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CITY OF SCOTTSDALE

DOWNTOWN INFRASTRUCTURE MASTER PLAN

VOLUME 3

DRAINAGE STUDY

December, 1986

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1. INTRODUCTION

As part of the proposed Master Plan for the redevelopment of Downtown Scottsdale, the City of Scottsdale contracted the services of Boyle Engineering Corporation to complete the following tasks:

Task 1. Master Plan Maps
Task 2. Roadway Plans
Task 3. Bridge Designs
Task 4. Right-of-Way
Task 5. Drainage Study/Plans

This Master Drainage Study fulfills the requirements of the first part of Task 5. The balance, Storm Drain Plans, will be finalized after review of this document by the City and subsequent approval/selection of a preferred alternative drainage system.

The study area, shown in Figure 1.1 is bounded by Camelback Road and Chaparral Road on the north, 68th Street on the west, generally Osborn Road on the south and Miller Road on the east. The Arizona Canal cuts diagonally across the northern one-third of this area, creating a barrier to the natural northwest to southeast drainage. With the exception of the strip immediately adjacent to the northerly embankment of the canal, flooding in the downtown area has been minor, consisting of temporary inundation of intersections and local flat street areas.

The framework for the redevelopment of downtown Scottsdale is the construction of a road couplet system to alleviate traffic on Scottsdale Road. This system will include facilities for necessary street drainage. The planned works present an opportunity for the City to improve the general drainage in the area by providing for the integrated drainage of the couplet system and auxiliary roadways.

This report presents the results of a Master Drainage Study for the downtown area and specifically includes:

1. A description of the existing drainage system.

2. The basis of design and hydrologic and hydraulic analysis.

3. Alternative proposals to upgrade the drainage system.

4. Proposed works including a planning cost estimates and schedule for construction.

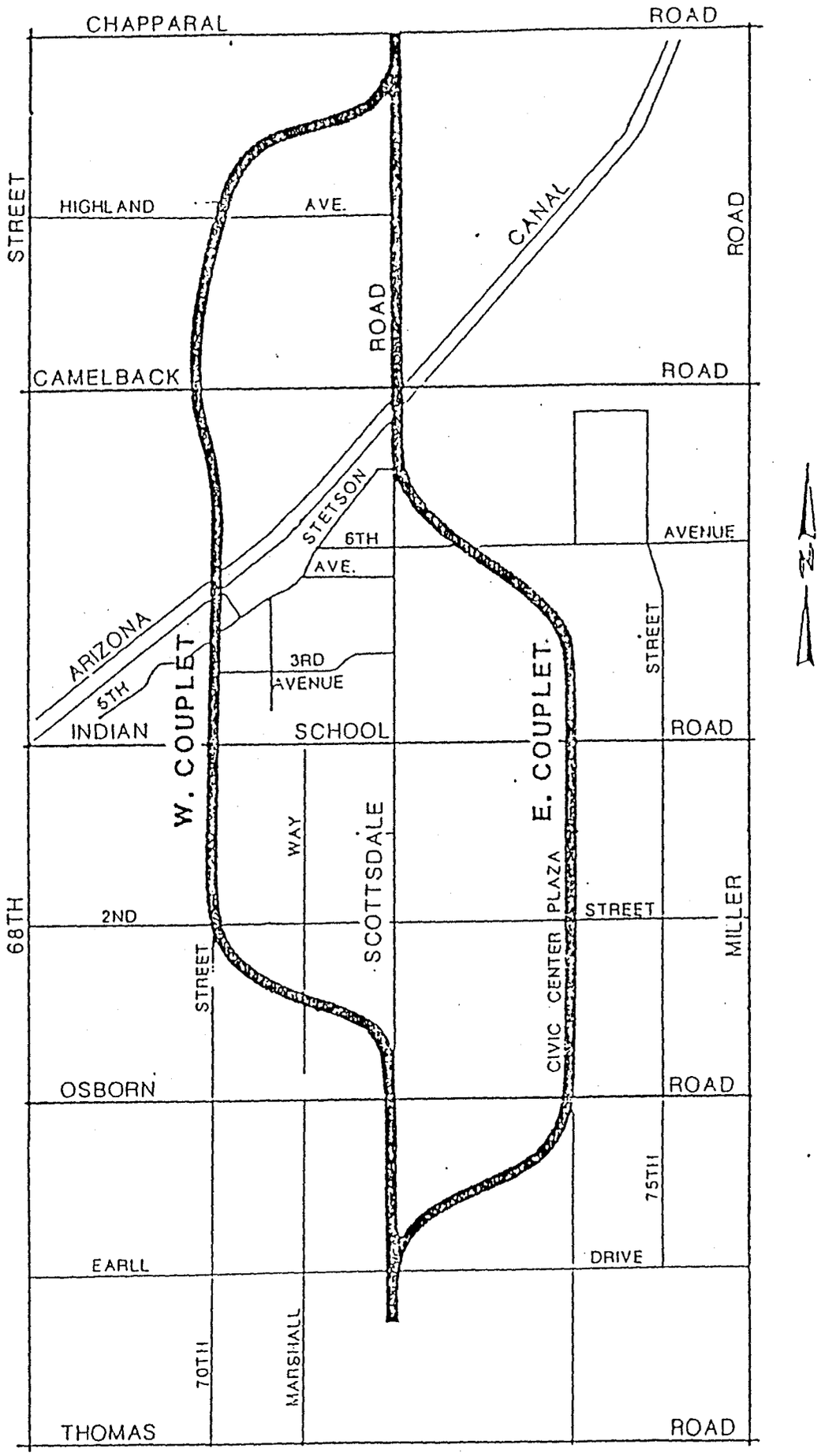

Figure 1.1 Study Area

2. SUMMARY AND RECOMMENDATIONS

2.1 SUMMARY

Drainage of the study area is toward the south-east to Indian Bend Wash with direction primarily governed by street patterns. The Arizona Canal blocks flow from the north and has, in the past, caused flooding immediately upstream of its banks. To alleviate this problem the Corps of Engineers has constructed a side channel and outfall system along Camelback Road for a 25 year storm event.

South of the canal flooding is limited to temporary inundation of roads causing inconvenience but no significant damage. Major drains are along Scottsdale and Thomas Roads and 2nd Street. The Scottsdale/Thomas Road drain is fully utilized however the 2nd Street drain has excess capacity.

A hydrological analysis of the 5, 10, 50 and 100 year storms has been performed of the existing and alternative systems using the SWMM computer model. This model is specifically applicable to small urbanized areas. Detention/retention of stormwater in the study area was not considered applicable because of the close proximity to Indian Bend Wash, the high cost of land and the incentive policy for redevelopment of downtown Scottsdale.

The hydraulics of the proposed system was established using STORM computer model. This model, based on the Los Angeles County Flood Control Method, provides a backwater curve analysis for pipelines. Tailwater conditions were not considered critical because the hydraulic grade of the outfalls was within 2-3 feet of the 100 year event for Indian Bend Wash. Further, the storm pattern that produces high levels in Indian Bend wash maybe different to that which produces high runoff on the study area. However peak discharges from the study area when routed to the Wash, occur before the peak in the Wash.

Two alternative drainage systems were analyzed to provide choices based on various levels of protection and cost estimates. Alternative A consists of the construction of two new outfall drains to the Indian Bend Wash along with new collector lines connecting to the major trunk and outfall drains. The new outfalls are along Indian School and Osborn Roads. Under this alternative the downtown area is divided into five basins as shown on Exhibit 1.

Alternate B consists of the construction of one new outfall drain to the Indian Bend Wash along Osborn Road together with collector lines to the major trunk and outfall drains. As this alternate serves larger areas with less new outfall drains, the maximum level of protection is generally lower than Alternate A. With this alternative the downtown area is divided into four basins as shown on Exhibit 2.

The level of protection available to provide one lane free of water in each direction varies between the alternatives and the basins. With new construction of outfalls it is possible to provide for the 100 year storm. For those areas making use of existing outfalls a lower standard is more practical. All alternatives provide protection for the 100 year storm to floor levels of buildings that are above street level . The difference in runoff between the 100 year and the final selected storm will be conveyed by the streets. Table 2.1 summarizes the maximum level of protection for each basin and alternative with full practical use of the existing drains.

Table 2.1 Maximum Levels of Protection (Years)

ALTERNATIVE A Basin	Protection (yrs)	ALTERNATIVE B Basin	Protection (yrs)
A	25	A	25
B	100	B	25
C	50	C	10
D	50		
E	100	D	100

Cost estimates were developed for each alternative drainage segment and level of protection. The results are summarized in Table 2.2. The costs allow for the installation of drainage pipes, inlets and connecting pipes and relocation of utilities. They do not include any allowance for contingency or engineering costs.

Table 2.2 Comparative Cost Summary - ($)

	Level of Protection (Years) 5	10	25-50 *	100
ALTERNATIVE A				
Basin A	194,400	226,500	251,800 *	
Basin B	1,286,150	1,394,750	1,695,550	1,725,950
Basin C	948,590	1,019,990	1,214,570	
Basin D	547,700	565,350	705,400	
Basin E	739,600	838,950	1,098,400	1,126,900
TOTAL ALT A	$3,716,440	4,045,540	4,965,720	
ALTERNATIVE B				
Basin A	194,400	226,500	251,800 *	
Basin B	1,700,160	1,797,160	2,044,180 *	
Basin C	932,850	985,800		
Basin D	739,600	838,950	1,098,400	1,126,900
TOTAL ALT B	$3,567,010	$3,848,410		

* 25 Year Maximum

2.2 RECOMMENDATIONS

The Alternative solutions for drainage of the downtown area were presented to the City at a meeting on April 10 with several departments (See Appendix B for attendees). At that time it was decided that Alternative A was the preferred solution for the following reasons:

1. It provided the capabilities for a higher level of protection (a minimum of 50 years for areas below the canal compared to 10 years for alternative B).

2. It would eliminate the flooding problem on Indian School Road.

3. The costs were not significantly different between the two alternatives.

An implementation schedule was prepared with Long Range Planning that spreads the works over the next 5 years plus a remainder. The details are given in Table 6.5 and summarized below.

Table 2.3 Proposed Implementation Schedule

1986-1987 ($)	1987-1988 ($)	1988-1989 ($)	1989-1990 ($)	1990-1991 ($)	Remainder ($)
$577,150	$1,057,300	$1,126,900	$634,310	$433,850	$1,195,110

3. EXISTING CONDITIONS

3.1 HISTORIC DRAINAGE PATTERNS AND FLOODING PROBLEMS

Prior to the construction of the Arizona Canal, the grid street pattern and the development of the various parcels, drainage in the Downtown Scottsdale area was from northwest to southeast, flowing in a diffuse pattern of shallow swales from the base of Camelback Mountain to the Indian Bend Wash. With development of the area, the natural drainage has been altered in several ways. Most significantly, the raised banks of the Arizona Canal create a barrier to storm runoff from the northwest, relieving the area southeast of the canal but causing flooding immediately upstream of the banks.

The downtown area to the southeast of the canal and the areas northwest of the canal have been free of serious flooding. Drainage problems have been limited to temporary inundation of intersections and streets with little slope. No homes or businesses in these areas are known to have suffered major losses due to stormwater flooding.

3.2 EXISTING DRAINAGE SYSTEM

Details of the existing drainage system are contained in the following Master Plan Maps (produced for Task 1 in this study).

STORM 15-44 15-45
STORM 16-44 16-45
STORM 17-44 17-45
STORM 18-44 18-45

The collection system upslope of the canal consists of a combination of open channels, circular pipes, and rectangular boxes, converging near the intersection of Scottsdale and Camelback Roads. The collected flows are then transported to Indian Bend Wash in a closed box section. The system was recently constructed by the Corps of Engineers to eliminate ponding along the canal up to the 25-year event (as defined by the Corps) and to prevent overtopping of the canal during the 100-year event.

South of the canal the most significant impact on the natural drainage is due to the grid street pattern. Runoff follows the streets south and east, concentrating at intersections. The direction of flow is often split or changed by overtopping the crown of an intersecting street or by overtopping the curb.

Existing major drains south and east of the canal are located at Scottsdale/Thomas Roads and 2nd Street. The Scottsdale/Thomas Roads drain varies in sizes from 48" dia. RCP north of Indian School Road to a 90" dia. RCP at Thomas Road. Along Thomas Road to the Indian Bend Wash the system consists of concrete box sections.

The 2nd Street storm drain consists of a 96" dia. RCP from west of Wells Fargo Avenue to Indian Bend Wash. The Civic Center Plaza underpass is drained by pumping into the 2nd Street drain. A summary of the existing major stormwater drains is given in Table 3.1.

Table 3.1 Summary of Existing Major Stormwater Drains

Storm Drain	Reach From	Reach To	Size (in)	Capacity (cfs)
CORPS OF ENGINEERS SIDE CHANNEL SYSTEM				
Camelback Rd	68th St	Scottsdale Rd	84" Dia.	465
Scottsdale Rd	Highland Ave	Camelback Rd	30"-42" Dia.	30- 66
Side Channel	68th St	Camelback Rd	75"-84" Dia.	165-220
Side Channel	Highland Ave	Camelback Rd	54"-72" Dia.	120-260*
Side Channel	Scottsdale Road	Indian Bend Wash	144" Dia. 1-9.5'x11' Box 2-6.2'x8' Box	1200 *
SCOTTSDALE/THOMAS ROADS DRAIN				
Scottsdale Rd	Indian School	Main St	48"-54" Dia.	80-130
Scottsdale Rd	Main Street	2nd St	60" Dia.	150
Scottsdale Rd	2nd Street	Osborne Rd	66" Dia.	170
Scottsdale Rd	Osborn Road	Earll Dr	72" Dia.	220
Scottsdale Rd	Earll Dr	Thomas Rd	90" Dia.	370
Thomas Road	Scottsdale Road	Indian Bend Wash	1-6'x7' Box 2-8'x7' Box 2-6'x6' Box	330 **
2ND STREET DRAIN				
2nd Street	Wells Fargo	Indian Bend Wash	96" Dia.	687 **
MILLER ROAD STORM DRAIN				
Miller Rd	Osborn Rd	2nd Street	48" Dia	70

* Per Corps of Engineers
** Pressure Flow

4. BASIS OF DESIGN

4.1 HYDROLOGIC ANALYSIS

4.1.1 Hydrologic Methods Considered

Several methods exist for determining stormwater runoff for urban areas. Those considered for this study included the Rational Method, the Soil Conservation Service's TR-20/TR-55, and the Environmental Protection Agency's Stormwater Management Model (SWMM). Of these, the Rational Method was considered too simplistic for this study, and TR-20 was considered less suitable than SWMM because it was originally developed for larger, predominately agricultural areas. SWMM, on the other hand, was developed specifically for urban areas and is able to:

- Produce reliable runoff hydrographs for small, highly urbanized drainage basins.
- Route the hydrographs through streets and storm drains, including partial diversions of flow.
- Simulate the effects of retention/detention and improvements to the storm drain system.
- Allow for ready modification of the input parameters to evaluate possible alternatives.

4.1.2 Description Of SWMM Computer Model

SWMM is a hydraulic runoff and routing model. It was developed for the Environmental Protection Agency in 1970, has been updated by the University of Florida (1973), the Missouri River Division, Corps of Engineers (1974), and most recently it has been modified for use on personal computers by Boyle Engineering Corporation in 1985.

SWMM models runoff hydraulically by computing excess rainfall from an input hyetograph and routing it through the watershed using a combination of Manning's and continuity equations. The watershed is assumed to be composed of pervious and impervious areas with a Manning's n for overland flow assigned to each area. Rainfall losses are accounted for by using storage losses for the impervious and pervious areas along with Horton's infiltration equation for pervious areas. Hydrographs generated by SWMM may be routed through open channels, gutters, storm drains and reservoirs.

4.1.3 SWMM Input Data

Input data to the SWMM model includes:

(a) Precipitation
(b) Rainfall losses
(c) Basin geometry
(d) Manning's n for overland flow.

A summary of general input data used in the analysis is given in Table 4.1 with discussions of the elements following.

Table 4.1 Summary of Hydrologic Input Data for SWMM Model

Input Parameter	Data Value
Infiltration Rate	
Maximum	4.0 inches/hour
Minimum	0.4 inches/hour
Decay Coefficient	0.00333/second
Depression Storage	
Impervious Areas	0.1 inches
Pervious Areas	0.3 inches
Manning's Resistance for Overland Flow (n)	
Impervious Areas	0.02
Pervious Areas	0.17
Percentages of Imperviousness	
Resort/Residential, Civic Center	60%
Mixed Office, Commercial, Residential	65%
Specialty Areas	85%

(a) Precipitation

Basic rainfall data was obtained from NOAA Atlas II and from the City of Scottsdale Drainage Report Preparation Manual. Precipitation and intensities were calculated at 5-minute intervals for time periods of five minutes to two hours.

As times of runoff concentration are all expected to be less than one hour, a design storm of two hours was considered appropriate. The design storm precipitation pattern was derived in the manner used by the Soil Conservation Service for its design storms (McCuen 1982), ie. the maximum 5-minute intensity was placed within the maximum 10-minute intensity, which in turn was placed within the maximum 15-minute intensity, etc. This arrangement ensures that the design storm will be appropriate for all sizes of drainage basins. A summary of the precipitation data used in the analysis is given in Table 4.2.

Table 4.2 Precipitation from a Two Hour Storm Distribution *

Time (Min)	% of Total	Incremental Rainfall 5-Year	10-year	25-Year	50-year	100-Year
0 - 5	.2	.003	.004	.004	.005	.006
5 - 10	.2	.003	.004	.004	.005	.006
10 - 15	.6	.009	.010	.012	.013	.015
15 - 20	.6	.009	.010	.012	.013	.015
20 - 25	.9	.014	.016	.019	.022	.025
25 - 30	.9	.014	.016	.019	.022	.025
30 - 35	2.5	.038	.044	.053	.060	.069
35 - 40	3.3	.050	.063	.076	.086	.099
40 - 45	4.7	.071	.082	.099	.112	.130
45 - 50	6.6	.099	.114	.137	.155	.179
50 - 55	11.2	.170	.196	.236	.267	.309
55 - 60	27.3	.413	.476	.574	.647	.751
60 - 65	15.3	.231	.266	.321	.362	.420
65 - 70	8.7	.132	.152	.184	.207	.240
70 - 75	5.4	.082	.095	.114	.129	.149
75 - 80	4.0	.061	.070	.084	.095	.110
80 - 85	3.3	.050	.058	.070	.079	.091
85 - 90	1.8	.027	.032	.038	.043	.050
90 - 95	.9	.014	.016	.019	.022	.025
95 - 100	.9	.014	.016	.019	.022	.025
100 - 105	.2	.003	.004	.004	.005	.006
105 - 110	.2	.003	.004	.004	.005	.006
110 - 115	.2	.003	.004	.004	.005	.006
115 - 120	.2	.003	.004	.004	.005	.006
TOTAL	100.0	1.513	1.751	2.109	2.382	2.760

* Precipitation values based on information in NOAA Atlas II and the City of Scottsdale Drainage Report Preparation Manual.

(b) Rainfall Losses

Rainfall losses include infiltration and depression storage.

Infiltration

SWMM models infiltration using Horton's equation:

$$f = f_o + (f_i - f_o)e^{-at}$$

where:
- f = infiltration rate (inches/hour);
- f_i = initial infiltration rate (inches/hour);
- f_o = final infiltration rate (inches/hour);
- a = decay coefficient (1/sec);
- t = time (sec).

Values selected for the infiltration variables were chosen based upon published data and judgment of conditions in Downtown Scottsdale. The variables are dependent upon soil conditions and are related to SCS hydrologic soil groups. Soils in Downtown Scottsdale are hydrologic soil group B, but since research on desert watersheds indicates somewhat less infiltration for soils of a given SCS hydrologic group (Pima County, 1979), the soils have been considered by Boyle as halfway between group B and group C.

The value of 4.0 inches per hour was selected for the beginning of storm (initial) infiltration rate. Published values from 8 inches/hour for SCS type B soils to 5 inches/hour for type C soils have been used in Albuquerque (Golding, 1980), and from 4.5 inches/hour (B) to 3.0 inches/hour (C) have been used in Denver (UDFCD, 1985), with 4.0 being about the average of the values. Sensitivity of SWMM to the initial infiltration value was found to be minimal within the range of 3.0 to 8.0 inches/hour.

A value of 0.4 inches/hour was used for the final (after saturation) infiltration rate. This is the average of values for B and C soils as used in Albuquerque and Denver and as referenced by Tipton and Kalmbach (1985). Also, the Corps of Engineers in their hydrologic investigations for Indian Bend Wash (U.S. Army Corps of Engineers, 1973), while using a hydrograph analysis method for simulating infiltration, used final infiltration rates ranging from 0.37 to 0.23 inches/hour. The selected value of 0.4 inches/hour compares favorably with the Corps of Engineers values.

A decay coefficient of 0.00333/sec was selected. This value is recommended for short duration, high intensity rainfall of the southwest (Tipton and Kalmbach, 1985) and has been verified in Tucson for urban watersheds with type B soils.

Depression Storage

The percentage of impervious area in each drainage basin was determined based upon anticipated ultimate development conditions as outlined in the City of Scottsdale's Downtown Plan (1983). Percentages varied from 60% for Resort/Residential and Civic Center areas to 65% for Mixed Office, Commercial and Residential areas to 85% for Specialty areas. These percentages are in agreement with those used previously by Johnson-Brittain, Inc. (1985).

An impervious area storage loss of 0.10 inches and a pervious storage loss of 0.30 inches was assumed based on recommendations of studies in Albuquerque (Sabol and others, 1982, and Hydro Science Engineers, 1983) and in Denver (Denver Urban Drainage and Flood Control District, 1984). The pervious storage loss value represents a combination of urban lawn and desert landscaping. The percentage of impervious area without storage losses was assumed to be 20%, which is slightly less than the SWMM default value of 25%.

(c) Basin Geometry

For each drainage basin, area, slope and a representative width are required. Areas and slopes were determined from the topographic maps of Downtown Scottsdale. and representative widths were established by dividing basin area by the average flow path length.

(d) Manning's n for Overland Flow

To use Manning's equation for runoff routing, n values for overland flow were required for both pervious and impervious areas. Overland flow n values are typically higher than values used for open channel flows.

For impervious areas, the SWMM Users Manual (UDFCD, 1985) recommends setting n equal to 0.02. For pervious areas, n varies with the vegetation. For urban lawns, an n of 0.25 is recommended (UDFCD, 1985) and for sparse vegetation (desert landscaping) an overland roughness factor N of 0.05 to 0.13 is recommended (HEC, 1981). For this study, an average value of 0.17 was used.

4.2 HYDRAULIC ANALYSIS

4.2.1 Description of STORM Model

Following storm drain sizing using SWMM, another model, STORM, was used to verify the adequacy of the system. STORM is a storm drain analysis program based on the Los Angeles County Flood Control District's Water Surface and Pressure and Gradient Program (WSPG). STORM models the hydraulic gradeline in either open channel or pressure flow situations, analyzes junctions, and determines hydraulic jumps for mainlines, laterals and catch basin connectors.

4.2.2 Street Drainage Criteria

The City of Scottsdale criteria for stormwater flow in any street is a maximum depth of 8 inches during the peak runoff from a 100-year storm. For the type of streets proposed an additional requirement is to maintain at least one dry lane in each direction during the peak of the 100-year storm.

In built-up areas with many storm drains already existing, it is not always feasible to provide for the 100 year storm and the more cost effective solution may be a lower standard. Therefore in evaluating the alternatives in the following section we have established the cost of providing drainage facilities for various return periods. These have included up to the 100 year event for new systems and to the maximum practical return period depending on the capacity of existing systems.

4.2.3 Detention-Retention

An accepted method of handling stormwater runoff is to augment storm drains with detention/retention storage schemes. In this way peak flows may be attenuated, generally reducing the sizes of downstream drains. However, the use of detention/retention in downtown Scottsdale is not considered practical because of the following:

1. Cost of land required for storage compared to the cost of conveying runoff to a regional drain of close proximity.

2. Incentives for redevelopment of Downtown Scottsdale.

3. The study area is at the lower end of the Indian Bend Wash basin. Detaining flows in this area can add to the peak because runoff [illegible] through the system.

4.2.4 Tailwater Conditions

The capacity of the outfalls for the study area start to decrease when levels in Indian Bend Wash are within 2-3 feet of the 100 year flood. The probability that a flood of this magnitude will occur in Indian Bend Wash similtaneously with a major storm on the study area is even more remote. This is because the peak timing of the storm over the larger area is different to the peak timing over the smaller area. For Indian Bend Wash basin, a longer duration, less intense storm would be critical whereas short, highly intense thunder shower activity is critical on the study area. Therefore we have assumed that high tailwaters will not diminish the capacity of the outfalls for design storms on the study area.

5. ALTERNATIVE PROPOSALS

5.1 DRAINAGE CONSIDERATIONS

The two general principles that have guided the selection and analysis of alternative drainage solutions for the downtown area are to utilize the existing drainage system to its fullest capacity and to carry out drainage improvements in the same alignment as future road improvements.

North of the canal, drainage improvements must essentially make use of the existing Corps of Engineers side channels and outfall along Camelback road to the Indian bend wash. Although alternative levels of protection can be provided for the couplets and other road improvements themselves, the ultimate limitation would be the 25 year return period capacity of the Corps outfall.

South of the canal the primary major existing drains include the Scottsdale/Thomas Roads drain and the 2nd Street drain. At present the Scottsdale/Thomas Roads drain is fully utilized and could not accept any further runoff without re-routing some of the existing flow. The 2nd Street drain has excess capacity and can accept additional flow.

The proposed road improvements for the study area are described below. As far as practical, the drain improvements follow the same alignments as the roads.

West Couplet	Separates from Scottsdale Road south of Chaparral Road, passing through a broken "S" curve to follow 70th Street south from Highland Avenue to 2nd Street before returning through another "S" curve to Scottsdale Road just north of Osborn Road.
East Couplet	Separates from Scottsdale Road at Earll Drive, passing through an "S" curve to follow Civic Center Plaza north of Osborn Road to Indian School Road before returning through another "S" curve to Scottsdale Road south of the Arizona Canal.
Scottsdale Rd	Widened between Chaparral Road and the northern end of the East Couplet and reconstructed at a narrower width and different lane configuration between Osborn Road and Earll Drive.
Camelback Rd	Widened from 68th Street to Brown Avenue.
Indian School	Widened from 66th Street to Hayden Road.
Marshall Way	Realigned between Indian School and 3rd Avenue to line up with Marshall Way south of 3rd.
2nd Street	Widened from East Couplet to West Couplet; from Miller Road to 75th Street and from West Couplet to just east of 68th Street.
5th Avenue	Connected to Stetson Drive, crossing the East Couplet.
3rd Avenue	Creates a continuous connection from 5th Avenue at Indian School Road to 3rd Avenue at Buckboard Trail, crossing the West Couplet and Scottsdale Road.

5.2 DESCRIPTION OF ALTERNATIVES

Two alternative drainage solutions have been proposed (A and B). Each has been analyzed for different levels of protection up to the capacity of major existing drains. The primary difference between the two is that Alternative A provides for a new major drain along Indian School enabling a higher level of protection for the study area. Alternative A is shown on Exhibit 1 and B on Exhibit 2. The proposed works include:

Alternative A

Basin A Two new storm drains are constructed along the West Couplet, one connecting to the existing side channel and the other connecting to the existing storm drain along Camelback Road.

Basin B A new storm drain is constructed along Indian School Road draining to the Indian Bend Wash. Branches are extended along Miller Road, 6th Avenue, Hinton Avenue, and the West Couplet north of Indian School.
EAST

Basin C The Scottsdale Road storm drain north of 2nd Street is re-routed to the 2nd Street storm drain and extended to north of 3rd Avenue with branches along Indian School Road and 3rd Avenue. The 2nd Street storm drain is extended west of the West Couplet. Branches extend north along Miller Road, north along the West Couplet and west along Indian School Road.

Basin D Branches are connected to the Scottsdale Road storm drain extending west along Earll Drive and Osborn Road, and northwest along the West Couplet.

Basin E A new storm drain is constructed along Osborn Road to the Indian Bend Wash. Branches drain Miller Road (existing), Hinton Avenue and the East Couplet north and south of Osborn.

Alternative B

Basin A Identical to Basin A in Alternate A.

Basin B The Scottsdale Road storm drain north of 2nd Street is re-routed to the 2nd Street storm drain and extended north of 3rd Avenue with branches extending west along 3rd Avenue and Indian School Road. The 2nd Street storm drain is extended west of Scottsdale Road and branches are constructed north along Miller Road, west along 6th Avenue, west along Indian School Road, north along the East Couplet and Hinton Avenue.

Basin C Branches are connected to the Scottsdale Road storm drain, extending west along Earll Drive and Osborn Road, and west and north along the West Couplet to north of Indian School Road. Other branches are connected to the West Couplet at Indian School Road and 2nd Street.

Basin D Identical to Basin E in Alternate A.

5.3 ALTERNATIVE LEVELS OF PROTECTION

For drainage improvements in built-up areas it is necessary to establish the costs and feasibility for different levels of protection. Therefore in this study we have analyzed each drainage section for the 5 and 10 year protection and up to the maximum feasible capacity while making full use of the existing major drains. A review of the Alternatives established the following maximum levels of protection that could be practically established.

Table 5.1 Maximum Levels of Protection

Basin	Maximum Protection (yrs)	Comments
Alternative A		
A	25	Limited by existing side channel and outfall on Camelback Road.
B	100	New System.
C	50	Limited by Scottsdale Road drain.
D	50	Limited by Scottsdale Road drain.
E	100	New System.
Alternative B		
A	25	Limited by existing side channel and outfall on Camelback Road.
B	25	Limited by 2nd Street drain.
C	10	Limited by Scottsdale Road drain.
D	100	New system.

5.4 ALTERNATIVE COST ESTIMATES

For the comparative cost estimates presented in this report, the costs of new storm drain installations were prepared separately from the costs of utility relocation. The new storm drain construction cost estimates were based on costs per lineal foot of storm drain by pipe size with an additional inlet structure cost based on required inflow.

The storm drain unit costs were developed from recent local storm drain bids and telephone conversations with a local contractor. Storm drain inlet unit costs were based on a standard 9-foot long curb opening inlet with a capacity of 6 cfs costing $1,800 or $300/cfs. This cost was also based on recent local construction bids.

Utility relocation costs are much more intangible since they depend on site specific circumstances. In order to develop a planning level estimate of these costs, unit rates were developed that are generally similar in magnitude to storm drain installation costs. They were broken into utility crossing, utility relocation (parallel) and utility removal (limited to storm drains where the new drains would be constructed along an existing alignment). These unit rates are at a reconnaissance level but were felt to be adequate for comparative cost purposes.

All cost estimates have been computer modeled for this study such that if unit rates were to be changed revised results could be readily developed.

Table 5.2 lists the unit costs used in the estimates and Table 5.3 provide a summary of the utility relocation, pipe and inlet costs for each drainage basin for Alternatives A and B respectively.

Table 5.2 Unit Costs for Storm Drains and Inlets

Pipe Diameter (in)	Unit Rate ($/ft)	Pipe Diameter (in)	Unit Rate ($/ft)	Drainage Inlets ($/cfs)
18	45	60	125	300
24	50	66	135	
30	65	72	155	
36	70	78	170	
42	85	84	225	
48	100	90	275	
54	110	96	310	

Source: Recent Storm Drain Bids and Telephone conversation with local contractors

Table 5.3 Comparative Cost Summary - ($)

	Level of Protection (Years) 5	10	25-50 *	100
ALTERNATIVE A				
Basin A	194,400	226,500	251,800 *	
Basin B	1,286,150	1,394,750	1,695,550	1,725,950
Basin C	948,590	1,019,990	1,214,570	
Basin D	547,700	565,350	705,400	
Basin E	739,600	838,950	1,098,400	1,126,900
TOTAL ALT A	3,716,440	4,045,540	4,965,720	
ALTERNATIVE B				
Basin A	194,400	226,500	251,800 *	
Basin B	1,700,160	1,797,160	2,044,180 *	
Basin C	932,850	985,800		
Basin D	739,600	838,950	1,098,400	1,126,900
TOTAL ALT B	3,567,010	3,848,410		

* 25 Year Maximum

6. PROPOSED WORKS

6.1 PREFERRED ALTERNATIVE

The Alternative solutions for drainage of the downtown area were presented to the City at a meeting with several departments. At that time it was decided that Alternative A was the preferred solution for the following reasons:

1. It provided the capabilities for a higher level of protection (a minimum of 50 years for areas below the canal compared to 10 years for alternative B).

2. It would eliminate the flooding problem on Indian School Road.

3. The costs were not significantly different between the two alternatives.

On the following Tables we have summarized all the details necessary to manage the proposed system. The proposed works are to be read in conjunction with Exhibit 3. They are:

Table 6.1	Hydrology Summary Alternative A
Table 6.2	Hydraulics Summary Alternative A - Maximum Protection
Table 6.3	Hydraulics Summary Alternative A - 10 Year Solution
Table 6.4	Planning Cost Estimate Alternative A (Proposed)
Table 6.5	Proposed Implementation Schedule

We have also included similar Tables in Appendix A for Alternative B.

6.2 SCHEDULE FOR CONSTRUCTION

At a meeting with the City, a preliminary schedule for implementation was established. If other schedules are more applicable in the future, Table 6.3 can be used to establish the estimated costs. The schedule takes into account the necessity of constructing outfalls before some of the smaller drains. The proposed schedule is shown in Table 6.5.

TABLE 6.1 Hydrology Summary - Alternate A

Basin	Pipe No.	Location	Width (ft)	Area (acs)	Imp (%)	Slope (%)	Runoff - (cfs) 5yr	10yr	50yr	100yr
BASIN A										
1	A5	West Couplet	680	47	60	.50	45	57	75	-
2	A4	West Couplet	290	10	80	.48	16	20	26	-
3	A3	West Couplet	360	10	80	.42	17	21	27	-
4	A2	West Couplet	340	9	65	.43	14	17	23	-
BASIN B										
1	B6	6th Avenue	555	31	65	.58	37	45	71	87
2	B4	6th Avenue	390	19	65	.56	24	30	46	56
3	B14	Miller Rd	150	6	80	.44	9	11	17	20
4	B3	Miller Rd	490	20	65	.40	25	31	49	60
5	B13	Indian School	370	23	65	.38	22	28	45	55
6	B10	East Couplet	250	17	65	.70	19	24	37	46
7	B9	Indian School	270	8	65	.41	12	15	22	28
8	B12	Hinton Avenue	240	18	65	.42	16	20	32	40
BASIN C										
0	C18	Indian School	415	12	80	.50	21	26	39	-
1	C16	West Couplet	315	10	80	.49	17	20	31	-
2	C17	2nd Street	290	18	60	.63	20	25	38	-
3	C14	West Couplet	375	15	60	.55	20	24	37	-
4	C13	2nd Street	390	22	70	.50	26	32	50	-
5	C11	Scottsdale Rd	410	16	80	.63	26	32	48	-
6	C20	3rd Avenue	310	22	77	.50	23	28	46	-
7	C19	Indian School	370	16	80	.51	23	28	44	-
8	C7	Scottsdale Rd	490	19	80	.55	30	36	56	-
9	C6	2nd Street	500	21	80	.55	31	39	60	-
10	C4	2nd Street	870	30 *	67	1.90	60	73	112	-
11	C3	2nd Street	260	15	71	.54	18	22	35	-
12	C12	Miller Rd	490	18	65	.56	26	32	49	-
BASIN D										
1	D11	West Couplet	460	15	60	.48	21	26	40	-
2	D9	West Couplet	450	19	72	.56	27	33	52	-
3	D16	Scottsdale Rd	170	5	80	.44	8	10	16	-
4	D14	Osborn Rd	500	27	60	.52	31	38	59	-
5	D13	Osborn Rd	470	20	78	.43	27	34	53	-
11	D12	Earll Drive	405	21	65	.45	24	30	47	-
12	D7	Scottsdale Rd	440	21	80	.40	27	33	52	-
14	D5	Scottsdale Rd	400	16	65	.31	19	24	37	-
BASIN E										
1	E9	East Couplet	395	19	80	.46	25	31	49	60
2	E10	Osborn Rd	370	20	80	.41	23	29	47	58
3	E5	East Couplet	630	11	80	.50	24	30	45	55
4	E8	Hinton Ave	790	36	60	.50	44	54	84	103
5	E7	Miller Rd	310	10	60	.38	14	17	25	31

* Pumped From Sump at 60 cfs

Table 6.2 Hydraulics Summary Alternative A - Maximum Protection

Pipe No.	Location	Size (in)	Slope (%)	Q (cfs)	Depth (ft)	Vel (f/s)
SIN A 25-Year (SWMM)						
	West Couplet	48	.30	54	2.8	5.7
	West Couplet	36	.40	29	2.1	5.5
	West Couplet	48	.65	101	3.7	8.3
	West Couplet	48	.65	77	2.8	8.2
SIN B 100-Year						
	Indian School	84	.42	362	5.0	12.3
	Miller Rd	78	.40	182-225	7.7 P	6.8
	6th Avenue	60	.50	147	5.2 P	7.5
	6th Avenue	60	.50	119	5.2 P	6.1
	6th Avenue	54	.40	91	4.0	6.1
	6th Avenue	54	.40	94	2.8	8.9
	Indian School	60	.50	160	5.0 P	8.1
	Indian School	54	.50	121	4.6 P	7.6
0	East Couplet	36	.50	31-41	2.5	4.9
1	East Couplet	36	.50	21	2.3	3.6
2	Hinton Avenue	36	.50	40	2.6	6.1
3	Indian School	42	.50	56	3.8 P	5.8
4	Miller Rd	42	.36	21	3.1	2.3
SIN C 50-Year						
	2nd Street	96 E	.10	535	11.1 P	13.5
	2nd Street	96 E	.10	505	13.0 P	10.0
	2nd Street	96 E	.10	478	14.7 P	9.5
	2nd Street	96 E	1.06	422	10.1 P	8.4
	2nd Street	90	.69	426	6.4	9.6
	Scottsdale Rd	60 E	.40	186	8.8 P	9.5
	Scottsdale Rd	54 E	.50	139	9.8 P	8.7
	Scottsdale Rd	48 E	.35	94	11.2 P	7.5
0	Scottsdale Rd	48	.56	94	10.0 P	7.5
1	Scottsdale Rd	42	.50	52	9.6 P	5.4
2	Miller Rd	42	.58	50	4.8 P	5.2
3	2nd Street	72	.41	191	3.5	6.8
4	West Couplet	54	.62	110	3.0	7.4
5	West Couplet	48	.62	73	2.5	5.8
6	West Couplet	36	.53	33	1.9	4.7
7	2nd Street	42	.48	39	4.9 P	4.1
8	Indian School	36	.48	40	2.3	7.8
9	Indian School	42	.62	44	5.3 P	4.6
0	3rd Avenue	42	.67	46	8.0 P	4.8
BASIN D 50-Year						
D2	Thomas Rd	102 X	.47	289	3.8	11.6
D3	Thomas Rd	107 X	.06	289	6.1	6.3
D4	Thomas Rd	85 X	.28	310	4.6	11.4
D5	Scottsdale Rd	90 E	.27	333	7.7	7.5
D6	Scottsdale Rd	72 E	.30	298	4.7	12.4
D7	Scottsdale Rd	72 E	.30	256	6.4 P	9.1
D8	Scottsdale Rd	66 E	.30	110	10.1 P	4.6
D9	West Couplet	54	.51	93	8.7 P	5.8
D10	West Couplet	42	.51	41	6.7 P	4.3
D11	West Couplet	42	.57	44	5.3 P	4.6
D12	Earll Drive	48	.46	47	5.9 P	3.7
D13	Osborn Rd	66	.32	112	8.7 P	4.7
D14	Osborn Rd	48	.48	60	7.0 P	4.8
D15	Osborn Rd	48	.40	64	5.1 P	5.1
D16	Scottsdale Rd	66 E	.30	16	9.5 P	0.7
BASIN E 100-Year						
E2	Osborn Rd	84	.25	279	4.3	11.0
E3	Osborn Rd	84	.25	276	5.9	8.0
E4	Osborn Rd	72	.25	172	5.8	6.1
E5	East Couplet	48	.25	54	4.2 P	4.3
E6	East Couplet	42	.58	60	2.4	8.4
E7	Miller Rd	48 E	.30	34	1.7	6.6
E8	Hinton Avenue	60	.33	109	5.2 P	5.6
E9	East Couplet	42	.50	61	3.2	6.6
E10	Osborn Rd	42	.50	56	3.2	6.0

E Existing storm drain.
X Existing storm drain - equivalent pipe diameter.
P Pressure flow - hydraulic grade below street grade.
(SWMM) Analyzed using SWMM only.

Table 6.3 Hydraulics Summary Alternative A - 10 Year Solution

Pipe No.	Location	Size (in)	Slope (%)	Q (cfs)	Depth (ft)	Vel (f/s)
SIN A (SWMM)						
	West Couplet	42	.30	40	2.6	5.2
	West Couplet	30	.40	22	2.1	5.0
	West Couplet	48	.65	78	2.8	8.3
	West Couplet	42	.65	57	2.5	7.8
SIN B						
	Indian School	72	.42	192	3.7	10.3
	Miller Rd	60	.40	88-114	3.6	7.5
	6th Avenue	48	.50	77	3.9	6.1
	6th Avenue	49	.50	62	3.7	5.1
	6th Avenue	42	.40	47	2.7	5.7
	6th Avenue	42	.40	27	3.2	2.9
	Indian School	48	.50	83	2.7	9.0
	Indian School	48	.50	63	3.9	5.0
0	East Couplet	30	.50	18-23	2.06	5.3
1	East Couplet	30	.50	12	1.4	3.9
2	Hinton Avenue	30	.50	20	1.9	4.9
3	Indian School	36	.50	28	2.4	4.5
4	Miller Rd	24	.36	11	1.1	5.7
SIN C						
	2nd Street	96 E	.10	362	4.8	11.4
	2nd Street	96 E	.10	350	7.4	7.2
	2nd Street	96 E	.10	333	7.9	6.6
	2nd Street	96 E	.06	282	8.6 P	5.6
	2nd Street	72	.69	281	4.2	13.0
	Scottsdale Rd	60 E	.40	123	7.6 P	6.3
	Scottsdale Rd	54 E	.50	90	6.6 P	5.7
	Scottsdale Rd	48 E	.35	62	5.4 P	4.9
0	Scottsdale Rd	42	.56	62	3.5	6.4
1	Scottsdale Rd	36	.50	33	3.6 P	4.7
2	Miller Rd	42	.58	33	2.8	3.9
3	2nd Street	66	.41	122	6.1 P	5.1
4	West Couplet	48	.62	70	2.9	7.2
5	West Couplet	42	.62	47	3.2	5.0
6	West Couplet	30	.53	21	2.6 P	4.3
7	2nd Street	30	.48	25	5.6 P	5.6
8	Indian School	30	.48	25	1.7	7.0
9	Indian School	36	.62	28	2.8	4.1
0	3rd Avenue	36	.67	29	2.8	4.2
BASIN D						
D2	Thomas Rd	102 X	.47	198	3.1	10.5
D3	Thomas Rd	107 X	.06	199	4.8	5.7
D4	Thomas Rd	85 X	.28	211	3.7	9.9
D5	Scottsdale Rd	90 E	.27	222	5.9	5.9
D6	Scottsdale Rd	72 E	.30	199	3.8	10.4
D7	Scottsdale Rd	72 E	.30	170	4.4	7.6
D8	Scottsdale Rd	66 E	.30	71	5.7 P	3.0
D9	West Couplet	42	.51	60	2.6	7.6
D10	West Couplet	36	.51	27	4.1 P	3.8
D11	West Couplet	36	.57	29	2.6	4.4
D12	Earll Drive	36	.46	30	2.9	4.3
D13	Osborn Rd	54	.32	72	3.4	5.5
D14	Osborn Rd	36	.48	39	3.3 P	5.5
D15	Osborn Rd	36	.40	40	2.0	7.8
D16	Scottsdale Rd	66 E	.30	10	4.6	0.5
BASIN E						
E2	Osborn Rd	72	.25	154	3.3	9.4
E3	Osborn Rd	72	.25	144	4.6	6.1
E4	Osborn Rd	60	.25	90	3.9	5.4
E5	East Couplet	36	.25	29	2.2	5.2
E6	East Couplet	36	.58	33	1.8	7.2
E7	Miller Rd	48 E	.30	17	1.2	5.3
E8	Hinton Avenue	48	.33	54	3.4	4.7
E9	East Couplet	36	.50	31	1.8	7.0
E10	Osborn Rd	36	.50	30	1.7	6.9

E Existing storm drain.
X Existing storm drain - equivalent pipe size.
P Pressure flow - hydraulic grade below street grade.

Table 6.4 Planning Cost Estimate - Alternative A (Proposed)

Location	Length (ft)	Utility Cost ($)	5 YEAR Pipe Cost ($)	5 YEAR Inlet Cost ($)	5 YEAR Total Cost ($)	10 YEAR Pipe Cost ($)	10 YEAR Inlet Cost ($)	10 YEAR Total Cost ($)	25-50 YEAR Pipe Cost ($)	25-50 YEAR Inlet Cost ($)	25-50 YEAR Total Cost ($)	100 YEAR Pipe Cost ($)	100 YEAR Inlet Cost ($)	100 YEAR Total Cost ($)
BASIN A														
West Couplet	250	1,500	17,500	4,200	23,200	21,250	5,100	27,850	25,000	6,900	33,400			
West Couplet	500		32,500	5,100	37,600	32,500	6,300	38,800	35,000	8,100	43,100			
West Couplet	880	2,000	74,800	4,800	81,600	88,000	6,000	96,000	88,000	7,800	97,800			
West Couplet	550		38,500	13,500	52,000	46,750	17,100	63,850	55,000	22,500	77,500			
TOTAL BASIN A		3,500	163,300	27,600	194,400	188,500	34,500	226,500	203,000	45,300	251,800			
BASIN B														
Indian School	1950	40,500	263,250		303,750	302,250		342,750	438,750		479,250	438,750		479,250
Miller Rd.	1320	32,900	145,200	7,500	185,600	165,000	9,300	207,200	204,600	14,700	252,200	204,600	18,000	255,500
6th Ave.	425	8,500	42,500	4,200	55,200	42,500	5,400	56,400	53,125	8,400	70,025	53,125	10,800	72,425
6th Ave.	425	17,500	42,500	3,000	63,000	42,500	3,600	63,600	53,125	5,400	76,025	53,125	6,000	76,625
6th Ave.	400	10,500	28,000	5,100	43,600	34,000	6,300	50,800	40,000	10,200	60,700	44,000	12,600	67,100
6th Ave.	450	20,500	31,500	6,000	58,000	38,250	7,200	65,950	45,000	11,100	76,600	49,500	13,500	83,500
Indian School	700	74,000	70,000	1,200	145,200	70,000	1,500	145,500	87,500	2,400	163,900	87,500	3,000	164,500
Indian School	670	31,650	56,950	3,600	92,200	67,000	4,500	103,150	73,700	6,600	111,950	73,700	8,400	113,750
East Couplet	1200		78,000	2,100	80,100	78,000	2,700	80,700	84,000	6,900	90,900	84,000	8,700	92,700
East Couplet	1100	27,500	71,500	3,600	102,600	71,500	4,500	103,500	77,000	4,200	108,700	77,000	5,100	109,600
Hinton St.	800		40,000	3,600	43,600	52,000	4,500	56,500	56,000	7,200	63,200	56,000	9,000	65,000
Indian School	600	30,000	39,000	6,600	75,600	42,000	8,400	80,400	51,000	13,500	94,500	51,000	16,500	97,500
Miller Rd.	500	10,000	25,000	2,700	37,700	25,000	3,300	38,300	32,500	5,100	47,600	32,500	6,000	48,500
TOTAL BASIN B		303,550	933,400	49,200	1,286,150	1,030,000	61,200	1,394,750	1,296,300	95,700	1,695,550	1,304,800	117,600	1,725,950
BASIN C														
2nd St.	1440													
2nd St.	600			4,800	4,800		6,000	6,000		10,500	10,500			
2nd St.	690													
2nd St.	565													
2nd St.	750	7,750	101,250	1,800	110,800	116,250	1,800	125,800	168,750	1,800	178,300			
Scottsdale Rd	658			7,200	7,200		9,900	9,900		15,900	15,900			
Scottsdale Rd	644			2,100	2,100		2,700	2,700		4,800	4,800			
Scottsdale Rd	130			300	300		600	600		1,200	1,200			
Scottsdale Rd	600	1,000	51,000	1,200	53,200	51,000	1,500	53,500	60,000	2,700	63,700			
Scottsdale Rd	600	6,000	39,000	7,800	52,800	42,000	9,600	57,600	51,000	14,400	71,400			
Miller Rd.	650		55,250	6,900	62,150	55,250	9,600	64,850	55,250	14,700	69,950			
2nd St.	1280	34,600	160,000	7,800	202,400	172,800	9,600	217,000	198,400	15,000	248,000			
West Couplet	640	10,250	54,400	4,500	69,150	64,000	5,400	79,650	70,400	8,100	88,750			
West Couplet	700	18,500	49,000	1,500	69,000	59,500	1,800	79,800	70,000	3,000	91,500			
West Couplet	830		53,950	5,100	59,050	53,950	6,000	59,950	58,100	9,300	67,400			
2nd St.	628	15,600	40,820	6,000	62,420	40,820	7,500	63,920	43,960	11,400	70,960			
Indian School	800	1,500	52,000	4,800	58,300	52,000	6,000	59,500	56,000	10,200	67,700			
Indian School	806	1,000	56,420	3,900	61,320	56,420	4,800	62,220	68,510	7,500	77,010			
3rd Ave.	500	36,000	32,500	5,100	73,600	35,000	6,000	77,000	42,500	9,000	87,500			
TOTAL BASIN C		132,200	745,590	70,800	948,590	798,990	88,800	1,019,990	942,870	139,500	1,214,570			

Table 6.4 Cont'd Planning Cost Estimate - Alternative A

Location	Length (ft)	Utility Cost ($)	5 YEAR Pipe Cost ($)	5 YEAR Inlet Cost ($)	5 YEAR Total Cost ($)	10 YEAR Pipe Cost ($)	10 YEAR Inlet Cost ($)	10 YEAR Total Cost ($)	25-50 YEAR Pipe Cost ($)	25-50 YEAR Inlet Cost ($)	25-50 YEAR Total Cost ($)	100 YEAR Pipe Cost ($)	100 YEAR Inlet Cost ($)	100 YEAR Total Cost ($)
BASIN D														
Thomas Rd.	350													
Thomas Rd.	1600													
Thomas Rd.	2208													
Scottsdale Rd	980			5,700	5,700		7,200	7,200		11,100	11,100			
Scottsdale Rd	450			1,200	1,200		1,500	1,500		3,000	3,000			
Scottsdale Rd	1300			7,500	7,500		9,300	9,300		15,000	15,000			
Scottsdale Rd	320			1,800	1,800		2,700	2,700		4,800	4,800			
West Couplet	950	12,250	80,750	4,800	97,800	80,750	6,000	99,000	104,500	9,000	125,750			
West Couplet	480	7,250	31,200	1,200	39,650	33,600	1,200	42,050	40,800	1,500	49,550			
West Couplet	350	6,500	22,750	6,300	35,550	24,500	7,800	38,800	29,750	12,000	48,250			
Earll Dr.	700	6,500	49,000	5,400	60,900	49,000	6,600	62,100	70,000	10,200	86,700			
Osborn Rd.	830	95,700	91,300	8,100	195,100	91,300	10,200	197,200	112,050	15,900	223,650			
Osborn Rd.	550	16,000	38,500	2,400	56,900	38,500	3,000	57,500	55,000	4,800	75,800			
Osborn Rd.	250	20,000	17,500	6,900	44,400	17,500	8,400	45,900	25,000	12,900	57,900			
Scottsdale Rd	1054			1,200	1,200		2,100	2,100		3,900	3,900			
TOTAL BASIN D		164,200	331,000	52,500	547,700	335,150	66,000	565,350	579,390	104,100	705,400			
BASIN E														
Osborn Rd.	1500		202,500		202,500	232,500		232,500	337,500		337,500	337,500		337,500
Osborn Rd.	650	15,000	87,750	3,300	106,050	100,750	4,200	119,950	146,250	6,300	167,550	146,250	7,800	169,050
Osborn Rd.	660	5,500	56,100	3,300	64,900	82,500	3,900	91,900	102,300	6,300	114,100	102,300	7,800	115,600
East Couplet	850	51,500	59,500	3,600	114,600	59,500	4,200	115,200	85,000	6,600	143,100	85,000	8,100	144,600
East Couplet	400	9,000	26,000	3,600	36,100	28,000	4,200	41,200	34,000	6,900	47,400	34,000	8,400	48,900
Miller Rd.	700			4,200	4,200		5,100	5,100		7,500	7,500		9,300	9,300
Hinton St.	800	1,500	68,000	6,600	76,100	80,000	8,100	89,600	88,000	13,200	102,700	100,000	15,300	116,800
East Couplet	600	3,000	39,000	7,500	49,500	42,000	9,300	54,300	51,000	14,700	68,700	51,000	18,000	72,000
Osborn Rd.	850	21,000	55,250	6,900	83,150	59,500	8,700	89,200	72,250	14,100	107,350	72,250	17,400	110,650
TOTAL BASIN E		106,500	594,100	39,000	739,600	684,750	47,700	838,950	916,300	75,600	1,098,400	928,300	92,100	1,126,900
TOTAL ALTERNATIVE A		709,950	2,767,390	239,100	3,716,440	3,037,390	298,200	4,045,540	3,795,570	460,200	4,965,720			

Table 6.5 Proposed Implementation Schedule

1986-1987		1987-1988		1988-1989		1989-1990		1990-1991		Remainder	
Pipe No.	Cost ($)	Pipe No.	Cost ($)	Pipe No.	Cost ($)	Pipe No.	Cost ($)	Pipe No.	Cost ($)	Pipe No.	Cost ($)
A4	97,800	B2	479,250	2E	337,500	C13	248,000	A2	33,400	B3	255,500
A5	77,500	B8	164,500	E3	169,050	C14	88,750	A3	43,100	B4	72,425
C6	178,300	B9	113,750	E4	115,600	C15	91,500	D13	223,650	B5	76,625
D9	125,750	B10	92,700	E5	144,600	C16	67,400	D14	75,800	B6	67,100
D10	49,550	B11	109,600	E6	51,400	C17	70,960	D15	57,900	B7	83,500
D11	48,250	B13	97,500	E7	9,300	C18	67,700			B12	65,000
				E8	116,800					B14	48,500
				E9	72,000					C3	10,500
				E10	110,650					C7	15,900
										C8	4,800
										C9	1,200
										C10	63,700
										C11	71,400
										C12	69,950
										C19	77,010
										C20	87,500
										D5	11,100
										D6	3,000
										D7	15,000
										D8	4,800
										D12	86,700
										D16	3,900
	$577,150		$1,057,300		$1,126,900		$634,310		$433,850		$1,195,110

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Table A.1 Hydrology Summary - Alternative B

Basin	Pipe No.	Location	Width (ft)	Area (acs)	Imp (%)	Slope (%)	Runoff - (cfs) 5yr	10yr	50yr	100yr
BASIN A										
1	A5	West Couplet	680	47	60	.50	45	57	75 +	-
2	A4	West Couplet	290	10	80	.48	16	20	26 +	-
3	A3	West Couplet	360	10	80	.42	17	21	27 +	-
4	A2	West Couplet	340	9	65	.43	14	17	23 +	-
BASIN B										
1	B10	Scottsdale Rd	410	16	80	.63	37	32	41	-
2	B27	3rd Avenue	310	22	77	.50	23	28	38	-
3	B26	Indian School	370	16	80	.51	23	28	37	-
4	B25	2nd Street	390	22	70	.50	26	32	42	-
5	B7	Scottsdale Rd	490	19	80	.55	30	36	48	-
6	B6	2nd Street	500	71	90	.55	31	39	51	-
7	B4	2nd Street	870	30	67	.90	60	73	95 *	-
8	B3	2nd Street	260	15	71	.54	18	22	29	-
9	B20	East Couplet	250	17	65	.70	19	24	31	-
10	B23	Indian School	370	23	65	.38	22	28	37	-
11	B16	6th Avenue	555	31	65	.58	37	45	60	-
12	B14	6th Avenue	390	19	65	.56	24	30	39	-
13	B24	Miller Rd	150	6	80	.44	9	11	14	-
14	B19	Indian School	270	8	65	.41	12	15	19	-
15	B22	Hinton Avenue	240	18	65	.42	16	20	27	-
16	B13	Miller Rd	490	20	65	.40	25	31	41	-
17	B11	Miller Rd	490	18	65	.86	29	35	46	-
BASIN C +										
0	C22	Indian School	415	12	80	.50	21	26	-	-
1	C14	West Couplet	315	12	80	.49	18	23	-	-
2	C21	2nd Street	290	18	60	.63	20	25	-	-
3	C12	West Couplet	375	15	60	.50	20	24	-	-
4	C20	West Couplet	460	15	60	.48	21	26	-	-
5	C9	West Couplet	450	19	72	.56	27	33	-	-
6	C17	Osborn Rd	500	27	60	.52	31	38	-	-
7	C16	Osborn Rd	470	20	78	.43	27	34	-	-
8	C19	Scottsdale Rd	170	5	80	.44	8	10	-	-
12	C15	Earll Drive	405	21	65	.45	24	30	-	-
13	C7	Scottsdale Rd	470	23	80	.40	29	36	-	-
17	C5	Scottsdale Rd	400	16	65	.31	19	24	-	-
BASIN D										
1	D11	West Couplet	460	15	60	.48	21	26	40	-
2	D9	West Couplet	450	19	72	.56	27	33	52	-
3	D16	Scottsdale Rd	170	5	80	.44	8	10	16	-
4	D14	Osborn Rd	500	27	60	.52	31	38	59	-
5	D13	Osborn Rd	470	20	78	.43	27	34	53	-
11	D12	Earll Drive	405	21	65	.45	24	30	47	-
12	D7	Scottsdale Rd	440	21	80	.40	27	33	52	-
14	D5	Scottsdale Rd	400	16	65	.31	19	24	37	-

Table A.2 Hydraulics Summary Alternative B - Maximum Protection

Location	Size (in)	Slope (%)	Q (cfs)	Depth (ft)	Vel (f/s)
N A					
West Couplet	48	.30	54	2.8	5.7
West Couplet	36	.40	29	2.1	5.5
West Couplet	48	.65	101	3.7	8.3
West Couplet	48	.65	77	2.8	8.2
N B 25-Year					
2nd Street	96 E	.10	607	6.2	14.4
2nd Street	96 E	.10	332	16.2 P	6.6
2nd Street	96 E	.10	303	16.7 P	6.0
2nd Street	96 E	1.06	246	17.3 P	4.9
2nd Street	72	.69	244	9.3 P	8.6
Scottsdale Rd	60 E	.40	156	7.6 P	7.9
Scottsdale Rd	54 E	.50	119	7.8 P	7.5
Scottsdale Rd	48	.56	82	7.6 P	6.5
Scottsdale Rd	42	.50	44	6.7 P	4.6
Miller Rd	84	.33	298	13.6 P	7.7
Miller Rd	78	.62	260	12.8 P	7.8
Miller Rd	66	.53	153	11.2 P	6.4
6th Avenue	54	.50	101	7.9 P	6.4
6th Avenue	54	.74	101	7.1 P	6.4
6th Avenue	48	.50	61	5.5 P	4.9
6th Avenue	48	.50	63	4.3 P	5.0
Indian School	54	.60	110	9.5 P	6.9
Indian School	48	.60	84	7.8 P	6.7
East Couplet	36	.50	30	6.6 P	4.2
East Couplet	36	.86	31	3.5 P	4.4
Hinton Avenue	36	.50	27	6.5 P	3.8
Indian School	36	.60	38	6.0 P	5.4
Miller Rd	30	.36	14	5.1 P	2.9
2nd Street	42	.64	42	5.8 P	4.4
Indian School	42	.62	37	5.8 P	3.8
3rd Avenue	42	.67	38	6.3 P	3.9

Pipe No.	Location	Size (in)	Slope (%)	Q (cfs)	Depth (ft)	Vel (f/s)
BASIN C 20-Year						
C2	Thomas Rd	102 X	.47	272	3.7	11.4
C3	Thomas Rd	107 X	.06	272	6.1	6.0
C4	Thomas Rd	85 X	.28	291	4.4	11.1
C5	Scottsdale Rd	90 E	.27	301	7.3	7.3
C6	Scottsdale Rd	72 E	.30	280	4.5	12.1
C7	Scottsdale Rd	72 E	.30	258	5.9	9.1
C8	Scottsdale Rd	66 E	.30	159	7.9 P	6.7
C9	West Couplet	60	.51	149	6.9 P	7.6
C10	West Couplet	54	.51	120	5.7 P	7.5
C11	West Couplet	54	.50	96	6.3 P	6.0
C12	West Couplet	48	.62	71	5.3 P	5.6
C13	West Couplet	42	.62	50	3.2	5.4
C14	West Couplet	36	.53	23	3.1 P	3.3
C15	Earll Drive	36	.46	30	4.4 P	4.2
C16	Osborn Rd	54	.20	70	5.8 P	4.4
C17	Osborn Rd	36	.48	38	4.1 P	5.4
C18	Osborn Rd	36	.40	40	3.3 P	5.7
C19	Scottsdale Rd	66 E	.31	10	7.4 P	0.4
C20	West Couplet	36	.57	29	4.8 P	4.1
C21	2nd Street	30	.48	25	3.6 P	5.1
C22	Indian School	36	.40	26	2.2	4.6
BASIN D						
D2	Osborn Rd	84	.25	279	4.3	11.0
D3	Osborn Rd	84	.25	276	5.9	8.0
D4	Osborn Rd	72	.25	172	5.8	6.1
D5	East Couplet	48	.25	54	4.2 P	4.3
D6	East Couplet	42	.58	60	2.4	8.4
D7	Miller Rd	48 E	.30	34	2.1	6.6
D8	Hinton Avenue	60	.33	109	5.2 P	5.6
D9	East Couplet	42	.50	61	3.2	6.6
D10	Osborn Rd	42	.50	56	3.2	6.0

xisting storm drain.
xisting storm drain - equivalent pipe size.
ressure flow - hydraulic grade below street grade.

Table A 3 Hydraulics Summary Alternative B - 10 Year Solution

ipe o.	Location	Size (in)	Slope (%)	Q (cfs)	Depth (ft)	Vel (f/s)
ASIN A						
2	West Couplet	42	.30	40	2.6	5.2
3	West Couplet	30	.40	22	2.1	5.0
4	West Couplet	48	.65	78	2.8	8.3
5	West Couplet	42	.65	57	2.5	7.8
ASIN B						
2	2nd Street	96 E	.10	488	5.6	12.9
3	2nd Street	96 E	.10	273	11.9 P	5.4
4	2nd Street	96 E	.10	252	12.1 P	5.0
5	2nd Street	96 E	1.06	190	8.0	3.8
6	2nd Street	66	.69	190	3.5	11.9
7	Scottsdale Rd	60 E	.40	123	5.5	6.3
8	Scottsdale Rd	54 E	.50	90	4.4	5.7
9	Scottsdale Rd	42	.56	62	2.8	7.3
10	Scottsdale Rd	36	.50	33	3.5 P	4.7
11	Miller Rd	78	.33	252	9.4 P	7.6
12	Miller Rd	72	.62	197	9.1 P	7.0
13	Miller Rd	60	.53	114	6.9 P	5.8
14	6th Avenue	48	.50	77	4.4 P	6.1
15	6th Avenue	48	.74	62	4.1 P	
.9						
16	6th Avenue	42	.50	47	2.7	5.7
17	6th Avenue	42	.50	24	3.3	2.5
18	Indian School	48	.60	82	5.4 P	6.5
19	Indian School	42	.60	62	3.7 P	6.4
20	East Couplet	42	.50	23	3.0	2.6
21	East Couplet	30	.86	21	1.9	5.1

Pipe No.	Location	Size (in)	Slope (%)	Q (cfs)	Depth (ft)	Vel (f/s)
BASIN C						
C2	2nd Street	96 E	.10	535	5.8	13.5
C3	2nd Street	96 E	.10	505	11.5 P	10.0
C4	2nd Street	96 E	.10	478	13.3 P	9.5
C5	2nd Street	96 E	1.06	422	15.3 P	8.4
C6	2nd Street	90	.69	426	7.5	9.6
C7	Scottsdale Rd	60 E	.40	186	7.6 P	9.5
C8	Scottsdale Rd	54 E	.50	139	9.3 P	8.7
C9	Scottsdale Rd	48 E	.35	94	11.0 P	7.5
C10	Scottsdale Rd	48	.56	94	11.2 P	7.5
C11	Scottsdale Rd	42	.50	52	10.7 P	5.4
C12	Miller Rd	42	.58	50	6.8 P	5.2
C13	2nd Street	72	.41	191	6.7 P	6.8
C14	West Couplet	54	.62	110	3.9	7.4
C15	West Couplet	48	.62	73	4.1 P	5.8
C16	West Couplet	36	.53	33	3.4 P	4.7
C17	2nd Street	42	.48	39	6.8 P	4.1
C18	Indian School	36	.48	40	2.0	7.8
C19	Indian School	42	.62	44	8.5 P	4.6
C20	3rd Avenue	42	.67	46	10.1 P	4.8
BASIN						
D2	Osborn Rd	72	.25	154	3.3	9.4
D3	Osborn Rd	72	.25	144	4.6	6.1
D4	Osborn Rd	60	.25	90	3.9	5.4
D5	East Couplet	36	.25	29	2.2	5.2
D6	Eastrotection					

for the 100 year storm to floor levels of buildings that are above street level . The difference in runoff between the 100 year and the final selected storm will be conveyed by the streets. Table 2.1 summarizes the maximum level of protection for each basin and alternative with full practical use of the existing drains.

Table A.4 Planning Cost Estimate - Alternative B

Location	Length (ft)	Utility Cost ($)	5 YEAR Pipe Cost ($)	5 YEAR Inlet Cost ($)	5 YEAR Total Cost ($)	10 YEAR Pipe Cost ($)	10 YEAR Inlet Cost ($)	10 YEAR Total Cost ($)	25-50 YEAR Pipe Cost ($)	25-50 YEAR Inlet Cost ($)	25-50 YEAR Total Cost ($)	100 YEAR Pipe Cost ($)	100 YEAR Inlet Cost ($)	100 YEAR Total Cost ($)
BASIN A		Same as Basin A in Alternative A												
TOTAL BASIN A		3,500	163,300	27,600	194,400	188,500	34,500	226,500	203,000	45,300	251,800			
BASIN B														
2nd St	1,440													
2nd St	600			4,800	4,800		6,000	6,000	7,800	10,500	18,300			
2nd St	690													
2nd St	565													
2nd St	750	7,750	93,750	6,300	107,800	101,250	7,800	116,800	116,250	12,000	136,000			
Scottsdale Rd	658			7,200	7,200		9,900	9,900		15,900	15,900			
Scottsdale Rd	644			2,100	2,100		2,700	2,700		4,800	4,800			
Scottsdale Rd	730	1,000	62,050	1,500	64,550	62,050	2,100	65,150	73,000	3,900	77,900			
Scottsdale Rd	600	9,000	39,000	7,800	55,800	42,000	9,600	60,600	51,000	14,400	74,400			
Miller Rd	650	10,500	100,750	4,800	116,050	100,750	5,700	116,950	146,250	7,500	164,250			
Miller Rd	620	18,250	83,700	3,900	105,850	96,100	4,800	119,150	96,100	6,300	120,650			
Miller Rd	1,320	80,900	145,200	7,500	233,600	165,000	9,300	255,200	178,200	12,300	271,400			
6th Ave	425	8,500	36,125	3,000	47,625	42,500	3,600	54,600	46,750	4,800	60,050			
6th Ave	425	17,500	36,125	4,200	57,825	42,500	5,400	65,400	46,750	6,900	71,150			
6th Ave	400	10,500	28,000	6,000	44,500	34,000	7,200	51,700	40,000	9,600	60,100			
6th Ave	450	20,500	31,500	5,100	57,100	38,250	6,300	65,050	45,000	8,400	73,900			
Indian School	700	74,000	70,000	1,200	145,200	70,000	1,500	145,500	77,000	2,100	153,100			
Indian School	670	31,650	56,950	3,600	92,200	56,950	4,500	93,100	67,000	5,700	104,350			
East Couplet	1,200		78,000	3,600	81,600	78,000	4,500	82,500	84,000	5,700	89,700			
East Couplet	1,100	27,500	71,500	2,100	101,100	71,500	2,700	101,700	77,000	3,600	108,100			
75th St	800		52,000	3,600	55,600	52,000	4,500	56,500	56,000	6,000	62,000			
Indian School	600	30,000	39,000	6,600	75,600	42,000	8,400	80,400	42,000	11,100	83,100			
Miller Rd	500	10,000	25,000	2,700	37,700	25,000	3,300	38,300	32,500	4,200	46,700			
2nd St	672	14,100	47,040	7,800	68,940	47,040	9,600	70,740	57,120	12,600	83,820			
Indian School	806	1,000	56,420	3,900	61,320	56,420	4,800	62,220	68,510	7,500	77,010			
3rd Ave	500	36,000	35,000	5,100	76,100	35,000	6,000	77,000	42,500	9,000	87,500			
TOTAL BASIN B		408,650	1,187,110	104,400	1,700,160	1,258,310	130,200	1,797,160	1,450,730	184,800	2,044,180			

Table A.4 Cont'd Planning Cost Estimate - Alternative B

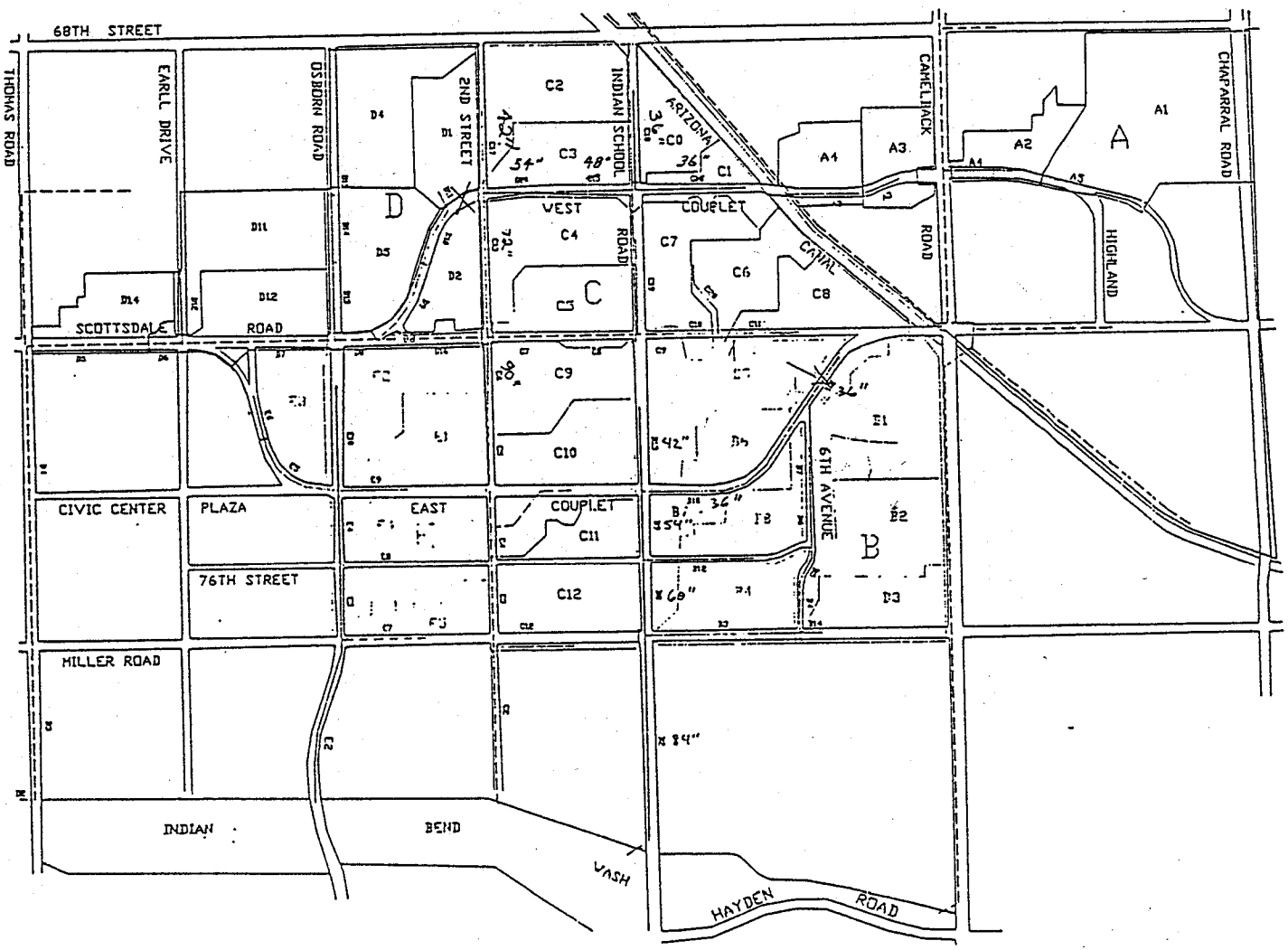
pe .	Location	Length (ft)	Utility Cost ($)	5 YEAR Pipe Cost ($)	5 YEAR Inlet Cost ($)	5 YEAR Total Cost ($)	10 YEAR Pipe Cost ($)	10 YEAR Inlet Cost ($)	10 YEAR Total Cost ($)	25-50 YEAR Pipe Cost ($)	25-50 YEAR Inlet Cost ($)	25-50 YEAR Total Cost ($)	100 YEAR Pipe Cost ($)	100 YEAR Inlet Cost ($)	100 YEAR Total Cost ($)
	BASIN C														
2	Thomas Rd.	350													
3	Thomas Rd.	1,600													
4	Thomas Rd.	2,208													
5	Scottsdale Rd	980			5,700	5,700		7,200	7,200						
6	Scottsdale Rd	450			1,200	1,200		1,500	1,500						
7	Scottsdale Rd	1,300			7,500	7,500		9,300	9,300						
8	Scottsdale Rd	320			1,800	1,800		2,700	2,700						
9	West Couplet	950	13,750	104,500	4,800	123,050	118,750	6,000	138,500						
10	West Couplet	480	7,250	52,800	1,200	61,250	52,800	1,200	61,250						
11	West Couplet	370	5,500	40,700		46,200	40,700		46,200						
12	West Couplet	640	11,000	64,000	6,000	81,000	64,000	7,200	82,200						
13	West Couplet	700	18,500	49,000	1,500	69,000	59,500	1,800	79,800						
14	West Couplet	830		53,950	5,100	59,050	58,100	6,000	64,100						
15	Earll Dr.	700	6,500	49,000	5,400	60,900	49,000	6,600	62,100						
16	Osborn Rd.	838	58,350	92,180	8,100	158,630	92,180	10,200	160,730						
17	Osborn Rd.	550	16,000	38,500	2,400	56,900	38,500	3,000	57,500						
18	Osborn Rd.	250	20,000	17,500	6,900	44,400	17,500	8,400	45,900						
19	Scottsdale Rd	1,054			1,200	1,200		2,100	2,100						
20	West Couplet	350	6,500	22,750	6,300	35,550	24,500	7,800	38,800						
21	2nd St.	628	14,100	40,820	6,000	60,920	40,820	7,500	62,420						
22	Indian School	800	1,500	52,000	5,100	58,600	56,000	6,000	63,500						
	TOTAL BASIN C		178,950	677,700	76,200	932,850	712,350	94,500	985,800						
	BASIN D			Same as Basin E in Alternative A											
	TOTAL BASIN D		106,500	594,100	39,000	739,600	684,750	47,700	838,950	916,300	75,600	1,098,400	928,300	92,100	1,126,900
	TOTAL ALTERNATIVE B		697,600	2,627,210	247,200	3,567,010	2,843,910	306,900	3,848,410						

APPENDIX B

List of attendees at meeting on April 10, 1986

Paul Basha
Larry Bassard
Dick Schaner
Donna Anderson
Greg Kiley
Ken Lewis

EXHIBIT 1



LEGEND

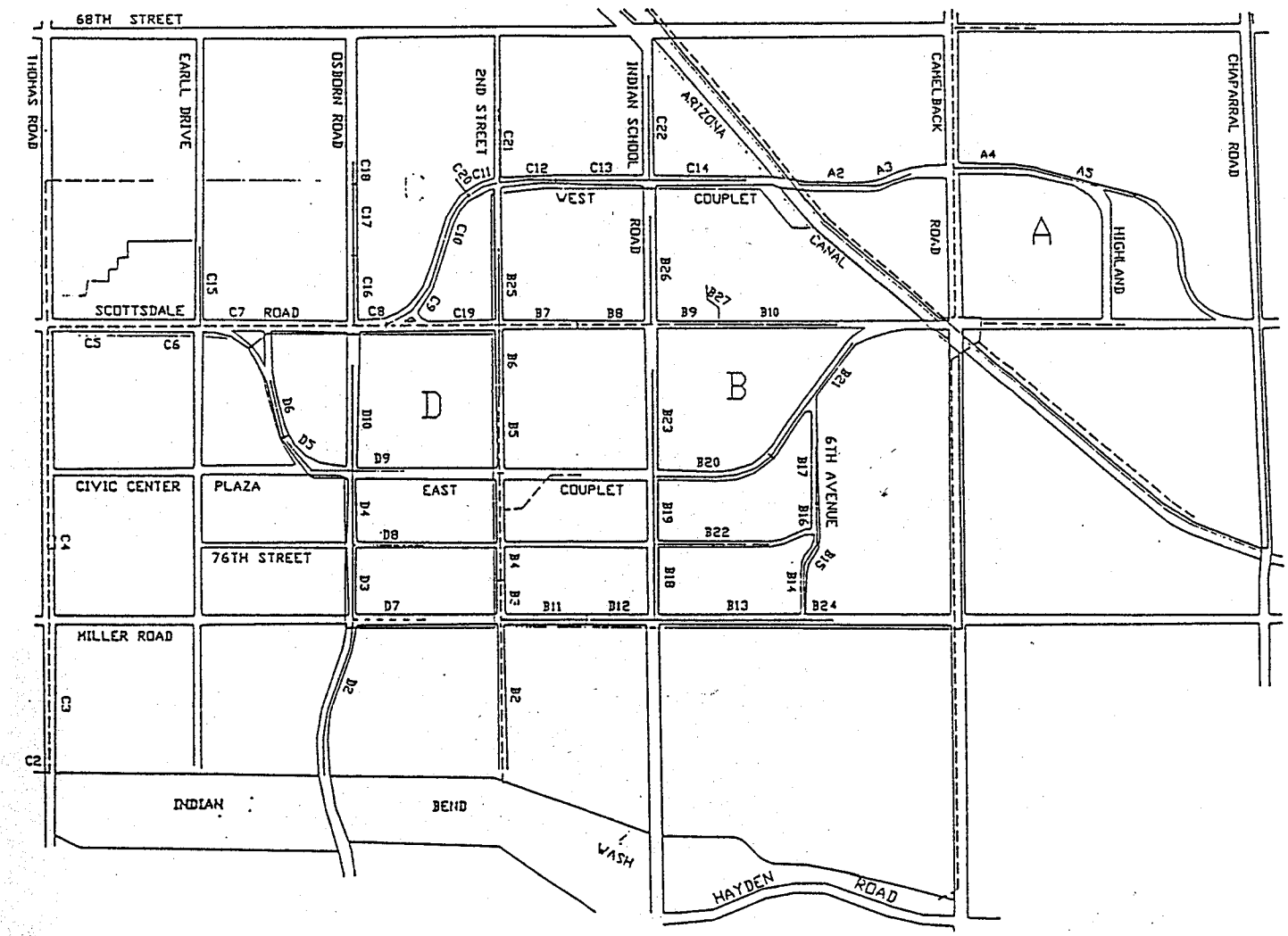
EXIST. STORM DRAINS

PROPOSED DRAINS

ALTERNATIVE A
DRAINAGE SYSTEM

BOYLE ENGINEERING CORPORATION

EXHIBIT 2



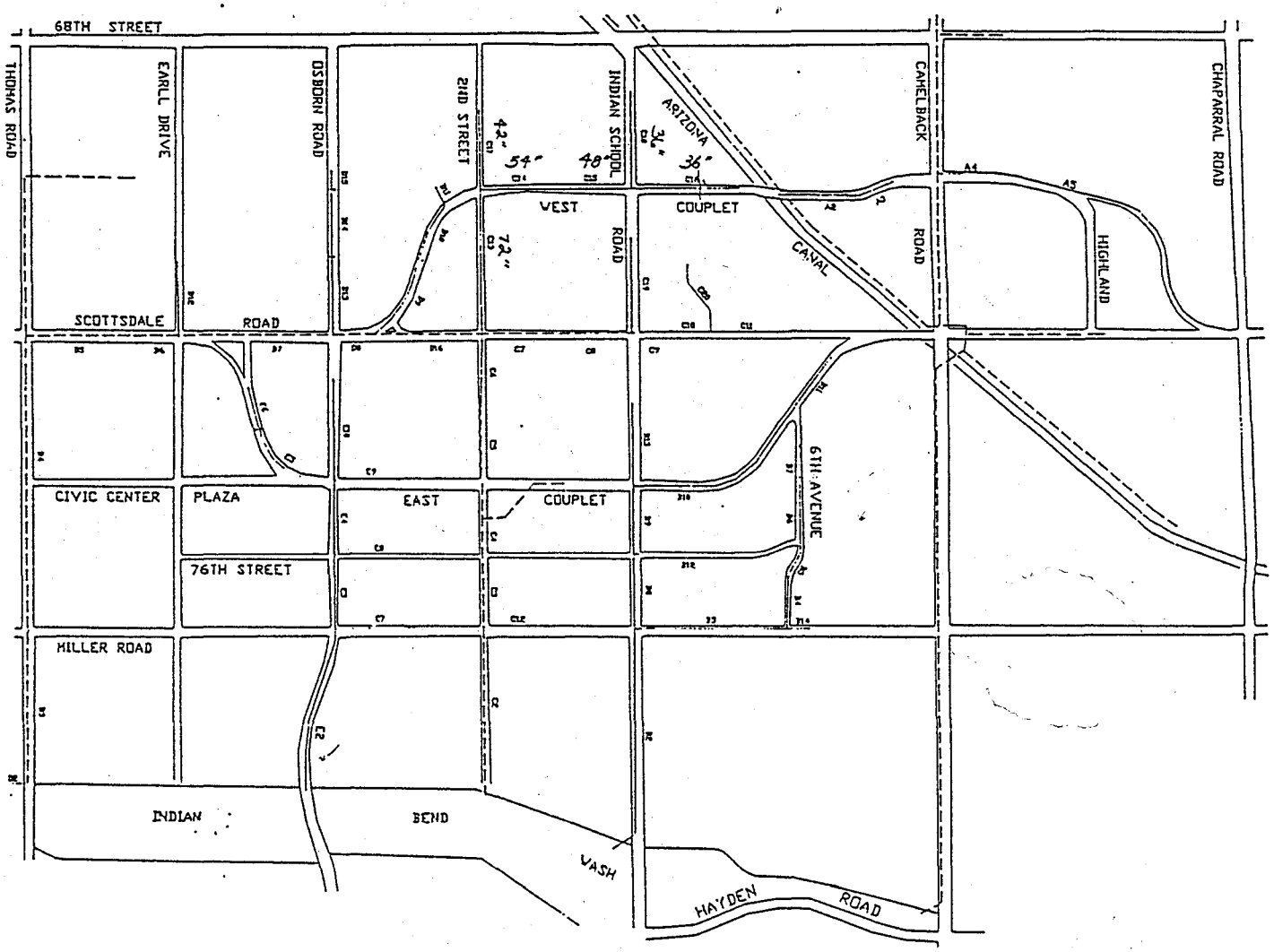
EXIST. STORM DRAINS

PROPOSED DRAINS

ALTERNATIVE B
DRAINAGE SYSTEM

BOYLE ENGINEERING CORPORATION

EXHIBIT 3



LEGEND

EXIST. STORM DRAINS

PROPOSED DRAINS

PROPOSED
STORM DRAINS
(ALTERNATIVE A)

BOYLE ENGINEERING CORPORATION