.5	.040	17.0	.937
5.0	.044	17.5	.942
5.5	.048	18.0	.947
6.0	.053	18.5	.951
6.5	.057	19.0	.956
7.0	.062	19.5	.96
7.5	.066	20.0	.964
8.0	.071	20.5	.969
8.5	.075	21.0	.973
9.0	.08	21.5	.978
9.5	.093	22.0	.982
10.0	.107	22.5	.987
10.5	.12	23.0	.991
11.0	.14	23.5	.995
11.5	.17	24.0	1.00
12.0	.50		

Table 5

Curve Number Selection

Based on Soil and Zoning

City of Phoenix

(For "B" Soil Group)

Zoning	% Roadway	CN
RE-43 S-1	8.8	77
RE-35	9.8	79
RE-25	11.4	79
R1-18	14.1	80
R1-14	14.6	80
R1-10	16.7	81
R1-8	18.3	82
R1-6	21.3	84
R-3	21.3	85
R-4 R-40 R-5	21.3	86
A-1 A-2	-	88
C-1 C-2 C-3	-	92
CO	-	88
PSC	-	95
HR	-	95
R4A	-	87
PAD-9	-	84
RSC		
PC	-	90

other points of reference downstream. The time of concentration for each drainage area was based on a combination of the overland flow time and the travel time in street gutters.

$$T_c = T_o + T_g \qquad \text{Eq. 1}$$

The overland flow time (T_o) was estimated by the SCS curve number procedure. The equation used in this procedure is as follows:

$$\cancel{T_o} = \frac{L^{0.8}\,(S+1)^{0.7}}{1900\,Y^{0.5}} \qquad \text{Eq. 2}$$

wrong

Lag

where $T_o = \frac{5}{3}(\text{lag})$

T_o = Overland travel time (hrs.)

L = Hydraulic length of watershed or sub-area (ft)

S = Potential for abstraction

$$S = \frac{1000}{CN} - 10$$

Y = Average slope of watershed or sub-area

The above curve number method of determining overland flow times was developed to span a broad set of conditions ranging from heavily forested watersheds with steep channels and a high percent of the runoff resulting from subsurface or interflow; meadows providing a high retardance to surface runoff; smooth land surfaces; and large paved parking areas.

The gutter flow travel time (T_g) is defined as the time required for water to flow to the concentration point of the drainage area, after it has reached the street. The T_g was based on a Manning's solution with full gutter flow (n=.015).

The north-south slopes in the study area are approximately three times steeper than the east-west slopes, therefore, all gutter travel times were the summation of the north-south (Tns) and east-west (Tew) gutter times.

$$Tg = Tns + Tew \qquad \text{Eq. 3}$$

The TR20 program requires velocity and length data for each reach to determine the travel time between collection points. The velocities used in this study for routing hydrographs downstream were as follows:

TABLE 6

VELOCITIES FOR

ESTIMATING TRAVEL TIMES

Type of System	Direction of Flow	Velocity ft/sec
Natural channel	North - South	3
Natural channel	East - West	1.5
Improved channel	North - South	5
Improved channel	East - West	3
Pipe	North - South	10
Pipe	East - West	5

A complete listing of the hydrologic parameter: areas, curve numbers, and time of concentrations for the Northeast Study Area are presented in Table 7. Plate 3 shows location of nodes and drainage areas.

TABLE 7

HYDROLOGIC PARAMETERS

DRAINAGE AREAS (DA), RUNOFF CURVE NO.(CN),

AND TIME OF CONCENTRATION (Tc)

DA/CN* NO.	DA (Sq.Mi.)	CN	Tc (hr)	Runoff[1] Q(cfs)	Runoff[2] Q_1(cfs)	Runoff[3] Q_6(cfs)
1	0.084	77	0.357	11	11	11
2	0.230	77	0.400	27	40	38
3	0.259	77	0.489	27	88	81
4	0.060	77	0.271	8	8	8
5	0.256	77	0.471	28	28	28
6	0.238	80	0.472	36	114	101
7	0.201	84	0.415	47	149	47
8	0.244	80	0.371	41	54	54
9	0.139	84	0.640	27	27	27
10	0.130	83	0.504	26	106	111
11	0.066	85	0.289	18	18	18
12	0.126	81	0.490	21	165	66
13	0.128	82	0.405	25	185	89
14	0.251	80	0.801	29	204	109
15	0.128	81	0.438	22	142	121
16	0.124	80	0.434	20	171	20
17	0.127	83	0.435	27	27	131
18	0.124	81	0.395	22	23	79
19	0.128	82	0.646	20	220	124
20	0.120	83	0.615	21	284	186
21	0.192	84	0.507	42	42	42
22	0.138	84	0.525	29	216	29
23	0.120	84	0.673	22	284	22
24	0.126	84	0.402	30	30	130
25	0.161	84	0.481	35	63	202
26	0.111	86	0.504	28	28	28
27	0.042	84	0.275	9	9	9
28	0.033	84	0.360	8	285	8
29	0.087	84	0.334	22	22	213
30	0.092	84	0.349	23	23	23
31	0.034	86	0.323	10	225	128
32	0.180	89	0.395	63	272	173
33	0.232	77	0.478	25	25	25
34	0.090	77	0.318	12	12	12
35	0.172	82	0.400	34	58	56
36	0.083	82	0.301	18	74	69
37	0.126	82	0.346	26	26	26
38	0.213	83	0.635	37	108	102
39	0.254	80	0.470	39	49	48
40	0.260	80	0.503	38	85	79
41	0.036	85	0.343	10	131	246
42	0.126	80	0.371	21	21	21
43	0.157	81	0.361	30	30	30

DA/CN* NO.	DA (Sq.Mi.)	CN	Tc (hr)	Runoff[1] Q(cfs)	Runoff[2] Q_1(cfs)	Runoff[3] Q_6(cfs)
44	0.117	80	0.418	19	19	19
45	0.116	80	0.322	20	178	73
46	0.253	83	0.584	46	126	236
47	0.130	80	0.536	19	154	70
48	0.131	80	0.536	19	19	19
49	0.094	84	0.679	17	164	17
50	0.064	80	0.509	9	169	25
51	0.129	83	0.573	24	184	24
52	0.120	80	0.609	16	207	130
53	0.150	80	0.639	19	237	186
54	0.250	80	0.857	27	27	27
55	0.129	80	0.763	15	15	15
56	0.100	81	0.773	13	31	31
57	0.034	80	0.334	6	6	6
58	0.111	84	0.559	23	199	23
59	0.037	82	0.271	8	8	8
60	0.054	83	0.374	12	240	214
61	0.037	84	0.222	9	9	9
62	0.123	90	0.538	42	243	215
63	0.084	90	0.464	30	244	222
64	0.066	82	0.438	13	13	13
65	0.124	82	0.520	22	22	22
66	0.062	89	0.423	21	51	115
67	0.086	93	0.319	38	56	123
68	0.123	93	0.352	57	31	31
69	0.043	93	0.246	20	20	20
70	0.068	90	0.301	25	72	124
71	0.200	90	0.595	65	65	166
72	0.033	90	0.333	13	64	101
73	0.021	90	0.407	8	68	103
74	0.232	80	0.531	33	33	33
75	0.256	80	0.552	36	67	64
76	0.147	80	0.399	24	24	24
77	0.263	80	0.576	35	58	56
78	0.257	80	0.639	33	96	163
79	0.253	80	0.700	31	124	61
80	0.253	80	0.561	35	90	85
81	0.258	80	0.578	35	119	35
82	0.077	80	0.303	14	127	62
83	0.146	80	0.569	20	20	20
84	0.038	81	0.241	8	147	80
85	0.140	81	0.401	25	160	92
86	0.043	81	0.414	8	165	96
87	0.080	81	0.381	15	15	15
88	0.131	81	0.539	20	150	38
89	0.121	80	0.378	20	20	20
90	0.063	80	0.323	11	183	67
91	0.069	80	0.403	11	31	31
92	0.123	80	0.123	23	23	23
93	0.067	81	0.349	13	168	98

DA/CN* NO.	DA (Sq.Mi.)	CN	Tc (hr)	Runoff[1] Q(cfs)	Runoff[2] Q_1(cfs)	Runoff[3] Q_6(cfs)
94	0.091	83	0.415	20	20	20
95	0.101	87	0.441	29	29	29
96	0.082	84	0.530	17	200	93
97	0.099	81	0.467	17	17	17
98	0.057	81	0.339	11	11	11
99	0.024	95	0.565	11	11	11
100	0.020	95	0.442	10	224	114
101	0.122	80	0.554	17	17	17
102	0.020	90	0.251	8	22	64
103	0.031	80	0.320	6	197	6
104	0.116	80	0.387	19	19	19
105	0.112	86	0.245	32	32	32
106	0.182	79	0.575	22	256	147
107	0.144	79	0.575	18	18	18
108	0.121	79	0.546	15	263	158
109	0.097	79	0.575	12	12	12
110	0.069	77	0.466	7	7	7
111	0.044	84	0.306	11	11	11

* DA/CN = Drainage Area/Computer Node
1 Runoff in cfs for individual area
2 Runoff in cfs for Alternate 1 at this concentration point
3 Runoff in cfs for Alternate 6 at this concentration point

CHAPTER 9
CONCLUSION

CONCLUSION

Alternate 1 and Alternate 6 have been selected by the City of Phoenix staff for presentation in Volume I. Alternate 1 primarily an underground storm drain system, while Alternate 6 is primarily a surface waterway system in combination with detention basins.

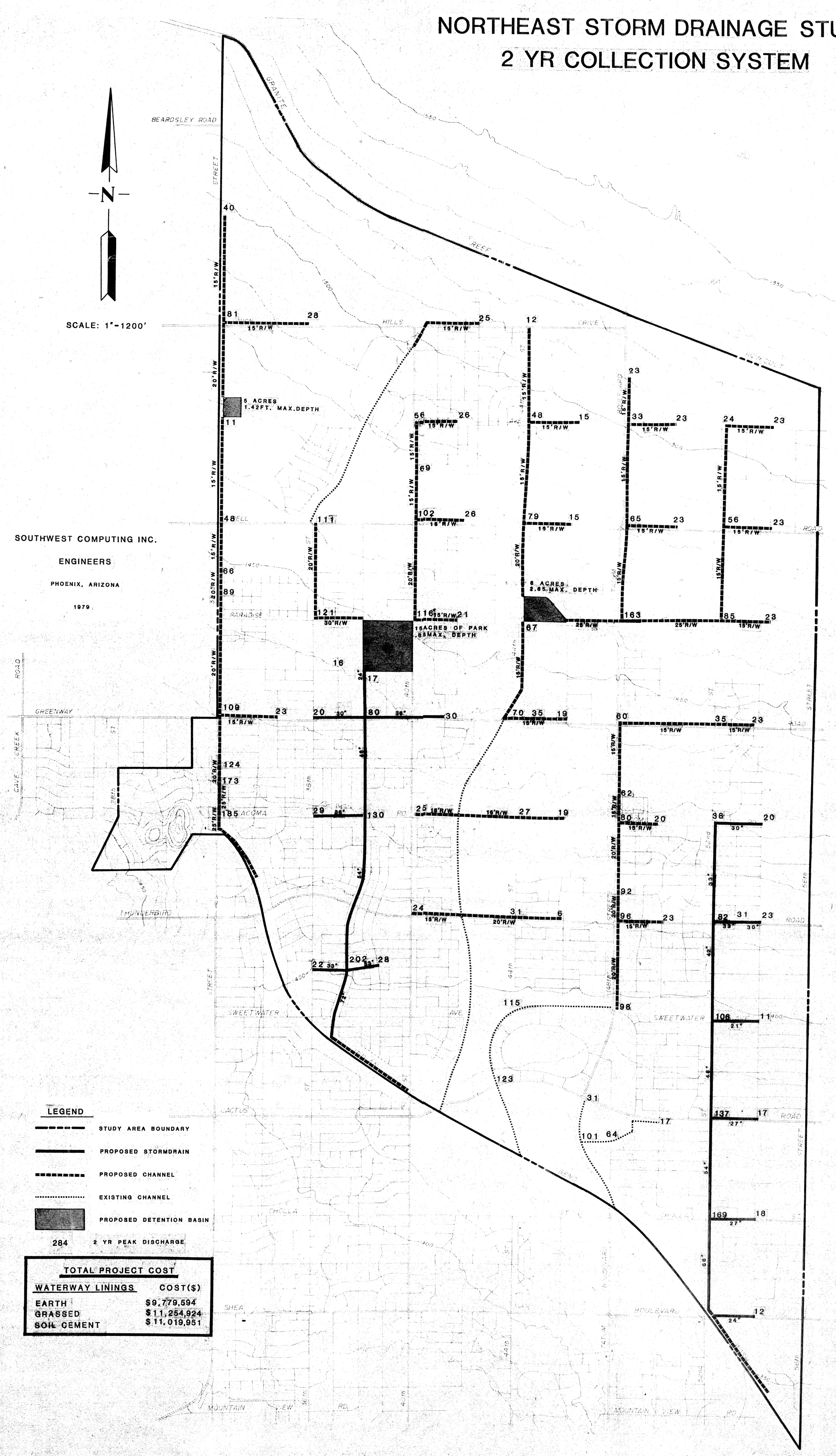
The estimated construction costs for the selected two alternates (2 year design storm) are as follows:

Alternate	Description	Waterway Channel Lining	Total Cost (X$1000)
1	Primarily underground storm drain system	Earth	$14,359
		Grass	$14,476
		Soil Cement Treatment	$14,428
6	Primarily above ground waterway system	Earth	$ 9,780
		Grass	$11,255
		Soil Cement Treatment	$11,020

The above estimated costs include materials, construction, right of way, engineering design, and contingencies. The cost estimates do not include maintenance costs. Estimates for maintenance cost will be furnished as a supplemental report by the City of Phoenix staff.

Additional data on the technological aspects of this study is found in Volume II.

NORTHEAST STORM DRAINAGE STUDY
2 YR COLLECTION SYSTEM



SOUTHWEST COMPUTING INC.

ENGINEERS

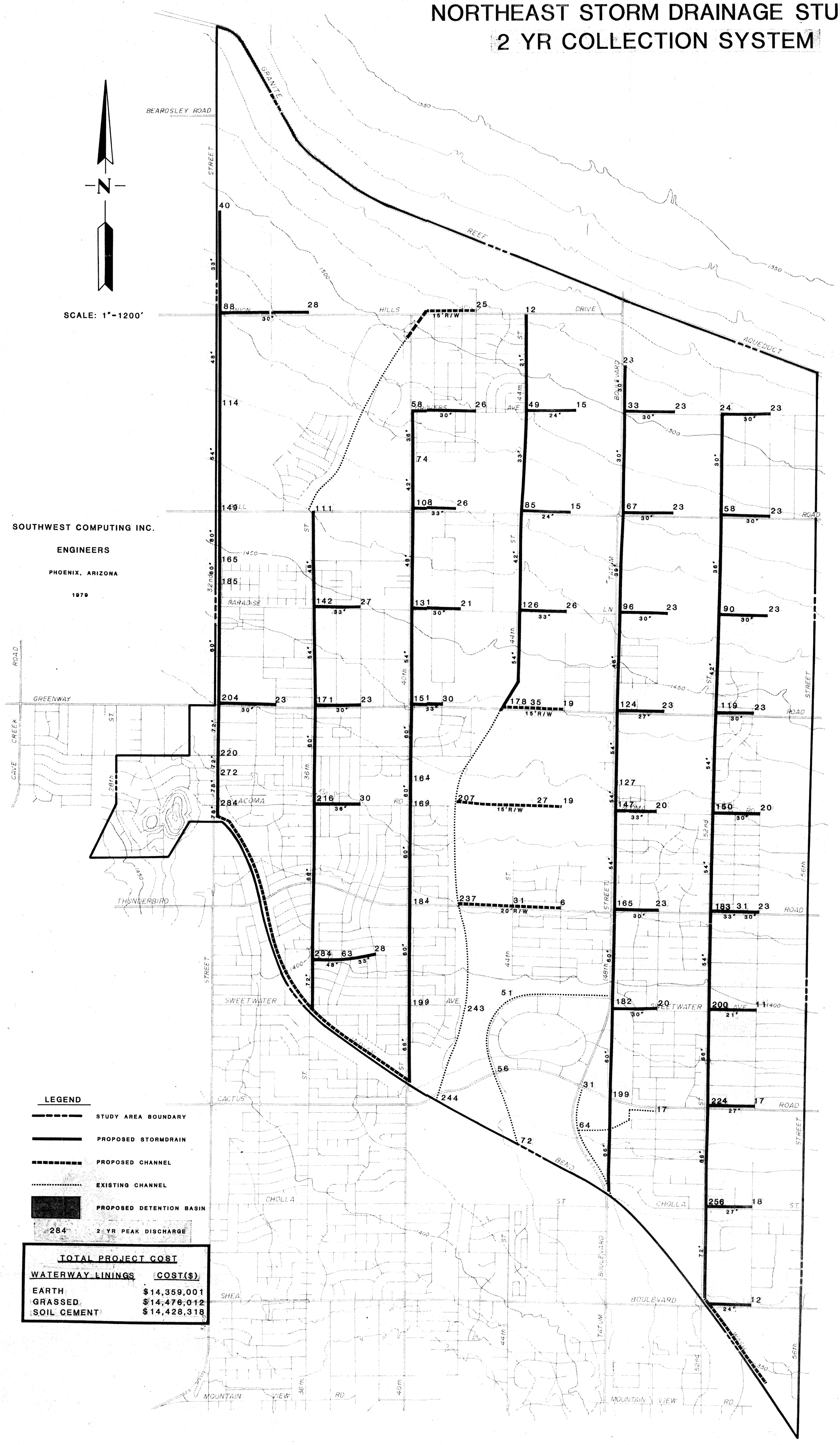
PHOENIX, ARIZONA

1979

ALTERNATE 6

NOTE: PIPE SIZES & R/W WIDTHS ARE FOR ESTIMATING PURPOSES ONLY

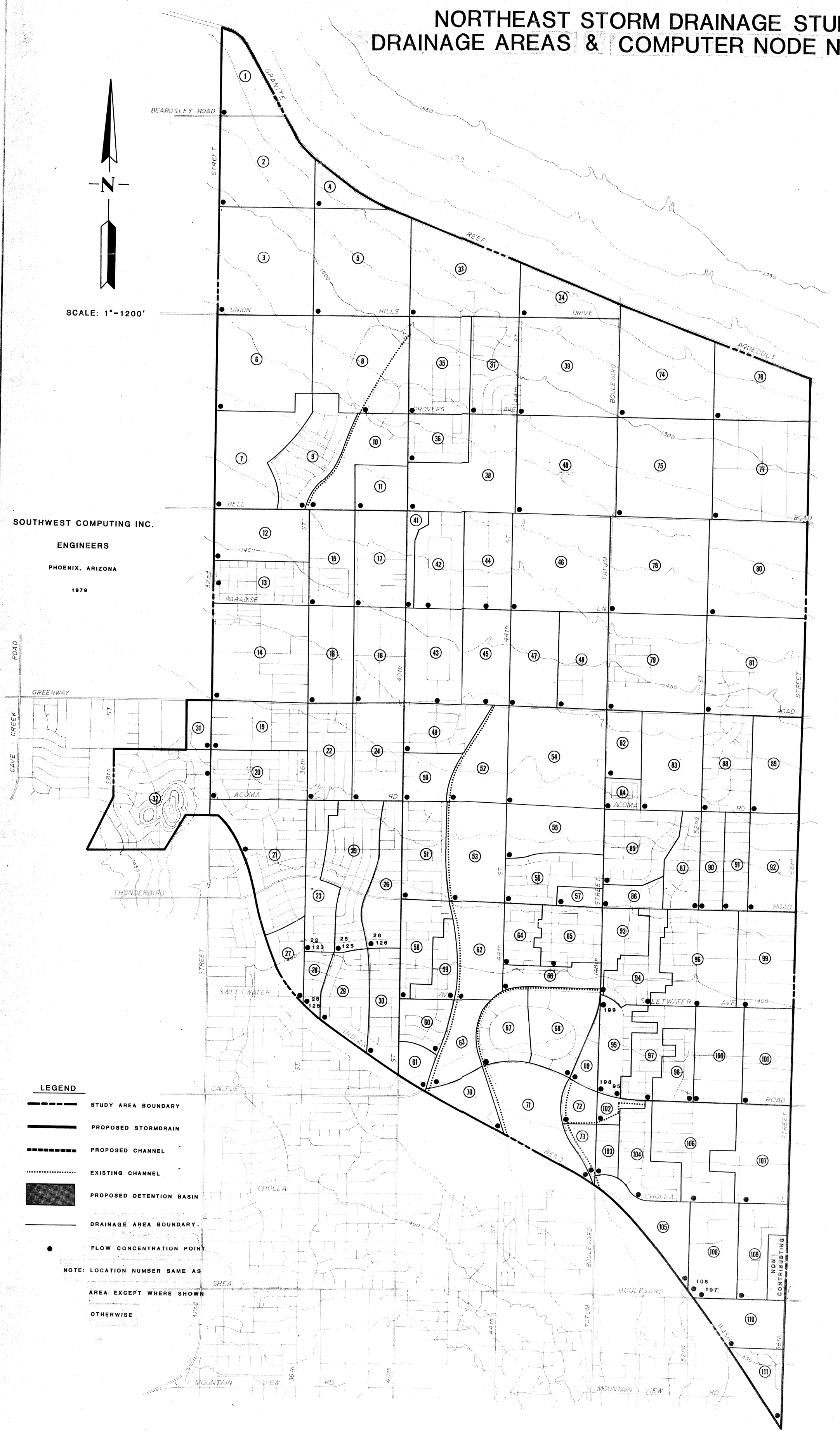
NORTHEAST STORM DRAINAGE STUDY
2 YR COLLECTION SYSTEM



ALTERNATE 1

NOTE: PIPE SIZES & R/W WIDTHS ARE FOR ESTIMATING PURPOSES ONLY

NORTHEAST STORM DRAINAGE STUDY
DRAINAGE AREAS & COMPUTER NODE NUMBERS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ACOMA RD
THUNDERBIRD ROAD
SWEETWATER AVE
INDIAN BEND
CACTUS ROAD
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