Area Drainage Master Study

BUCHANAN WASH

Drainage / Storm Drain Master Plan

Volume 1, Report

Prepared for:

CITY OF PHOENIX, ARIZONA

Engineering Department

Floodplain Management Section

Index Number ST-886382
Contract Number 51372

Huitt-Zollars, Inc
6245 North 24th Parkway , Suite 201
Phoenix, Arizona 85016

AREA DRAINAGE MASTER STUDY

BUCHANAN WASH CONCEPTUAL DRAINAGE & STORM DRAIN MASTER PLAN REPORT MARICOPA COUNTY, ARIZONA

Prepared for:

City of Phoenix, Arizona
Floodplain Management Section
Engineering Department

Index Number ST-886382
Contract Number 51372

Registered Professional Engineer (Civil)
CERTIFICATE NO.
21730
THOMAS W.
WILHITE
Date Signed 3/22/90
ARIZONA, U. S. A.

March 1990

Prepared by:

Huitt-Zollars, Inc.
6245 North 24th Parkway, Suite 201
Phoenix, Arizona

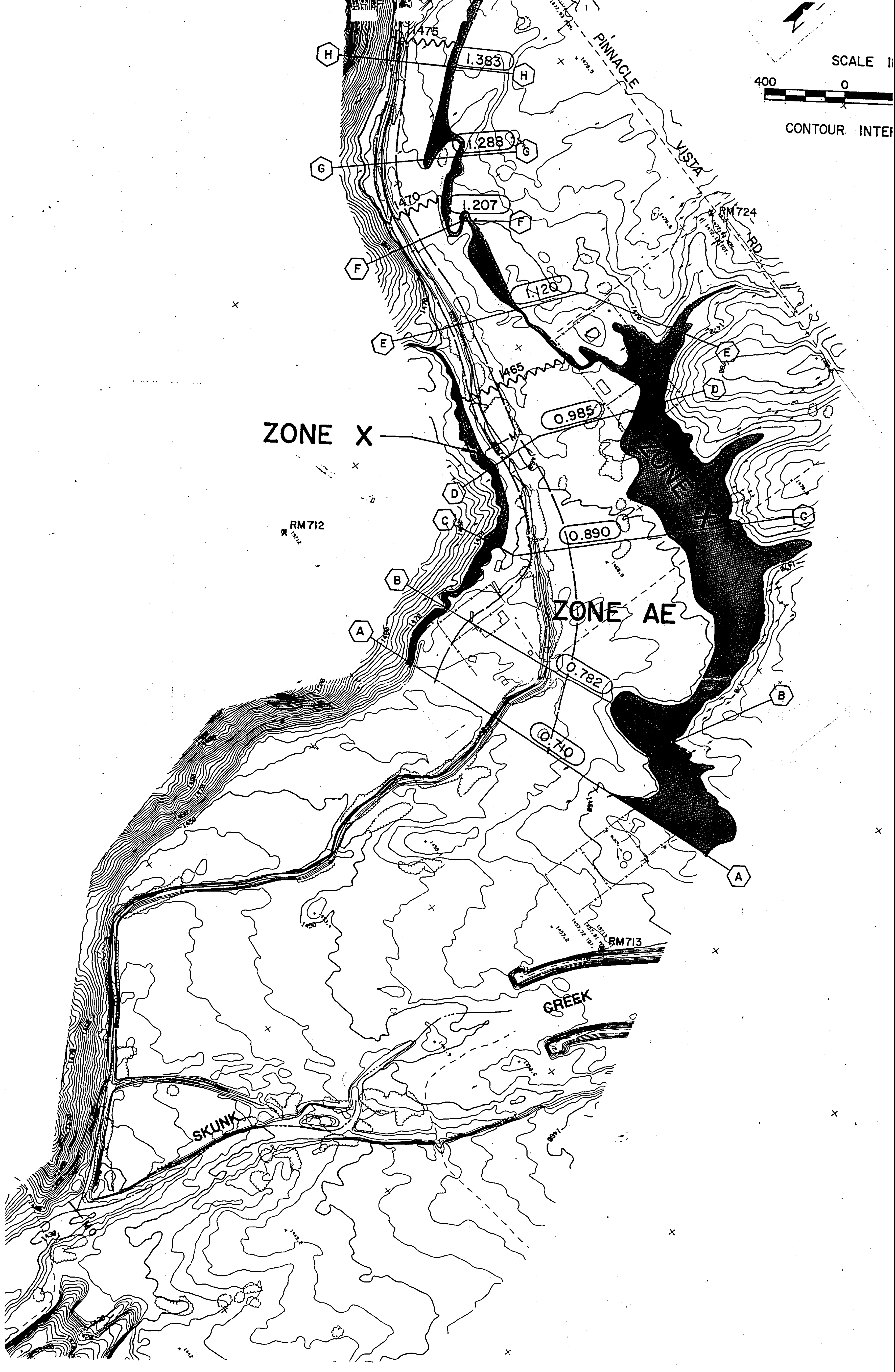
Huitt-Zollars Project No. 05-0049-01

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

LIST OF TABLES

LIST OF FIGURES


SCALE I
400 0
CONTOUR INTER
PINNACLE
VISTA
RD
RM724
RM712
RM713
ZONE X
ZONE AE
ZONE X
1.383
1.288
1.207
1.120
0.985
0.890
0.782
0.710
1475
1470
1465
H
G
F
E
D
C
B
A
CREEK
SKUNK

EXECUTIVE SUMMARY

The Buchanan Wash Conceptual Drainage and Storm Drain Master Plan is intended to provide a major system drainage master plan in conjunction with a storm drain master plan for the Buchanan Wash Watershed. This master plan will be based on future developed conditions as defined by the General Plan for Peripheral Areas C and D as approved by the Council of the City of Phoenix on the 18th of November, 1987. This master plan identifies potential drainage problem areas and recommends solutions to these problems. The Buchanan Wash Watershed as it exists today is described within Section 2.0 and the various aspects of the watershed as it impacts storm runoff is discussed within this section. Section 3.0 describes the means and methods used for determining the storm runoff not only for existing conditions but for future developed conditions for the Buchanan Wash Watershed. This methodology also includes sizing of major channels and storm drain systems. Sections 4 through 8 describe the five cases that were analyzed as part of this conceptual drainage study. These hydrologic study cases ranged from the existing basin conditions through to the future developed conditions including sizing of major channels and storm drains. Section 9 provides cost estimates for the alternatives that were discussed within Sections 6 and 7. These alternatives address the various types and configurations of storm drain facilities that could be constructed within the Buchanan Wash Watershed. Public comments on this study are contained within Section 10 and any conclusions and recommendations derived from the public hearing and the study are contained within Section 11. The technical appendix contains the various worksheets and copies of the computer models that were used to determine the sizes and alignments of the various storm drainage facilities recommended within this report. This technical appendix is contained within a separate binder.

Buchanan Wash is an approximately 11 square mile watershed that is a tributary of Skunk Creek and is located immediately west of Interstate 17 (Black Canyon Freeway) between the Carefree Highway and Happy Valley Road. This watershed generally drains from north to south with the confluence of Buchanan Wash and Skunk Creek being located immediately north of Happy Valley Road. The majority of the watershed is undeveloped and under the management of the Arizona State Land Department. The topography of the watershed varies from a gently sloping alluvial plain from the north and central watershed areas to a combination of isolated bare hillsides with the alluvial plain in the south watershed area. The Deem Hills bounds the watershed on the southwest. The Central Arizona Project (CAP) Canal, constructed in the early 1980's, is an east-west linear feature that intercepts about two thirds of the natural north to south drainage of the watershed. The CAP canal created detention areas both north and south of the Canal. A triple barrel 66-inch diameter concrete pipe culvert provides a crossing under the canal for the Buchanan Wash Drainage. Figure 1 shows the general location of the Buchanan Wash Watershed.

The recommendations of the Buchanan Wash Conceptual Drainage and Storm Drain Study are based on hydrologic analyses of the watershed using the U.S. Army

Corps of Engineers HEC-1 computer model. These hydrologic analyses are differentiated by case numbers and are summarized as follows:

1. CASE 1: The drainage patterns for Case 1 has been established by the existing watershed washes and are shown in Figure 6. The Case 1 analysis of the Buchanan Wash Watershed is intended to establish the peak flood flows for existing or predevelopment conditions.

2. CASE 2: Case 2 is intended to determine the effect of changing land use on peak runoff flows in the Buchanan Wash Watershed. The drainage patterns remained the same as for Case 1.

3. CASE 3: The drainage patterns for Case 3 will generally follow the same routes as established by the existing washes. The intent of the Case 3 analysis is to establish the best path for channels and natural washes through the watershed so that drainage works well with the proposed circulation and land use plan.

4. CASE 4: The Case 4 analysis is an extension of the Case 3 analysis. The purpose of the Case 4 analysis was to define the storm drain system in the streets shown on the circulation plan. The Case 3 drainage area map as shown in Figure 12 was subdivided to define the sub-basins that would naturally drain to a street before being routed to the nearest major channel. This subdivided drainage area map is shown in Figure 14.

5. CASE 5: A HEC-1 model was not developed for Case 5. The major channels as determined in the Case 3 analyses and the storm drainage systems as determined in the Case 4 analyses were combined into essentially the alternatives for a comprehensive system to serve the Buchanan Wash Watershed. Figure 17 illustrates the drainage patterns that would be necessary to make the major drainage system and storm drainage system act in combination.

The adopted circulation and land use plan will have an impact on the Buchanan Wash Watershed with respect to slightly altering drainage paths. The crossing of these future thoroughfares will be accomplished by the major channels. The recommended alignment for major channels will provide a drainage corridor for runoff from the 100-year frequency storm. Minor channels and other storm drainage facilities within each tract bounded by the proposed thoroughfare system has not been defined by this study.

Alignment of minor channels to accommodate drainage within a sub-basin will be dependent on development and is not considered a part of this drainage master plan. It was assumed that drainage flows will be conveyed to the major channels through a combination of minor channels, street gutters and storm drains. The approximate sizes and alignment of a storm drain system in the proposed thoroughfare was determined as a part of this study. This storm drain system was sized for runoff from a 2-year frequency storm with a duration of 24-hours.

Based on the results of the Case 2 studies, it was determined that future

Based on the results of the Case 2 studies, it was determined that future development in the Buchanan Wash Watershed should comply with the following conditions:

1. All projects must provide retention in accordance with City policies.

2. No project may discharge more than the predevelopment flow rate.

3. No project may discharge increased volume of runoff by changing the hydrograph for a sub-basin without recomputing the model for the entire watershed and demonstrating that the project would have no adverse impact on the drainage system.

The major channel and the storm drain system as determined by Cases 3 and 4 used predevelopment runoff values as a part of being consistent with the previously stated policy. The Case 3 peak runoff flows, which is recommended to be the benchmark model for development in the watershed, are slightly higher than the peak flows established for Buchanan Wash downstream (south) of the CAP Canal in the 1987 Flood Insurance Study (FIS). For example, Table 13 shows that the flows at combination point 6 (Figure 12) is 12% higher for the Case 3 study when compared to the 1987 FIS peak runoff flows. It is believed that the differences in the peak runoff flows are primarily due to the storm distributions used in this study as compared to the 1987 flood insurance study. The modeling differences between the 1987 FIS study and the Case 3 study are as follows:

1. The Case 3 study is based on a SCS Type IIA storm distribution. The 1987 FIS study is based on a SCS Type II distribution. The combining of hydrographs will differ between the two studies due to the different shapes of storm hydrograph distribution.

2. The routing of the runoff flow in the Case 3 study is different than that of the 1987 FIS study. The Case 3 study is based on natural drainage paths being intercepted by the proposed thoroughfares with the collected runoff being routed in channels. The 1987 FIS was based on existing land use in the watershed with the drainage paths defined by the natural washes.

The alternatives available for addressing the differences in peak flows are as follows:

1. Adopt the revised flows as the community standard for development in the Buchanan Wash Watershed above the CAP Canal.

2. At the time the major channels are constructed, alter the existing detention areas north of the CAP Canal with the intent to keep the peak flows in Buchanan Wash south of the CAP Canal to that defined by the 1987 FIS.

Changes to the adopted land use plan are recommended as a result of this drainage master plan of the Buchanan Wash Watershed (see Figure 18). It is recommended to change the land usage of one area from 0 to 2 dwelling units per acre to a regional park and recreation area. This area is bounded by the

the north and a large hillside area on the east. The majority of this defined area provides detention for the watershed. It is also recommended that the detention area south of the CAP Canal be added to the land use plan. The recommended alignments of the major channels are shown in Figure 11. The recreation and drainage corridors as discussed in Section 9.4 would generally correspond to the major channels with some additional corridor being required to provide access to adjacent watersheds. The recommended alignment for the recreation and drainage corridors are shown in Figure 18. This figure also shows the recommended land use changes. The recommended storm drain system is shown in Figure 16.

Three alternatives for the typical cross-section of the major channels were examined (see Section 8.0 and Figure 19). Alternative A is defined to be earth channels with the channel right-of-way width being the top width of channel plus 30 feet. Alternative B is defined to be concrete channels with the right-of-way width being the top width of channel plus 30 feet. Alternative C is defined to be earth channels situated within a minimum 200 foot wide landscaped recreation and drainage corridor. The storm drain system as determined by the Case 4 analyses will be the same for all three alternatives. Each alternative essentially describes a combined system. The total cost estimates for the three alternatives are as follows (estimate includes contingency costs):

Alternative A - Earth Channels with 164 Acres of R.O.W. Required	$17,167,500
Alternative B - Concrete Channels with 108 Acres of R.O.W. Required	$25,256,900
Alternative C - Drainage and Recreation Corridors with 269 Acres of R.O.W. Required	$19,853,650

For a detailed summary of costs, see Table 20.

SECTION 1.0 INTRODUCTION

<u>Section 1.1 Purpose.</u> The Buchanan Wash conceptual drainage and storm drain study is intended to provide a major system drainage master plan in conjunction with a storm drain master plan for the Buchanan Wash Watershed. This master plan will be based on future developed conditions as defined by the General Plan for Peripheral Areas C and D as approved by the Council of the City of Phoenix on the 18th of November, 1987. This master plan will identify potential drainage problem areas and recommend solutions to these problems. The proposed solutions may include both structural and nonstructural measures including but not limited to natural channels with setbacks, constructed channels, detention basins, low flow pipes, no build areas, and building pads raised to prevent flooding. A direct result of this drainage master plan will be to provide a preliminary cost estimate for the recommended future drainage systems within the Buchanan Wash Watershed. Since the majority of the Buchanan Wash Watershed is undeveloped, this report would be utilized to formulate any appropriate assessment fees for construction of the required major storm drainage facilities within the watershed and for determination of any needed right-of-way for the drainage facilities.

<u>Section 1.2 Report Presentation.</u> This report has been divided into the sections necessary for describing the conceptual drainage and storm drain study. The Buchanan Wash Watershed as it exists today is described within Section 2.0 and the various aspects of the watershed as it would impact on storm runoff is discussed within this section. Section 3.0 describes the means and methods used for determining the storm runoffs not only for existing conditions but for future developed conditions for the Buchanan Wash Watershed. This methodology also includes sizing of major channels and storm drain systems. Sections 4 through 8 describes the five cases that were analyzed as part of this conceptual drainage study. These hydrologic study cases ranged from the existing basin conditions through to the future developed conditions including sizing of major channels and storm drains. Section 9 provides cost estimates for the alternatives that were discussed within Sections 6 and 7. These alternatives address the various types and configurations of storm drain facilities that could be constructed within the Buchanan Wash Watershed. Public comments on this study are contained within Section 10 and any conclusions and recommendations derived from the public hearing and the study are contained within Section 11. The technical appendix contains the various worksheets and copies of the computer modules that were used to determine the sizes and alignments of the various storm drainage facilities recommended within this report. This technical appendix is contained within a separate binder.

<u>Section 1.3 Steering Committee Review.</u> This study benefited from the periodic review by a Steering Committee consisting of representatives from: The Arizona State Land Department; Flood Control District of Maricopa County; the City of Phoenix Departments of Engineering (Floodplain Management Section, Storm Drain Section); Planning (Long Range Planning Division); Parks, Recreation and Library; and Water and Wastewater Department. Copies of the HEC-1 analyses were supplied to the Flood Control District for review, comment, and approval.

SECTION 2.0 PROJECT AND SITE DESCRIPTION

2.1 Buchanan Wash Basin Description. Buchanan Wash is an approximate 11 square mile watershed that is a tributary of Skunk Creek and is located immediately west of Interstate 17 (Black Canyon Freeway) between Carefree Highway and Happy Valley Road. The Deem Hills bounds the watershed on the southwest. This watershed generally drains from north to south with the confluence of Buchanan Wash and Skunk Creek being located immediately north of Happy Valley Road. The majority of the watershed is undeveloped and under the management of the Arizona State Land Department. The topography of the watershed varies from gently sloping alluvial plain from the north and central watershed areas to a combination of isolated bare hillsides with the alluvial plain in the south watershed area. The majority of the watershed can be considered as a natural sparse desert vegetation consisting of desert shrubs, cacti, and scattered palo verde and mesquite trees. This vegetation is thicker along the natural washes. The basin slopes generally vary from 0 to 2 percent except for the hillside areas where slopes exceed 10 percent. The Central Arizona Project (CAP) Canal, constructed in the early 1980's, is an east-west linear feature that intercepts about two thirds of the natural north to south drainage of the watershed. The CAP created detention areas both north and south of the Canal. A triple barrel 66-inch diameter concrete pipe culvert provides a crossing under the canal for the Buchanan Wash Drainage. Figure 1 shows the general location of the Buchanan Wash Watershed.

Section 2.2 Existing Basin Development. Two-thirds of the Buchanan Wash Watershed is under the management of the Arizona State Land Department and is currently undeveloped. This land has sparse usage as grazing territory for cattle in those areas where some stock tanks were established for providing water for the cattle. Light residential development consistent with a zoning of two to five dwelling units per acre is established below the central Arizona Project Canal and due east of the Deem Hills. Figure 2 illustrates the current land use of the Buchanan Wash Watershed.

2.3 Hydrologic Soils Groups. Three major soil complexes make up the majority of the Buchanan Watershed. These complexes are the Rillito-Gunsite-Pinal association, Cherioni-Gachabo-Rock outcrop association and the Ebon-Pinamt-Tremant association. These soils associations were classified primarily be in the hydrologic group D which makes up about 80% of the basin. A mixture of hydrologic groups B and D are located along the western part of the watershed. Three minor pockets of soil group C occurs near the Central Arizona Project Canal. Figure 3 shows the soil types and which hydrologic group they belong to for the Buchanan Wash Watershed.

Section 2.4 Regional Climatology. The climatology of this area is characterized by infrequent rainfall with hot summers and mild winters. The mean annual rainfall is 7.1 inches that generally occurs in two seasons. One season extends from July to mid-September and is primarily caused by local convection storms. The other season extends from December to March and is primarily caused by frontal storms. The local convection storms are considered to be the critical type of storm for producing flooding events in this area.

Section 2.5 Circulation and Land Use Plan. The transportation plan developed for areas C and D had identified the northwest outer loop within the Buchanan Wash Watershed to be a planned limited access highway. Map 6 within the general plan for peripheral areas C and D shows that this highway would have intersections with 51st Avenue, 43rd Avenue, and Interstate 17, all within the Buchanan Wash Watershed. Two commercial areas (thirty to fifty acres each) occur within the Buchanan Wash Watershed. One of these commercial areas, located at the intersection of Carefree Highway with Interstate 17, is surrounded by an extensive amount of mixed-use development. The second commercial area is surrounded by medium to heavy residential use. The general plan has identified the CAP to provide an open space corridor and trail along its full length. This corridor will facilitate pedestrian circulation within the various planned areas and to points outside of this particular watershed. The detention areas immediately north of the CAP have also been identified as a regional storm water retention site. An extensive amount of low density development has been identified to occur around the numerous hillsides that occurs north of the CAP and south of Dixileta Drive. This low density development is intended to minimally disrupt the desert environment characteristic of that area. Overall, the hillside areas near the CAP adds tremendously to the aesthetic appeal of this particular watershed. Figure 4 shows the thoroughfare layout for the Buchanan Wash Watershed. The land use plan for the watershed is illustrated within Figure 5.

3.0 ENGINEERING METHODOLOGIES

3.1 Design Storms. As discussed in Section 2.4, the local convective storms are considered as the critical storm for this region. To simulate this storm in a computer model, the rainfall distribution known as the Soil Conversation Service (SCS) Type IIA was selected for this study. This distribution essentially defines the incremental and total precipitation for a given time interval and total duration. The design criteria for establishing runoffs in the watershed was the 100-year frequency storm event with a duration of 24-hours. This design storm was used to size the major channels as described in Section 6.0. A second design storm of a 2-year frequency that also used the SCS type IIA distribution was used to size the storm drain facilities as described in Section 7.0. The 2-year frequency storm is also a 24-hour duration storm. Table 1 shows the SCS type IIA 24-hour rainfall distribution and Table 2 shows the total rainfall precipitation for the 2-year through to the 100-year frequency storms. The total precipitation data for these design storms was derived from the "Precipitation Frequency Atlas of the United States," NOAA Atlas 2, Volume VIII, Arizona. The time step interval used in the SCS Type II A Distribution was 30 minutes.

3.2 Losses. Section 2.0 discussed the current and future land uses for the Buchanan Wash Watershed. This section will discuss how these land usages impacts on the precipitation losses due to interception and infiltration. For this study, the SCS method was used for determining the infiltration capacity of the basin soil. Generally, the direct storm runoff varies with the drainage basin characteristics such as area, shape, slope, vegetation type, percent of vegetative cover and soil infiltration capacity. The hydrologic groups discussed in Section 2.3 were related to a SCS curve number based on the vegetative type and percent of vegetative cover for a given land usage. Table 3 shows the SCS curve numbers used for current and future land uses in the Buchanan Wash Watershed. The infiltration capacity of hydrologic soil groups could be described as follows:

Group B: Soils having moderate infiltration rates when thoroughly wetted, consisting of moderately fine to fine texture.

Group C: Soils having slow infiltration rates when thoroughly wetted, consisting of moderately fine to fine texture that impedes the downward movement of water.

Group D: Soils having very slow infiltration rates when thoroughly wetted consisting of clay soils.

Two other hydrologic parameters that impacts on the interception of storm floods are percent impervious and percent contributing. The percent impervious indicates that portion of the drainage basin that is impervious or the SCS curve number will be 100. The percent contributing was used in the Case 2.0 analyses to approximate the impact of the storm drainage policy of all developments shall make provisions to retain the runoff of a 100-year 2-hour duration storm. Table 3 also shows the percent impervious and percent contributing.

3.3 Hydrologic Analyses. Hydrologic analyses were carried out to establish the peak discharge for the design storms of 100-year and 2-year frequency interval. These events have a 1 and 50 percent chance, respectively, of being equaled or exceeded during any one year. Since no gaging system is available in the watershed, there is no means to develop discharge-frequency relationships from historical flood records. As a result, the HEC-1 computer model as developed by the U.S. Army Corps of Engineers was used to generate synthetic runoff hydrographs at various concentration points in the watershed. Although the input rainfall hyetographs for the 100-year and 2-year storms used a 30 minute time step for a total duration of 24-hours, the runoff hydrographs were computed using a 5-minute time step. The SCS Type IIA distribution has the peak of the storm occurring around the 6-hour mark of the 24-hour storm.

The Buchanan Wash Watershed was previous studied in 1987 by AGK Engineers, Inc. for the Federal Emergency Management Agency (FEMA) to determine the flood hazard of Buchanan Wash between the CAP canal and the confluence of Buchanan Wash with Skunk Creek. This study used a SCS TYPE II rainfall distribution with durations varying from one-hour to 24-hours. The critical storm duration for producing the maximum peak runoff for the storm distribution was determined to be the 6-hour duration storm. The flood insurance study examined the 10-year, 50-year, 100-year, and 500-year frequency storms.

The watershed was subdivided into a number of sub-basins to form a system that is interconnected with stream network components. The boundaries of the sub-basins were determined using the USGS 7.5 minute quadrangle maps (1" = 2000') and the 1" = 1000' aerial mapping provided by the City of Phoenix. Other materials utilized to determine the sub-basin and watershed boundaries are as-built plans for Interstate 17, as-built plans for the CAP, and the circulation and land use plan and the flood insurance study for the Buchanan Wash as prepared by AGK Engineers, Inc. for FEMA in November of 1987. The boundaries were field verified; however, due to the relative flat slopes of the watershed, a more detailed definition of sub-basin boundaries could not be done without more detailed topography.

Two basic drainage patterns were modeled in this drainage master plan. The drainage patterns as established by existing washes were used in Cases 1 and 2. Altered drainage patterns based on the future land use and circulation plan were analyzed in Cases 3 and 4.

The kinematic wave overland-flow option of the HEC-1 computer model was used to determine runoff from sub-basins within the watershed. This particular option relates the sub-basin shape, slope and effective roughness to runoff. The effective roughness parameters were based on the category of sparse vegetation as defined within the HEC-1 users manual. The kinematic wave methods was used to route runoff hydrographs through sub-basins and to the various collection points within the watershed. The cross sectional shape of the channels modeled by this method was trapezoidal. The roughness factor used by this method is the same as Mannings roughness coefficient and was based on an unlined channel.

The CAP canal created storm runoff detention areas both north and south of the CAP canal. The north detention area consists of two parts that act simultaneously during the 100-year storm event. Buchanan Wash feeds one part and the major wash that is east of Buchanan Wash and approximately parallel to Interstate 17 feeds the second part. A triple 66-inch diameter concrete pipe culvert provides a crossing under the CAP canal for storm runoff release from the north detention area. The south detention area is located in the valley between two peaks of the Deem Hills immediately west of the Buchanan Wash crossing of the CAP canal. The storm runoff release from this detention area is along a cut roadway parallel and adjacent to the CAP canal. The level-pool reservoir routing option of HEC-1 was used to model the two storm detention areas. The stage-storage-runoff relationship for the two detention areas was determined from the 1" = 200' scale topographic mapping with 2-foot contour intervals that was produced as part of the 1987 Flood Insurance Study. The HEC-1 model developed as a part of the 1987 flood study did incorporate these detention areas. The stage-storage-runoff relationship of this HEC-1 model was verified and modified as necessary based on the verification. Table 4 summarizes the stage-storage-runoff relationship for the two detention areas.

The HEC-1 computer program used with this study was the PC based 1985 version. The models developed for usage with this version of the HEC-1 program will not work with the 1988 release of HEC-1.

3.4 Model Verification. The results of the HEC-1 computer analysis has been verified by an independent method. The independent method is the tabular hydrograph method as described in the SCS publication, "Urban Hydrology for Small Watershed," Technical Release Number 55. This method uses a SCS Type II rainfall distribution. The computer model developed for Case 1 has been verified by this method. A comparison of the results is in Section 4.0, Case 1: Existing Land Use Conditions Analysis.

The 1987 Flood Insurance Study can be considered as a second method of model verification. The results of this method is also compared to the Case 1 results in Section 4.0.

4.0 CASE 1: EXISTING LAND USE CONDITIONS ANALYSIS

4.1 Drainage Area Map. The drainage patterns for Case 1 has been established by the existing watershed washes and is shown in Figure 6. The Case 1 analysis of the Buchanan Wash Watershed is intended to establish the peak flood flows for existing or predevelopment conditions. Each of the washes shown in Figure 6 were incorporated into a sub-basin and subsequently modeled using the HEC-1 computer model as described in Section 3.0. Figure 7 shows the sub-basins for the Case 1 model. Table 5 summarizes the sub-basin hydrologic data used in the Case 1 model. It should be noted that the HEC-1 model used two options of kinematic flow to describe the runoff characteristics of each sub-basin. The first options was overland flow and the second option was channel flow. Each of the existing washes were modeled using a trapezoidal shaped channel. Table 6 summarizes the geometric shape of each existing wash.

4.2 Case 1 Computer Model. The sub-basin as shown in Figure 7 are interconnected so that storm runoffs use the flow path as shown in Figure 6, existing major washes. Figure 8 is a schematic that shows how the sub-basins are interconnected. The three symbols shown on the schematic directly relates to the drainage area map and represent the sub-basin area, combination of collection point, and the routing stream. The HEC-1 model incorporates the network of interconnected sub-basins as shown in Figure 8.

4.3 Summary of Storm Runoffs. The results of the HEC-1 analysis for Case 1 are summarized in Table 7. For comparison purposes, the results from the 1987 Flood Insurance Study (FIS) are also included in Table 7. The hand verification runoff results using the TR-55 method are also shown in Table 7.

4.4 Comparison to Previous Study. As Table 7 shows, there are similar results between the 1987 FIS and this study. The differences in modeling techniques are as follows:

a. The 1987 FIS use a 100-year, 6-hour SCS Type II Design Storm. This study used a 100-year, 24-hour SCS Type IIA Design Storm.
b. The reservoir routing was revised based on the available topographic data.
c. The model in this study uses more sub-basins than the 1987 Flood Insurance Study.

4.5 Model Verification. Table 7 shows that the peak flows using the TR-55 tabular hydrograph method are consistently higher than the peak flows off the HEC-1 Model. The TR-55 method is approximate and the manual states that the accuracy decreases as the complexity of the water shed increases. Generally, the times of concentration used in the tabular hydrograph method matches with an average stream velocity of 3.5 feet per second. Two aspects that would contribute to the differences in peak flows are as follows:

1. Different modeling methods which impacts on hydrograph attenuation through routing. The TR-55 Model did not use shallow stream routing, which for the typical Buchanan Wash sub-basin slopes, would result in stream velocities of 1 to 2 feet per second.

2. Different types of input design storm.

5.0 CASE 2: FUTURE LAND USE CONDITIONS ANALYSIS

5.1 Drainage Area Map. This case is intended to determine the effect of changing land use on peak runoff flows in the Buchanan Wash Watershed. The drainage patterns remained the same as for Case 1. Table 3 in section 3.2 lists the different SCS soil group curve numbers that applies to the proposed land use types as shown in Figure 5. Normally, the proposed roadways would alter the drainage paths of the natural washes; however, for this case, the effect of land use change only involved modifying the soil group number and incorporating the percent impervious and percent contributing (also shown on Table 3) from those values used in the Case 1 analysis.

The sub-basin designations and delineations for the Case 2 analysis remained the same as for the Case 1 analysis. This particular case is actually represented by two HEC-1 analyses. Case 2 reduces the basin areas of parcels within a sub-basin in accordance with the percent contributing shown on Table 3. This reduction of area is a simplified approximation of the effect of a regional policy of requiring on site detention of developments. Case 2A does not reduce the basin area size and represents the effect of changing land use without the benefit of detention to reduce peak flows. Table 8 shows the percentage of land types that is located within each sub-basin. Figure 9 shows the drainage area map for Cases 2 and 2A.

With the basin area being reduced for the Case 2 analysis based on the percent contribution for some land use types, the weighted average SCS curve number differs slightly between Case 2 and Case 2A. Table 9 summarizes the weighted SCS curve number for Cases 2 and 2A. It should be noted that a weighted percentage of each sub-basin was also modeled as being impervious based on percent impervious for each land use as shown in Table 3. A SCS curve number of 98 was used to represent the impervious area.

5.2 Case 2 and 2A Computer Model. The Case 2 and 2A computer models used the same interconnectivity of sub-basins as for Case 1. Figure 10 is a schematic diagram of the computer models for Cases 2 and 2A. The overland and channel geometry for Cases 2 and 2A are the same as for Case 1.

5.3 Summary of Storm Runoffs. The results of HEC-1 analysis for Cases 2 and 2A are summarized in Table 10. The peak flows for Case 1 are repeated in Table 10 to better illustrate the effect of land use change on the watershed.

The peak storm runoffs for Case 2, which included an approximation of a regional on-site detention policy, varied from the Case 1 peak flows by up to 17 percent. Generally, the Case 2 peak flows in the upper part of the basin were lower than the Case 1 flows. The Case 2 peak flows were consistently higher than the Case 1 flows in the region of Buchanan Wash south of the CAP Canal. The Case 2A flows show the impact of the regional on site detention policy.

The evaluation of the Case 2 and 2A computer model was instrumental in determining the approach for Cases 3 through 5. As directed by the City of Phoenix staff, Cases 3 through 5 would use predevelopment land use conditions and the drainage patterns will be modified to accommodate the proposed circulation plan. The usage of predevelopment land use conditions is consistent with the following conditions that should be complied with by future development in the Buchanan Wash Watershed.

1. All projects must provide retention in accordance with City policies.

2. No project may discharge more than the predevelopment flow rate.

3. No project may discharge increased volume of runoff by changing the hydrograph for a sub-basin without recomputing the model for the entire watershed and demonstrating that the project would have no adverse impact on the drainage system.

6.0 CASE 3: MAJOR DRAINAGE SYSTEM ANALYSIS

6.1 Drainage Area Map. The drainage patterns for Case 3 will generally follow the same routes as established by the existing washes. The intent of the Case 3 analysis is to establish the best path for channels and natural washes through the watershed so that drainage works well with the proposed circulation plan. The first step to the Case 3 analysis was to submit to the Steering Committee alternatives for the route of the major channels. The selected routing of the major channels is shown in Figure 11.

The roadways as defined by the circulation plan will act to define sub-basin boundaries. The crossing of these thoroughfares will be accomplished by the major channels. Alignment of minor channels to accommodate drainage within a sub-basin will be dependent on development and is not considered a part of this drainage master plan. It was assumed that drainage flows will be conveyed to the major channels through a combination of minor channels, street gutters and storm drains. Figure 12 shows the drainage sub-basins for the Case 3 analysis. With the redefinition of the sub-basin geometry and realignment of the natural washes to conform to the recommended major channel alignment, Table 11 summarizes the sub-basin hydrologic data used in the HEC-1 model. Each of the major channels were modeled using a trapezoidal shape. Two types of channel liner were modeled as part of the Case 3 analysis. Table 12 summarizes the geometric shape of each type of channel.

6.2 Case 3 Computer Model. The sub-basins as shown in Figure 12 are interconnected so that the storm runoff patterns match the paths as shown in Figure 11 for major channels. Figure 13 is a schematic that shows the interconnection of the sub-basins.

6.3 Summary of Storm Runoffs. The results of the HEC-1 analysis for Case 3 is summarized in Table 13. These storm runoffs were used to size the major channel system as tabulated in Table 12. For comparison purposes, the Case 1 storm runoffs are included in Table 13. The Case 1 runoff locations are not completely equivalent to that of Case 3 due to the different size and shape of the sub-basins between the two cases. The detention area upstream (North) of the CAP Canal significantly decreases the peak flow in Buchanan Wash. The time to peak for storm flows released through the triple pipe culverts crossing the CAP Canal is over three hours different than that of the peak flow in Buchanan Wash downstream (South) of the CAP Canal.

The light residential area south of the CAP Canal and east of Deem Hills has two minor washes located through the residential area. The plan for major channels does not include these washes. It was assumed that the drainage facilities for this light residential area will be defined and constructed as a part of the normal development of this area.

6.4 Summary of Alternative Channel Configurations. As discussed in Section 6.1, two types of channel liner were considered in the Case 3 analysis. The size of the channel was determined by limitations on the channel velocity and depth of the flow. A third alternative to the channel options consists of providing a 200 foot corridor as a combination landscaped recreation and drainage corridor. The type of channel used in this corridor would be earth lined. For the earth and concrete lined channels not contained in a landscaped recreation corridor, the right-of-way width was assumed to be top width of channel plus 30 feet.

7.0 CASE 4: STORM DRAIN SYSTEM ANALYSIS

7.1 Drainage Area Map. The Case 4 analysis is an extension of the Case 3 analysis. The purpose of the Case 4 analysis was to define the storm drain system in the streets shown on the circulation plan. This storm drain system was sized for a 2-year frequency storm with a duration of 24-hours.
The Case 3 drainage area map as shown in Figure 12 was subdivided to define the sub-basins that would naturally drain to a street before being routed to the nearest major channel. This subdivided drainage area map is shown in Figure 14. The sub-basin numbers shown in the Case 3 analysis were used for the same sub-basin location in the Case 4 analysis. These sub-basins were modified by reducing the sub-basin drainage area only. Table 14 summarizes the hydrologic data used in the Case 4 HEC-1 computer model. A conveyance shape of a circle was used in the kinematic wave routing model to size the storm drains.

7.2 Case 4 Computer Model. The Case 4 computer model is the most complex of the study models for Buchanan Wash. The pipe network has been described using the channel routing option of the kinematic wave method. For the storm drain network, a circular shape was selected so that the pipe is in a partial flow regime. The HEC-1 computer model uses a pipe friction in the routing of hydrographs; however, the model does not compute head losses in the pipe or at pipe junctions. Figure 15 shows the interconnection between the sub-basins as defined in the drainage area map, Figure 14.

7.3 Recommended Storm Drain Alignment. Figure 16 illustrates the recommended storm drain alignment for the Buchanan Wash Watershed. The storm drain system is also shown to be located under the major channels which is denoted as a low flow system. This system is intended to convey any of the frequent, low intensity flows such as storms less than the 2-year frequency or runoff due to irrigation systems. The low flow pipe system under the channels was generally set to a size of 30" in diameter. A minimum pipe size of 18-inch diameter was used in the study.

7.4 Summary of Storm Runoffs. The results of the Case 4 analysis is summarized in Table 15. These peak flows were used to size the storm drain system shown in Figure 16. As discussed in Section 7.1, the design storm for the storm drain system was the 2-year frequency, 24-hour duration SCS Type IIA storm. As a convenient comparison, the 100-year frequency storm peak channel runoffs are also included in Table 15.

8.0 CASE 5: COMBINED SYSTEM ANALYSIS

Figure 17 illustrates the drainage patterns that would be necessary to make the major drain system and storm drain system act in combination. As stated in section 7 of this report, some minor channels parallel to the roadways that are sized for the 100-year frequency storm may be required. The minor channels would be required when the flow in the street exceeds 100 cfs. A HEC-1 model was not developed for Case 5. The major channels as determined in the Case 3 analyses and the storm drain systems as determined in the Case 4 analyses were combined into essentially the alternatives for a comprehensive system to serve the Buchanan Wash Watershed. Alternative A is defined to be earth channels with the channel right-of-way width being the top width of channel plus 30 feet. Alternative B is defined to be concrete channels with the right-of-way width being the top width of channel plus 30 feet. Alternative C is defined to be earth channels situated within a 200 foot wide landscaped recreation and drainage corridor. The storm drain system as determined by Case 4 analyses will be the same for all three alternatives. Each alternative essentially describes a combined system.

9.0 COST ESTIMATES

<u>9.1 Cost Estimates.</u> The cost estimates included in this section are based on estimated material quantities for constructing the drainage improvements outlined in Alternatives A, B and C. Only the number of acres of right-of-way required for each alternative was estimated. The unit prices as supplied by the City of Phoenix Engineering Department was used in the preparation of the cost estimates. Table 16 shows the unit prices.

<u>9.2 Alternative A, Earth Channels.</u> Table 17 summarizes the quantities and costs necessary for construction of the drainage improvements for Alternative A consisting of major earth channels, bridge crossings of the channels and the storm drain system. The required right-of-way has also been estimated.

<u>9.3 Alternative B, Concrete Channels.</u> Table 18 summarizes the quantities and costs for the drainage improvements of Alternative B. This alternative differs from Alternative A in that the channels are concrete lined and generally smaller than the earth channels of Alternative A. The bridge costs and excavation costs are lower in Alternative B compared to Alternative A. Alternative B has the additional cost of a liner that makes the overall cost of Alternative B to be higher than Alternative A.

<u>9.4 Alternative C, Earth Channels with Recreation Corridor.</u> Table 18 summarizes the quantities and cost for Alternative C. The concept of a landscaped recreation and drainage corridor consists of a 200 foot wide corridor with an earth channel set in the corridor. Figure 18 shows the alignment of the proposed recreation and drainage corridor. The corridor would connect to similar corridors in adjacent watersheds. This alternative is identical to Alternative A except for the additional required right-of-way and landscaping costs.

<u>9.5 Summary of Costs.</u> The total costs for alternatives A, B and C are summarized in Table 20 which includes the low flow pipes in the major channels. A contingency for design, surveying, construction management and construction was added to each estimate.

10.0 PUBLIC HEARING

A public meeting to inform and receive comments by the public on the conceptual drainage alternatives for the Buchanan Wash Watershed was held on September 13, 1989. A total of seven people attended the meeting. The public comments centered on the channel alternatives and the route of the recreation/drainage corridors. These comments were incorporated into the exhibits of this report.

11.0 CONCLUSIONS

The adopted circulation and land use plan will have an impact on the Buchanan Wash Watershed with respect to slightly altering drainage paths. The recommended alignment for major channels will provide a drainage corridor for runoff from the 100-year frequency storm. Minor channels and other storm drainage facilities within each tract bounded by the proposed thoroughfare system has not been defined by this study. However, the approximate sizes and alignment of a storm drain system in the proposed thoroughfare was determined as a part of this study. This storm drain system was sized for runoff from a 2-year frequency storm.

Based on the results of the Case 2 studies, it was determined that future development in the Buchanan Wash Watershed should comply with the following conditions:

1. All projects must provide retention in accordance with City policies.

2. No project may discharge more than the predevelopment flow rate.

3. No project may discharge an increased volume of runoff by changing the hydrograph for a sub-basin without recomputing the model for the entire watershed and demonstrating that the project would have no adverse impact on the drainage system.

The major channels and the storm drain system as determined by Cases 3 and 4 used predevelopment runoff values as a part of being consistent with the previously stated policy. The Case 3 peak runoff flows, which is recommended to be the benchmark model for development in the watershed, are slightly higher than the peak flows established for Buchanan Wash downstream (south) of the CAP Canal in the 1987 Flood Insurance Study (FIS). For example, Table 13 shows that the flows at combination point 6 (Figure 12) is 12% higher for the Case 3 study when compared to the 1987 FIS peak runoff flows. The modeling differences between the 1987 FIS study and the Case 3 study are as follows:

1. The Case 3 study is based on a SCS Type IIA storm distribution. The combining of hydrographs will differ between the two studies due to the different shapes of storm hydrograph distribution.

2. The routing of the runoff flows in the Case 3 study is different than than of the 1987 FIS study. The Case 3 study is based on natural drainage paths being intercepted by the proposed thoroughfares with the selected runoff being routed in channels. The 1987 FIS was based on existing land use in the watershed with the drainage paths defined by the natural washes.

The alternatives available for addressing the differences in peak flows are as follows:

1. Adopt the revised flows as the community standard for development in the Buchanan Wash Watershed above the C.A.P.

   It is believed that the differences in the peak runoff flows are primarily due to the storm distributions used in this study as compared to the 1987 flood insurance study.

2. At the time the major channels are constructed, alter the existing detention areas north of the CAP Canal with the intent to keep the peak flows in Buchanan Wash south of the CAP Canal to that defined by the 1987 FIS.

Changes to the adopted land use plan are recommended as a result of this drainage master plan of the Buchanan Wash Watershed (see Figure 18). It is recommended to change the land usage of one area from 0-2 dwelling units per acre to a regional park and recreation area. This area is bounded by the CAP Canal on the south, 51st Avenue on the west, Patton Road/Dixileta Drive on the north and a large hillside area on the east. The majority of this defined area provides detention for the watershed. It is also recommended that the detention area south of the CAP Canal be added to the land use plan. The recommended alignments of the major channels are shown in Figure 11. The recreation and drainage corridors as discussed in Section 9.4 would generally correspond to the major channels with some additional corridor being required to provide access to adjacent watersheds. The recommended alignment for the recreation and drainage corridors are shown in Figure 18. This figure also shows the recommended land use changes.

12.0 REFERENCES

1. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Precipitation-Frequency Atlas of the Western United States, Volume VIII-Arizona, 1973.

2. U.S. Department of the Interior, Geological Survey, 7.5 Minute Services Topographic Maps, Scale 1:24,000, Contour Intervals vary: Biscuit Flat, Hedgpeth Hills, New River SE, and Union Hills, Maricopa County, Arizona.

3. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, Generalized Computer Program 723-X6-L2010, HEC-1 Flood Hydrograph Package, Davis, California, September 1981, Revised January 1985.

4. U.S. Department of Agriculture, Soil Conservation Service, General Soil Map of Maricopa County, Arizona, 1973.

5. Arizona Department of Transportation, As-Built Plan for Phoenix-Cordes Junction Highway from Happy Valley Road to Carefree Highway, September 1984.

6. Hill, R.H. and Seller, W.D., Arizona Climate 1931-1972, 1974.

7. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, 1972.

8. Flood Control District of Maricopa County, Hydrologic Analyses for Buchanan Wash, Maricopa County, Arizona, AGK Engineers, Phoenix, AZ, November 1987.

Table 1. SCS Type IIA Rainfall Distribution
(24-Hour Storm Duration, 30 Minute Time Step)

Time (HRS)	Rainfall %	Time (HRS)	Rainfall %	Time (HRS)	Rainfall %	Time (HRS)	Rainfall %
0.0	0.0	6.0	66.0	12.0	89.1	18.0	96.1
0.5	0.5	6.5	74.5	12.5	90.0	18.5	96.3
1.0	0.9	7.0	77.6	13.0	90.5	19.0	96.9
1.5	1.0	7.5	80.0	13.5	91.2	19.5	97.1
2.0	1.3	8.0	81.6	14.0	91.9	20.0	97.4
2.5	1.9	8.5	83.0	14.5	92.3	20.5	97.9
3.0	2.1	9.0	84.0	15.0	93.0	21.0	98.1
3.5	2.8	9.5	85.0	15.5	93.4	21.5	98.5
4.0	3.2	10.0	86.1	16.0	93.9	22.0	98.9
4.5	4.4	10.5	86.8	16.5	94.4	22.5	99.1
5.0	5.7	11.0	87.8	17.0	95.0	23.0	99.3
5.5	10.0	11.5	88.4	17.5	95.8	23.5	99.6
						24.0	100.0

Table 2. Summary of 24-Hour Precipitations

Storm Recurrance Frequency	Total Precipitation (Inches)
2-year	1.70
5-year	2.25
10-year	2.42
25-year	3.23
50-year	3.65
100-year	4.13

Table 3. SCS Curve Numbers

Land Usage	Soil Group B	Soil Group C	Soil Group D	% Impervious	% Contributing*
Desert-Fair Cover	72	81	86	0	100
Hillside	98	98	98	50	100
0-2 DU/AC	80	84	87	25	100
2-5 DU/AC	82	87	90	50	50
5-10 DU/AC	84	88	90	75	50
10+ DU/AC	88	90	92	85	50
Mixed Use	87	90	92	85	50
Commercial	95	95	95	95	50
Interstate	72	81	86	60	100
Floodplain	72	81	86	0	100

*% Contributing was used in Case 2.0 Analyses to approximate the impact of a regional on-site detention policy that is described in the City of Phoenix Storm Drainage Design Manual for Subdivision Drainage Design.

Table 4. Summary of Stage-Storage-Runoff Relationships for Storm Detention Areas

Reservoir 1: North of CAP Canal

Pool Stage Elevation (FEET)	Total Impoundment Volume (AC-FT)	Total Runoff Discharge (C.F.S.)
1493	0	0
1495.75	0.10	153
1496	0.11	183
1498	3.91	420
1498.5	4.75	480
1500	7.71	731
1502	30.60	887
1504	79.48	1019
1506	164.73	1135
1508	293.46	1241
1510	463.36	1339
1512	670.00	1430

Reservoir 2: South of CAP Canal

Pool Stage Elevation (FEET)	Total Impoundment Volume (AC-FT)	Total Runoff Discharge (C.F.S.)
1504	0	0
1506	2.98	0
1508	10.59	99.1
1510	23.57	424.9
1512	41.57	1118.7
1514	70.00	2309.3

Table 5. Summary of Hydrologic Parameters for Case 1 Analysis

Sub Basin	Drainage Area (SQ. MI.)	SCS Curve Number*	Flow Type**	Length (FT)	Slope (FT/FT)	Roughness Factor	% Of Sub Basin Area
1	0.77	86	O	1200	.0080	0.130	97
			O	600	.0700	0.150	3
			C	6000	.0077	.070	57
			C	2900	.0066	.050	100
1A	0.37	85	O	1200	.0080	.130	100
			C	400	.1130	.070	5
			C	6100	.0100	.070	97
			C	350	.0060	.050	100
2	1.39	86	O	1100	.0080	.130	99
			O	600	.0700	.150	1
			C	15700	.0075	.070	98
			C	750	.0027	.050	100
			O	1400	.0080	0.130	100
2A	0.50	80	C	5750	.0150	.070	98
			C	500	.0026	.050	100
			O	700	.0400	.130	87
3	0.58	80	O	500	.0900	.150	13
			C	6300	.0413	.070	99
			C	2700	.0022	.050	100
3A	0.68	86	O	1800	.0800	.130	80
			O	500	.0100	.130	20
			C	1200	.0073	.070	96
			C	650	.0015	.050	100
3B	0.46	82	O	1000	.0080	.130	100
			C	400	7.500	.150	4
			C	6800	.0230	.130	100
4	0.72	86	O	650	.0150	.130	94
			O	500	.0800	.150	6
			C	9900	.0076	.070	33
			C	3600	.0072	.050	100
4A	0.57	84	O	2000	.0100	.150	70
			O	1200	.0150	.150	30
			C	4500	.0130	.070	80
			C	2600	.0080	.050	100
6	0.43	95	O	800	.0100	.130	37
			O	550	.0400	.150	63
			C	4500	.0780	.070	30
			C	10	.0080	.050	100

Table 5. Summary of Hydrologic Parameters for Case 1 Analysis (Continued)

Sub Basin	Drainage Area (SQ. MI.)	SCS Curve Number*	Flow Type**	Length (FT)	Slope (FT/FT)	Roughness Factor	% Of Sub Basin Area
7	0.39	90	O	800	.0070	.130	54
			O	400	.1000	.150	46
			C	3000	.1170	.070	59
			C	1580	.0038	.055	100
8	1.30	85	O	1100	.0300	.130	91
			O	500	.0600	.150	9
			C	7700	.0058	.070	40
			C	3900	.0046	.055	100
9	3.12	87	O	950	.0087	.130	95
			O	500	.0600	.150	5
			C	25100	.0078	.070	79
			C	2600	.0023	.050	100

* The SCS Curve Number shown on this table is a weighted average number based on the acreages of differnt land uses and soil types within a sub basin.

** O = Overland Flow Option for Kinematic Wave Method.
C = Channel Flow Option for Kinematic Wave Method.

Table 6. Summary of Existing Wash Channel Geometry

Sub Basin or Routing Reach	Base Width (FT)	Side Slope	Channel Type
1	10	10:1	Collector
	12	4:1	Main
	2	10:1	Collector
1A	10	10:1	Collector
	12	4:1	Main
2	10	10:1	Collector
	13	4:1	Main
2A	10	10:1	Collector
	13	4:1	Main
3	10	3:1	Collector
	17	4:1	Main
3A	10	10:1	Collector
	17	4:1	Main
3B	5	10:1	Collector
	10	3:1	Main
4	10	10:1	Collector
	20	4:1	Main
4A	10	5:1	Collector
	20	4:1	Main
6	10	3:1	Collector
	24	2:1	Main
7	10	3:1	Collector
	25	2:1	Main
8	10	10:1	Collector
	28	2:1	Main
9	10	5:1	Collector
	20	4:1	Main
Route 1	13	4:1	Main
Route 2	17	4:1	Main
Route 3	20	4:1	Main
Route 4	25	2:1	Main
Route 5	28	2:1	Main

Table 7. Summary of Storm Runoff for Case 1

Location	Case 1 Peak Flow (CFS)	Case 1 Time of Peak (HRS)	1987 FIS Peak Flow (CFS)	Model Verification Peak Flow (CFS)
SUB 1	505	6.75		572
SUB 1A	236	6.75		273
COMB 1	741	6.75	724	
ROUTE 1	735	6.92		
SUB 2	637	7.00		922
SUB 2A	227	6.92		265
COMB 2	1592	6.92	1437	
ROUTE 2	1586	7.08		
SUB 3	520	6.33		545
SUB 3A	280	7.17		386
SUB 3B	269	6.67		342
COMB 3	2258	7.00	2221	
ROUTE 3	2242	7.08		
SUB 4	381	6.67		685
SUB 4A	291	6.67		506
SUB 9	1442	7.00	1207	
SUB 5	4269	7.00	4098	
RES 5	1304	9.25	1297	
SUB 6	956	6.00	743	
RES 6	467	6.33	301	
COMB 6	1386	7.08		
ROUTE 4	1384	7.17		
SUB 7	619	6.00		
COMB 7	1540	6.67	1609	
ROUTE 5	1511	7.00		
SUB 8	708	6.83		
COMB 8	2202	6.92	2303	

Table 8. Summary of Land Use Types for Case 2 & 2A Analysis

Sub Basin	Case 2A Unadjusted Basin Area (SQ.MI.)	Case 2 Adjusted Basin Area (SQ.MI.)	0-2 DU/AC	2-5 DU/AC	5-10 DU/AC	Lot DU/AC	Mixed Use	Commercial	Hillside	Misc*
1	0.77	.394	0	61	29	8	2	0	0	0
1A	0.37	.184	0	16	43	36	0	0	5	0
2	1.39	.659	10	48	18	6	1	8	0	9
2A	0.50	.246	0	45	31	7	0	15	2	0
3	0.58	.437	21	54	2	0	0	0	23	0
3A	0.68	.440	27	61	9	0	3	0	0	0
3B	0.46	.472	67	0	0	0	0	0	33	0
4	0.72	.513	56	42	2	0	0	0	0	0
4A	0.57	.584	58	0	0	0	0	0	33	9
6	0.43	.436	20	0	0	0	0	0	80	0
7	0.39	.323	0	37	0	0	0	0	63	0
8	1.30	.810	0	62	0	0	0	0	20	0
9	3.12	2.187	25	32	3	0	0	0	11	6

* Miscellaneous is Interstate for Sub Basin 2 and Floodplain for Sub Basins 4A and 9.

Table 9. Summary of SCS Curve Numbers for Cases 2 and 2A

Sub Basin	Weighted Average SCS Curve Number		Percent Impervious per Sub Basin	
	Case 2	Case 2A	Case 2	Case 2A
1	90	90	59	59A
1A	91	90	76	75
2	89	90	56	58
2A	89	89	66	66
3	87	86	43	45
3A	89	89	42	46
3B	86	86	35	35
4	88	88	34	37
4A	88	88	33	33
6	95	95	46	46
7	95	94	50	49
8	92	90	54	55
9	90	90	44	50

Table 10. Summary of Storm Runoff for Cases 2 and 2A

Location	Case 2 Peak Flow (CFS)	Time of Peak (HRS)	Case 2A Peak Flow (CFS)	Time of Peak (HRS)	Case 1 Peak Flows (CFS)	Time of Peak (HRS)
SUB 1	493	6.17	1067	6.17	505	6.75
SUB 1A	255	6.08	586	6.17	236	6.75
COMB 1	747	6.17	1583	6.17	741	6.75
ROUTE 1	734	6.25	1621	6.25	735	6.92
SUB 2	430	6.50	1189	6.67	637	7.00
SUB 2A	359	6.08	797	6.08	227	6.92
COMB 2	1405	6.25	3164	6.25	1592	6.92
ROUTE 2	1400	6.42	3129	6.33	1586	7.08
SUB 3	794	6.17	1044	6.08	520	6.33
SUB 3A	251	6.83	506	6.75	280	7.17
SUB 3B	455	6.33	467	6.25	269	6.67
COMB 3	2527	6.17	4772	6.25	2258	7.00
ROUTE 3	2491	6.42	4698	6.33	2242	7.08
SUB 4	377	6.50	687	6.58	381	6.67
SUB 4A	495	6.25	483	6.25	291	6.67
SUB 9	1391	6.67	2516	6.75	1442	7.00
SUB 5	4631	6.50	7903	6.42	4269	7.00
RES 5	1287	8.58	1466	8.83	1304	9.25
SUB 6	936	6.08	923	6.08	956	6.00
RES 6	505	6.33	494	6.33	467	6.33
COMB 6	1547	6.50	1662	6.67	1386	7.08
ROUTE 4	1545	6.67	1661	6.75	1384	7.17
SUB 7	673	6.00	786	6.00	619	6.00
COMB 7	1778	6.50	1936	6.50	1540	6.67
ROUTE 5	1724	6.75	1888	6.75	1511	7.00
SUB 8	750	6.42	1441	6.42	708	6.83
COMB 8	2392	6.67	3170	6.58	2202	6.92

Table 11. Summary of Hydrologic Parameters for Case 3 Analysis

Sub Basin	Drainage Area (SQ. MI.)	SCS Curve Number*	Flow Type**	Length (FT)	Slope (FT/FT)	Roughness Factor	% of Sub Basin Area
1	0.821	86	O	1200	.0800	.130	100
			C	2200	.0090	.050	26
			C	6300	.0084	.050	100
2	0.744	86	O	2000	.0015	.130	100
			C	4200	.0083	.050	100
			O	2500	.0020	.130	70
3	1.019	86	O	2800	.0090	.130	30
			C	6400	.0056	.050	100
			O	1800	.0004	.130	30
4	0.573	79	O	1500	.0160	.130	70
			C	2000	.0140	.050	100
			O	1000	.030	.130	70
5	0.150	76	O	1000	.015	.130	30
			C	1000	.020	.050	100
6	0.690	85	O	1500	.0070	.130	70
			O	1000	.0100	.050	30
			C	4500	.0700	.050	35
			C	1200	.0058	.050	100
7	1.245	88	O	650	.0150	.130	66
			O	500	.0800	.150	34
			C	3500	.0072	.050	100
8	0.303	86	O	800	.0100	.130	30
			O	7500	.0067	.130	70
			C	1200	.0100	.050	100
9	0.673	86	O	2500	.0048	.130	100
			C	4000	.0075	.050	100
10	1.147	86	O	3000	.0033	.130	100
			C	5000	.0075	.050	100
11	0.316	79	O	1500	.2400	.130	45
			O	1600	.0125	.130	55
			C	500	.0200	.050	100
12	1.435	86	O	1300	.1230	.150	35
			O	2500	.0830	.130	65
			C	2600	.0023	.050	100
13	0.430	95	O	800	.0100	.130	37
			O	500	.0400	.150	63
			C	4500	.0780	.070	30
			C	10	.0080	.050	100

Table 11. Summary of Hydrologic Parameters for Case 3 Analysis (Continued)

Sub Basin	Drainage Area (SQ. MI.)	SCS Curve Number*	Flow Type**	Length (FT)	Slope (FT/FT)	Roughness Factor	% of Sub Basin Area
14	0.390	90	O	800	.0070	.130	54
			O	400	.1000	.150	46
			C	3000	.1170	.070	59
			C	1580	.0038	.055	100
15	1.343	85	O	1100	.0090	.130	91
			O	500	.0600	.150	9
			C	7700	.0058	.070	32
			C	3900	.0046	.055	100

* The SCS Curve Number shown on this table is a weighted average number based on the acreages of differnt land uses and soil types within a sub basin.

** O = Overland Flow Option for Kinematic Wave Method.
C = Channel Flow Option for Kinematic Wave Method.

Table 12. Summary of Channel Geometries for Case 3

Location	Length (FT)	Earth Base Width (FT)	Channels Side Slope (H:V)	Concrete Base Width (FT)	Channels Side Slope (H:V)
A. Buchanan Wash					
A.1 Carefree to Dove Alley	6250	40	4:1	46	2:1
A.2 Dove Alley to 43rd Ave	4250	40	4:1	61	2:1
A.3 43rd Ave to NW Outer Loop	6250	50	4:1	50	2:1
A.4 NW Outer Loop to Dixileta Dr.	2500	75	4:1	30	2:1
A.5 Dixileta Dr. to Patton Rd.	5000	125	4:1	60	2:1
A.6 Patton Rd. to CAP	3000				
B.					
B.1 Tributary A					
B.2 I-17 to Dove Valley	1500	50	4:1	10	2:1
B.3 Dove Valley to NW Outer Loop	5200	50	4:1	20	2:1
B.4 NW Outerloop to Dixileta Dr.	5700	100	4:1	50	2:1
B.5 Dixileta Dr. to CAP	4500	100	4:1	50	2:1
C.					
C.1 Tributary B					
C.2 51st Ave to Patton Rd.	5000	30	4:1	40	2:1
D.					
D.1 Tributary C					
D.2 51st Ave to Dixileta Dr.	3200	25	4:1	15	2:1
E.					
E.1 Tributary D					
E.2 51st Ave to NW Outer Loop	3250	25	4:1	27	2:1

Table 13. Summary of Storm Runoffs for Case 3

Location	Case 3 Peak Flow (CFS)	Case 3 Time of Peak (HR)	Case 1 Peak Flow (CFS)	1987 FIS Flow (CFS)
SUB 1	624	6.67		
SUB 2	814	6.83		
SUB 3	1097	7.00		
SUB 4	249	6.50		
ROUTE 1	248	6.67		
COMB 1	1280	6.92	741	724
ROUTE 2	1275	7.08		
SUB 5	102	6.33		
ROUTE 3	97	6.42		
SUB 6	405	6.33		
COMB 2	1636	7.00	1592	1437
ROUTE 4	1608	7.17		
SUB 7	2183	6.08		
SUB 11	271	6.08		
ROUTE 5	222	6.25		
COMB 3	2246	6.08		
ROUTE 7	2168	6.17		
SUB 8	134	6.25		
SUB 9	338	6.58		
SUB 10	649	7.67		
ROUTE 6	648	7.83		
SUB 12	1746	6.08		
COMB 4	3731	6.17	4269	4098
RES 1	1272	9.50		
SUB 13	956	6.00		
RES 2	467	6.33		
COMB 5	1490	6.42		
ROUTE 8	1481	6.50		
SUB 14	619	6.00		
COMB 6	1800	6.42	1540	1609
ROUTE 9	1727	6.67		
SUB 15	731	6.83		
COMB 7	2438	6.75	2202	2303

Table 14. Summary of Hydrologic Parameters for Case 4 Analysis

Sub Basin	Drainage Area (SQ. MI.)	SCS Curve Number*	Flow Type**	Length (FT)	Slope (FT/FT)	Roughness Factor	% of Sub Basin Area	Shape
1	.614	86	O	1200	.0080	.130	100	
			C	2200	.0090	.050	76	TRAP
			C	6300	.0084	.050	100	TRAP
1A	.088	86	O	3000	.0087	.130	100	
			C	1250	.0016	.015	100	CIRC
			O	1600	.0130	.150	40	
1B	.119	86	O	2000	.0065	.130	60	
			C	1150	.0035	.015	100	CIRC
2	.287	86	O	2000	.0015	.130	100	
			C	4200	.0083	.050	100	TRAP
			O	800	.0175	.150	15	
2A	.195	86	O	3000	.0063	.130	85	
			C	1500	.0007	.015	100	CIRC
2B	.028	86	O	1400	.0079	.150	100	
			C	800	.0050	.015	100	CIRC
			O	1100	.0082	.130	10	
2C	.141	86	O	4500	.0069	.130	90	
			C	1500	.0020	.015	100	CIRC
2D	.083	86	O	2300	.0100	.150	100	
			C	950	.0011	.015	100	CIRC
			O	1500	.0120	.150	100	
2E	.010	86	C	700	.0014	.015	100	CIRC
			O	2500	.0020	.130	70	
3	.655	86	O	2800	.0090	.130	30	
			C	3700	.0056	.050	100	TRAP
3A	.085	86	O	1400	.0064	.130	100	
			C	1900	.0075	.015	100	CIRC
3B	.031	86	O	900	.0056	.130	100	
			C	3100	.0087	.015	100	CIRC
3C	.160	86	O	500	.0100	.150	100	
			C	3300	.0073	.050	90	TRAP
			C	1400	.0079	.015	100	CIRC
3D	.018	86	O	700	.0043	.150	100	
			C	500	.0080	.015	100	CIRC
			O	1000	.0040	.150	100	
3E	.070	86	C	3200	.0063	.015	100	CIRC
			O	1500	.0160	.130	100	

Table 14. Summary of Hydrologic Parameters for Case 4 Analysis (Continued)

Sub Basin	Drainage Area (SQ. MI.)	SCS Curve Number*	Flow Type**	Length (FT)	Slope (FT/FT)	Roughness Factor	% of Sub Basin Area	Shape
4	.190	79	C	2000	.0140	.050	100	TRAP
			O	1350	.0120	.130	100	
4A	.055	79	C	1400	.0029	.075	100	CIRC
			O	1000	.0200	.150	20	
4B	.175	79	O	2700	.0130	.130	80	
			C	900	.0044	.015	100	CIRC
5	.051	76	O	2700	.0360	.130	100	
			C	300	.0089	.015	100	CIRC
5A	.019	76	O	2600	.0350	.130	100	
				250	.0089	.015	100	CIRC
5B	.023	79	O	800	.0038	.130	100	
			C	900	.0078	.015	100	CIRC
5C	.030	79	O	800	.2000	.150	100	
			C	2400	.0379	.015	100	CIRC
			O	3000	.0260	.130	100	
5D	.058	76	C	300	.0260	.050	100	TRAP
			O	1300	.0185	.150	100	
5E	.022	76	C	400	.0080	.015	100	CIRC
			O	1300	.0550	.150	40	
5F	.144	79	O	1200	.0240	.130	60	
			C	1700	.0080	.015	100	CIRC
5G	.009	79	O	700	.0760	.130	100	
			C	200	.0210	.015	100	CIRC
5H	.049	79	O	1200	.3500	.150	60	
			O	450	.0440	.130	40	
			C	500	.0260	.015	100	CIRC
6	.287	85	O	2500	.0070	.130	70	
			O	1000	.0100	.130	30	
			C	1200	.0058	.050	100	TRAP
6A	.050	85	O	500	.0040	.130	40	
			O	1000	.0130	.100	60	
			C	1000	.0080	.015	100	CIRC
6B	.035	85	O	1800	.0083	.130	100	
			C	2400	.0071	.015	100	CIRC
			O	1000	.0080	.130	100	
6C	.318	85	C	3100	.0058	.050	85	TRAP
			C	1900	.0063	.015	100	CIRC

Table 14. Summary of Hydrologic Parameters for Case 4 Analysis (Continued)

Sub Basin	Drainage Area (SQ. MI.)	SCS Curve Number*	Flow Type**	Length (FT)	Slope (FT/FT)	Roughness Factor	% of Sub Basin Area	Shape
7	.873	88	O	650	.0150	.130	66	
			O	500	.0800	.150	34	
			C	3500	.0072	.050	100	TRAP
7A	.017	88	O	250	.0010	.130	100	
			C	2300	.0170	.015	100	CIRC
7B	.034	88	O	1500	.0073	.130	100	
			C	1300	.0032	.015	100	CIRC
			O	2500	.0056	.130	100	
7C	.050	88	C	1000	.0040	.015	100	CIRC
			O	3500	.0060	.130	100	
7D	.111	88	C	1500	.0033	.015	100	CIRC
			O	2200	.0068	.130	100	
7E	.067	88	C	1000	.0033	.015	100	CIRC
			O	1500	.0087	.130	30	
7F	.093	86	O	700	.3500	.150	70	
			C	500	.0150	.015	100	CIRC
8	.258	86	O	800	.0100	.130	30	
			O	7500	.0067	.130	70	
			C	1200	.0100	.050	100	TRAP
8A	.045	86	O	1100	.0100	.130	100	
			C	1000	.0013	.015	100	CIRC
			O	2500	.0048	.130	100	
9	.465	86	C	4000	.0075	.050	100	TRAP
			O	2000	.0075	.130	100	
9A	.096	86	C	1200	.0067	.050	100	TRAP
			C	1500	.0011	.015	100	CIRC
9B	.065	86	O	1600	.0088	.130	100	
			C	1300	.0011	.015	100	CIRC
9C	.047	86	O	1500	.0067	.130	100	
			C	1100	.0082	.015	100	CIRC
			O	3000	.0033	.130	100	
10	.684	86	C	5000	.0075	.050	100	TRAP
			O	1000	.0050	.130	100	
10A	.167	86	C	2500	.0052	.050	100	TRAP
			C	2000	.0032	.015	100	CIRC
10B	.151	86	O	2500	.0072	.130	100	
			C	1700	.0032	.015	100	CIRC

Table 14. Summary of Hydrologic Parameters for Case 4 Analysis (Continued)

Sub Basin	Drainage Area (SQ. MI.)	SCS Curve Number*	Flow Type**	Length (FT)	Slope (FT/FT)	Roughness Factor	% of Sub Basin Area	Shape
10C	.145	86	O	2000	.0071	.130	100	
			C	1800	.0056	.015	100	CIRC
			O	1500	.2400	.130	45	
11	.138	79	O	1600	.0125	.130	55	
			C	500	.0200	.050	100	TRAP
11A	.076	79	O	1900	.0279	.130	100	
			C	1300	.0030	.015	100	CIRC
			O	1300	.1230	.150	35	
12	1.435	98	O	2500	.0080	.130	65	
			C	2600	.0023	.050	100	TRAP
13	.430	95	O	800	.0100	.130	37	
			O	550	.0400	.150	63	
			C	4500	.0780	.070	30	TRAP
			C	10	.0080	.050	100	TRAP
			O	800	.0070	.130	54	
14	.390	90	O	400	.1000	.150	46	
			C	3000	.1170	.070	59	TRAP
			C	1580	.0038	.055	100	TRAP
			O	1100	.0090	.130	91	
15	1.343	85	O	500	.0600	.150	9	
			C	7700	.0058	.070	39	TRAP
			C	3900	.0046	.055	100	TRAP

* The SCS Curve Number shown on this table is a weighted average number based on the acreages of differnt land uses and soil types within a sub basin.

** O = Overland Flow Option for Kinematic Wave Method.
C = Channel Flow Option for Kinematic Wave Method.

Table 15. Summary of Storm Runoffs for Case 4

	Case 4		Case 3	
Location	Peak Flow (CFS)	Time of Peak (HR)	Storm Drain Diameter (IN)	100-year Peak Flow (CFS)
SUB 1	41	8.08	N/A	
SUB 1A	4	9.50	18	
SUB 1B	7	8.00	21	
COMB 1A	51	8.08	N/A	
RTE 1A	51	8.42	N/A	
SUB 2	8	11.92	N/A	
SUB 2E	1	7.75	18	
SUB 2A	8	6.92	27	
SUB 2B	10	7.00	21	
SUB 2C	4	11.42	18	
SUB 2D	8	8.75	27	
COMB 1B	74	8.50	N/A	
RTE 1B	72	9.08	N/A	
SUB 3	19	10.00	N/A	
SUB 3E	4	8.08	18	
SUB 3D	2	7.42	18	
COMB 1C	6	7.67	N/A	
RTE 1C	6	8.33	N/A	
SUB 4	5	8.42	N/A	
SUB 4A	2	8.42	18	
SUB 4B	4	7.92	18	
COMB 1D	11	8.33	N/A	
ROUTE 1	10	8.67	N/A	248
SUB 3A	6	8.00	18	
SUB 3B	3	7.42	18	
SUB 3C	22	6.92	27	
COMB 1	117	9.00	N/A	1280
ROUTE 2	116	9.25	N/A	1275
SUB 5C	1	6.50	18	
SUB 5H	4	6.50	18	
COMB 2C	5	6.50	N/A	
RTE 3A	5	6.48	N/A	
SUB 5F	10	6.67	21	
SUB 5E	10	6.75	21	
SUB 5C	3	6.50	18	
SUB 5B	1	8.50	18	
COMB 2B	3	6.50	N/A	

Table 15. Summary of Storm Runoffs for Case 4 (Continued)

	Case 4		Case 3	
Location	Peak Flow (CFS)	Time of Peak (HR)	Storm Drain Diameter (IN)	100-year Peak Flow (CFS)
SUB 5A	3	6.58	18	
SUB 5	4	6.58	18	
SUB 5D	1	10.25	N/A	
COMB 2A	14	6.67	N/A	
ROUTE 3	13	7.08	N/A	97
SUB 6B	2	8.42	18	
SUB 6C	25	7.58	30	
SUB 6	13	7.33	N/A	
SUB 7F	76	6.00	36	
SUB 6A	77	6.00	42	
COMB 2	153	9.00	N/A	1636
ROUTE 4	150	9.58	N/A	1608
SUB 7	164	6.42	N/A	
SUB 11	6	6.67	N/A	
SUB 11A	2	8.17	18	
COMB 3A	8	6.67	N/A	
ROUTE 5	7	7.42	N/A	222
SUB 7B	3	7.67	18	
SUB 7C	5	7.92	18	
SUB 7D	9	8.17	21	
SUB 7E	13	8.42	24	
SUB 7A	3	6.75	18	
COMB 3	189	9.42	N/A	2246
ROUTE 7	188	9.58	N/A	2168
SUB 8	10	7.00	N/A	
SUB 8A	4	7.25	21	
COMB 4C	14	7.08	N/A	
SUB 9	26	7.83	N/A	
SUB 9A	5	8.67	21	
SUB 9B	9	8.08	27	
SUB 9C	3	8.08	18	
COMB 4B	38	7.92	N/A	
SUB 10	53	9.00	N/A	
SUB 10A	12	7.83	24	
SUB 10B	18	8.00	30	
SUB 10C	8	8.58	21	
COMB 4A	76	8.67	N/A	

Table 15. Summary of Storm Runoffs for Case 4 (Continued)

	Case 4		Case 3	
Location	Peak Flow (CFS)	Time of Peak (HR)	Storm Drain Diameter (IN)	100-year Peak Flow (CFS)
SUB 9	26	7.83	N/A	
SUB 9A	5	8.67	21	
SUB 9B	9	8.08	27	
SUB 9C	3	8.08	18	
COMB 4B	38	7.92	N/A	
SUB 10	53	9.00	N/A	
SUB 10A	12	7.83	24	
SUB 10B	18	8.00	30	
SUB 10C	8	8.58	21	
COMB 4A	76	8.67	N/A	
ROUTE 6	75	9.42	N/A	648
SUB 12	397	6.17	N/A	
COMB 4	407	6.25	N/A	3731
RES 1	379	6.67	N/A	1272
SUB 13	218	6.17	N/A	
RES 2	78	6.92	N/A	
COMB 5	452	6.67	N/A	1490
ROUTE 8	450	6.83	N/A	
SUB 14	112	6.17	N/A	
COMB 6	504	6.75	N/A	1800
ROUTE 9	475	7.17	N/A	
SUB 15	73	8.42	N/A	
COMB 7	508	7.17	N/A	2438

TABLE 16: CITY OF PHOENIX UNIT CONSTRUCTION COSTS

ITEM NO.	DESCRIPTION	UNIT	PRICE $
1.	Channel Excavation (100,000CY-500,000CY) includes detention basins	CY	3.00
2.	Channel Excavation (more than 500,000CY) includes detention basins	CY	2.00
3.	Berms and Dykes (less than 10,000CY) includes importing material	CY	10.00
4.	Berms and Dykes (10,001CY - 50,000CY) includes importing material	CY	7.00
5.	Berms and Dykes (50,001CY - 100,000CY) includes importing material	CY	5.00
6.	Berms and Dykes (more than 100,001CY) includes importing material	CY	3.00
7.	Structural Concrete, complete in place	CY	300.00
8.	Grader Ditch	LF	5.00
9.	Chain Link Fence (72")	LF	10.00
10.	Sidewalk	SF	2.00
11.	Rip Rap	CY	75.00
12.	Retaining Walls	SF	30.00
13.	Channel Lining - 6" conc.	SY	30.00
14.	Bridge at Major Streets (use 80' street width)	SF	55.00
15.	Drop Structures (up to 6')	LF	600.00
16.	Landscaping	ACRE	7,500.00
17.	Land Cost (tentative)	ACRE	10,000.00
18.	12" Storm Drain Pipe (6' deep)	LF	50.44
19.	15" Storm Drain Pipe (6' deep)	LF	52.38
20.	18" Storm Drain Pipe (6' deep)	LF	55.29
21.	21" Storm Drain Pipe (6' deep)	LF	56.26
22.	24" Storm Drain Pipe (6' deep)	LF	59.17
23.	27" Storm Drain Pipe (6' deep)	LF	62.08
24.	30" Storm Drain Pipe (6' deep)	LF	66.93
25.	33" Storm Drain Pipe (6' deep)	LF	71.78
26.	36" Storm Drain Pipe (6' deep)	LF	78.57
27.	39" Storm Drain Pipe (6' deep)	LF	87.30
28.	42" Storm Drain Pipe (6' deep)	LF	96.03
29.	45" Storm Drain Pipe (6' deep)	LF	104.76
30.	48" Storm Drain Pipe (6' deep)	LF	113.49
31.	51" Storm Drain Pipe (7' deep)	LF	125.13
32.	54" Storm Drain Pipe (7' deep)	LF	133.86
33.	57" Storm Drain Pipe (8' deep)	LF	146.47
34.	60" Storm Drain Pipe (8' deep)	LF	157.14

Table 17. Cost Estimate for Alternate A: Earth Channels

I. Channels	Length (FT)	Base Width,	Depth (FT)**	Top Width, FT
A. Buchanan Wash				
A.1 Carefree to Dove Alley	6250	40	4	72
A.2 Dove Alley to 43rd Ave	4250	40	4	72
A.3 43rd Ave to NW Outer Loop	6250	50	5	90
A.4 NW Out Loop to Dixileta	2500	75	5	115
A.5 Dixileta Dr. to Patton Rd.	5000	125	4.5	161
A.6 Patton Rd. To C.A.P.	3000			
B. Tributary A				
B.1 I-17 to Dove Valley	1500	50	2	66
B.2 Dove Valley to NW Outer Loop	5200	50	2.5	70
B.3 NW Outerloop to Dixileta Dr.	5700	100	2.5	120
B.4 Dixileta Dr. to C.A.P.	4500	100	3	124
C. Tributary B				
C.1 51st Ave to Patton Rd.	5000	30	2.5	50
D. Tributary C				
D.1 51st Ave to Dixileta Dr.	3200	25	2	41
E. Tributary D				
E.1 51st Ave to NW Outer Loop	3250	25	3	49

**Includes Free Board.

Table 17. Cost Estimate for Alternate A: Earth Channels (Continued)

I. Channels	Area (SF)	Volume (CY)	Unit Cost Comments ($/CY)	Total Cost ($)
A. Buchanan Wash				
A.1 Carefree to Dove Alley	224	51,850	3.00	155,550
A.2 Dove Alley to 43rd Ave	224	32,260	3.00	105,780
A.3 43rd Ave to NW Outer Loop	350	81,020	3.00	243,060
A.4 NW Out Loop to Dixileta	475	43,980	3.00	131,940
A.5 Dixileta Dr. to Patton Rd.	644	119,200	3.00	357,780
A.6 Patton Rd. To C.A.P.			*Natural Channel	
B. Tributary A				
B.1 I-17 to Dove Valley	116	6,450	3.00	19,350
B.2 Dove Valley to NW Outer Loop	150	28,890	3.00	86,670
B.3 NW Outerloop to Dixileta Dr.	275	58,060	3.00	174,180
B.4 Dixileta Dr. to C.A.P.	336	56,000	3.00	168,000
C. Tributary B				
C.1 51st Ave to Patton Rd.	100	18,520	3.00	55,560
D. Tributary C				
D.1 51st Ave to Dixileta Dr.	66	7,820	3.00	23,460
E. Tributary D				
E.1 51st Ave to NW Outer Loop	111	13,360	3.00	40,080
	Total	520,470		1,561,410

Table 17. Alternate A

	Channel Top Width (FT)	Bridge Width* (FT)	Area of Deck (SQ. FT.)	Unit Cost (SQ. FT.)	Total Cost ($)
II. Bridges					
A. Buchanan Wash	72	85	6970	60	418,200
A.1 At Dove Valley Rd.	72	85	6970	60	418,200
A.2 At 43rd Ave	115	85	10625	60	637,500
A.3 At NW Outer Loop	161	85	14535	60	872,100
A.4 At Dixileta Dr.	171	85	15385	60	923,100
A.5 At Patton Rd.					
B. Tributary A					
B.1 At Dove Valley Rd.	66	85	6460	60	387,600
B.2 At NW Outer Loop	70	85	6800	60	408,000
B.3 At Dixileta Dr.	120	85	11050	60	663,100
C. Tributary B					
C.1 At 51st Ave	50	85	5100	60	306,000
D. Tributary C					
D.1 At 57th Ave	41	85	4335	60	260,100
E. Tributary D					
E.1 At 51st Ave	49	85	5015	60	300,900
*Includes Abutments		Total	93,245		5,594,700

Table 17. Alternate A.	Size in Diameter	Length	Unit Cost ($/LF)	Total Cost ($)
III. Storm Drain				
A.1 Section from Dove Valley Rd. to 43rd Ave	21"	4250	56.26	239,105
A.2 Section from 43rd Ave to NW Outer Loop	30"	6250	66.93	418,313
A.3 Section from NW Outer Loop to Dixileta Drive	30	2500	66.93	167,325
A.4 Section from Dixileta Drive to Patton Road	30	5000	66.93	334,650
A.5 Section from Patton Road to the C.A.P.	30	3000	66.93	200,790
A.6 Lateral A-1	18	2300	55.29	127,167
A.7 Lateral A-2	18	2300	55.29	127,167
	21	1500	56.26	84,390
	24	1000	59.17	59,170
A.8 Lateral A-3	18	1300	55.29	71,877
	21	5000	56.26	281,300
A.9 Lateral A-4	36	500	78.57	39,285
	42	1000	96.03	96,030
A.10 Lateral A-5	18	2400	55.29	132,696
	30	1900	66.93	127,167
A.11 Lateral A-6	18	1900	55.29	105,051
A.12 Lateral A-7	18	3100	55.29	171,399
	27	1400	62.08	86,912
A.13 Lateral A-8	18	700	55.29	38,703
	21	800	56.26	45,008
	27	1500	62.08	93,120
A.14 Lateral A-9	18	1500	55.29	82,935
	27	950	62.08	58,976
A.15 Lateral A-10	18	1250	55.29	69,113
A.16 Lateral A-11	21	1150	56.26	64,699
B. Line B				
B.1 Section from 51st Ave to Dixileta Drive	30	3200	66.93	214,176
B.2 Lateral B-1	18	2950	55.29	163,106
B.3 Lateral B-2	18	900	55.29	46,761
B.4 Lateral B-3	18	2750	55.29	152,048
	21	2100	56.26	118,146

Table 17. Alternate A	Diameter Size (in)	Length	Unit Cost ($/LF)	Total Cost ($)
C. Line C				
C.1 Section from 51st Ave to NW Outer Loop	30	3250	66.93	217,523
C.2 Lateral C-1	18	1400	55.29	77,406
C.3 Lateral C-2	18	900	55.29	49,761
D. Line D				
D.1 Section from 51st Ave to Outer Loop	30	3250	66.93	217,523
D.2 Lateral D-1	18	500	55.29	27,645
D.3 Lateral D-2	18	3200	55.29	176,928
E. Line E				
E.1 Section from Dove Valley Road to NW Outer Loop	21	5200	56.26	292,552
E.2 Section from NW Outer Loop to Dixileta Drive	30	5700	66.93	381,501
E.3 Section from Dixileta Drive to	30	4500	66.93	301,185
C.A.P.	30	3000	66.93	200,790
E.4 Lateral E-1	24	2000	59.17	118,340
	30	1700	66.93	113,781
E.5 Lateral E-2	21	1800	56.26	101,268
E.6 Lateral E-3	21	1500	56.26	84,390
	27	1300	62.08	80,704
E.7 Lateral E-4	18	1100	55.29	60,819
E.8 Lateral E-5	21	1000	56.26	56,260
		Total		6,577,960

Table 17. Alternate A.

	Corridor Width	Corridor Length	Area (AC)	Comments
IV. Right-of-Way				
A. Buchanan Wash				
A.1 Carefree to Dove Valley	102	6250	14.6	
A.2 Dove Valley to 43rd Ave	102	4250	10.0	
A.3 43rd Ave to NW Outer Loop	145	6250	20.8	
A.4 NW Outer Loop to Dixileta	191	2500	11.0	
A.5 Dixileta to Patton	201	5000	23.1	
A.6 Patton to C.A.P.	201	3000	13.8	
B. Tributary A				
B.1 I-17 to Dove Valley	96	1500	3.3	
B.2 Dove Valley to NW Outer Loop	100	5200	11.9	
B.3 NW Outer Loop to Dixileta	150	5700	19.6	
B.4 Dixileta to C.A.P.	150	4500	15.5	
C. Tributary B				
C.1 51st Ave to Patton Dr.	80	5000	9.2	
D. Tributary C				
D.1 51st Ave to Dixileta Dr.	71	3200	5.2	
E. Tributary D				
E.1 51st Ave to NW Outer Loop	80	3250	6.0	
Total			164.0	

Table 18. Cost Estimate for Alternate B: Concrete Channels

I. Channels	Length (FT)	Base Width, (FT)	Depth (FT)**	Top Width, (FT)	Area (SF)	Volume (CY)
A. Buchanan Wash						
A.1 Carefree to Dove Alley	6250	46	2.5	56	128	29,510
A.2 Dove Alley to 43rd Ave	4250	61	2.5	71	165	25,970
A.3 43rd Ave to NW Outer Loop	6250	50	5.5	47	198	45,830
A.4 NW Out Loop to Dixileta	2500	30	6.5	56	280	25,880
A.5 Dixileta Dr. to Patton Rd.	5000	60	5	80	350	64,810
A.6 Patton Rd. To C.A.P.	3000					
B. Tributary A						
B.1 I-17 to Dove Valley	1500	10	2.5	20	38	2,080
B.2 Dove Valley to NW Outer Loop	5200	20	3	32	78	15,020
B.3 NW Outerloop to Dixileta Dr.	5700	50	2.5	60	138	28,030
B.4 Dixileta Dr. to C.A.P.	4500	50	3	62	168	28,000
C. Tributary B						
C.1 51st Ave to Patton Rd.	5000	40	2	48	88	16,300
D. Tributary C						
D.1 51st Ave to Dixileta Dr.	3200	15	2	23	38	4,500
E. Tributary D						
E.1 51st Ave to NW Outer Loop	3250	27	2	35	62	7,460
Total						293,390

Table 18. Cost Estimate for Alternate B: Concrete Channels (Continued)

I. Channels	Unit Cost ($/CY)	Total Cost ($)	Linear Area (SY)	Unit Cost ($/SY)	Total Cost ($)
A. Buchanan Wash					
A.1 Carefree to Dove Alley	3.00	88,530	39,580	30	1,187,400
A.2 Dove Alley to 43rd Ave	3.00	77,910	34,000	30	1,020,000
A.3 43rd Ave to NW Outer Loop	3.00	137,490	34,720	30	1,041,600
A.4 NW Out Loop to Dixileta	3.00	77,640	16,390	30	491,700
A.5 Dixileta Dr. to Patton Rd.	3.00	194,430	46,110	30	1,383,300
A.6 Patton Rd. To C.A.P.					
B. Tributary A					
B.1 I-17 to Dove Valley	3.00	6,240	3,500	30	105,000
B.2 Dove Valley to NW Outer Loop	3.00	45,060	19,070	30	572,100
B.3 NW Outerloop to Dixileta Dr.	3.00	84,090	38,630	30	1,158,900
B.4 Dixileta Dr. to C.A.P.	3.00	84,000	31,500	30	945,000
C. Tributary B					
C.1 51st Ave to Patton Rd.	3.00	48,900	27,220	30	816,600
D. Tributary C					
D.1 51st Ave to Dixileta Dr.	3.00	13,500	8,530	30	255,900
E. Tributary D					
E.1 51st Ave to NW Outer Loop	3.00	22,380	13,000	30	390,000
Total		880,170	312,25		9,367,500

Table 18. Cost Estimate for Alternate B: Concrete Channels

	Channel Top Width (FT)	Bridge Width (FT)	Area of Deck* (SF)	Unit Cost ($/SF)	Total Cost ($)
II. Bridges					
A. Buchanan Wash	56	85	5610	60	336,600
A.1 At Dove Valley Rd.	71	85	6885	60	413,100
A.2 At 43rd Ave	47	85	4845	60	290,700
A.3 At NW Outer Loop	56	85	5610	60	336,600
A.4 At Dixileta Dr.	80	85	7650	60	459,000
A.5 At Patton Rd.					
B. Tributary A					
B.1 At Dove Valley Rd.	20	85	2550	60	153,000
B.2 At NW Outer Loop	32	85	3570	60	214,200
B.3 At Dixileta Dr.	60	85	5950	60	357,000
C. Tributary B					
C.1 At 51st Ave	48	85	4930	60	295,800
D. Tributary C					
D.1 At 57th Ave	33	85	3655	60	219,300
E. Tributary D					
E.1 At 51st Ave	45	85	4675	60	280,500
*Includes Abutments		Total	55,930		3,355,800

Table 18. Alternate B.	Size in Diameter	Length	Unit Cost ($/LF)	Total Cost ($)
III. Storm Drain				
A.1 Section from Dove Valley Rd. to 43rd Ave	21"	4250	56.26	239,105
A.2 Section from 43rd Ave to NW Outer Loop	30"	6250	66.93	418,313
A.3 Section from NW Outer Loop to Dixileta Drive	30	2500	66.93	167,325
A.4 Section from Dixileta Drive to Patton Road	30	5000	66.93	334,650
A.5 Section from Patton Road to the C.A.P.	30	3000	66.93	200,790
A.6 Lateral A-1	18	2300	55.29	127,167
A.7 Lateral A-2	18	2300	55.29	127,167
	21	1500	56.26	84,390
	24	1000	59.17	59,170
A.8 Lateral A-3	18	1300	55.29	71,877
	21	5000	56.26	281,300
A.9 Lateral A-4	36	500	78.57	39,285
	42	1000	96.03	96,030
A.10 Lateral A-5	18	2400	55.29	132,696
	30	1900	66.93	127,167
A.11 Lateral A-6	18	1900	55.29	105,051
A.12 Lateral A-7	18	3100	55.29	171,399
	27	1400	62.08	86,912
A.13 Lateral A-8	18	700	55.29	38,703
	21	800	56.26	45,008
	27	1500	62.08	93,120
A.14 Lateral A-9	18	1500	55.29	82,935
	27	950	62.08	58,976
A.15 Lateral A-10	18	1250	55.29	69,113
A.16 Lateral A-11	21	1150	56.26	64,699
B. Line B				
B.1 Section from 51st Ave to Dixileta Drive	30	3200	66.93	214,176
B.2 Lateral B-1	18	2950	55.29	163,106
B.3 Lateral B-2	18	900	55.29	46,761
B.4 Lateral B-3	18	2750	55.29	152,048
	21	2100	56.26	118,146

Table 18. Alternate B.	Diameter Size (in)	Length	Unit Cost ($/LF)	Total Cost ($)
C. Line C				
C.1 Section from 51st Ave to NW Outer Loop	30	3250	66.93	217,523
C.2 Lateral C-1	18	1400	55.29	77,406
C.3 Lateral C-2	18	900	55.29	49,761
D. Line D				
D.1 Section from 51st Ave to Outer Loop	30	3250	66.93	217,523
D.2 Lateral D-1	18	500	55.29	27,645
D.3 Lateral D-2	18	3200	55.29	176,928
E. Line E				
E.1 Section from Dove Valley Road to NW Outer Loop	21	5200	56.26	292,552
E.2 Section from NW Outer Loop to Dixileta Drive	30	5700	66.93	381,501
E.3 Section from Dixileta Drive to	30	4500	66.93	301,185
C.A.P.	30	3000	66.93	200,790
E.4 Lateral E-1	24	2000	59.17	118,340
	30	1700	66.93	113,781
E.5 Lateral E-2	21	1800	56.26	101,268
E.6 Lateral E-3	21	1500	56.26	84,390
	27	1300	62.08	80,704
E.7 Lateral E-4	18	1100	55.29	60,819
E.8 Lateral E-5	21	1000	56.26	56,260
		Total		6,577,960

Table 18. Alternate B

	Corridor Width	Corridor Length	Area (AC)
IV. Right-of-Way			
A. Buchanan Wash			
A.1 Carefree to Dove Valley	86	6250	12.3
A.2 Dove Valley to 43rd Ave	101	4250	9.9
A.3 43rd Ave to NW Outer Loop	77	6250	11.0
A.4 NW Outer Loop to Dixileta	86	2500	4.9
A.5 Dixileta to Patton	110	5000	12.6
A.6 Patton to CAP	201	3000	13.8
B. Tributary A			
B.1 I-17 to Dove Valley	50	1500	1.7
B.2 Dove Valley to NW Outer Loop	62	5200	7.4
B.3 NW Outer Loop to Dixileta Dr.	90	5700	11.8
B.4 Dixileta to CAP	92	4500	9.5
C. Tributary B			
C.1 51st Ave to Dixileta Dr.	78	5000	9.0
D. Tributary C			
D.1 51st Ave to Dixileta Dr.	53	3200	3.9
E. Tributary D			
E.1 51st Ave to NW Outer Loop	65	3250	4.8
Total			112.6

Table 19. Alternate C: Earth Channels with Landscape Recreation and Drainage Corridors

I. Channels	Length (FT)	Base Width	Depth (FT)**	Top Width, FT
A. Buchanan Wash				
A.1 Carefree to Dove Alley	6250	40	4	72
A.2 Dove Alley to 43rd Ave	4250	40	4	72
A.3 43rd Ave to NW Outer Loop	6250	50	5	90
A.4 NW Out Loop to Dixileta	2500	75	5	115
A.5 Dixileta Dr. to Patton Rd.	5000	125	4.5	161
A.6 Patton Rd. To C.A.P.	3000			
B. Tributary A				
B.1 I-17 to Dove Valley	1500	50	2	66
B.2 Dove Valley to NW Outer Loop	5200	50	2.5	70
B.3 NW Outerloop to Dixileta Dr.	5700	100	2.5	120
B.4 Dixileta Dr. to C.A.P.	4500	100	3	124
C. Tributary B				
C.1 51st Ave to Patton Rd.	5000	30	2.5	50
D. Tributary C				
D.1 51st Ave to Dixileta Dr.	3200	25	2	41
E. Tributary D				
E.1 51st Ave to NW Outer Loop	3250	25	3	49

**Includes Free Board

Table 19. Alternate C: Earth Channels with Landscape Recreation and Drainage Corridors (Continued)

	Area (SF)	Volume (CY)	Unit Cost Comments ($/CY)	Total Cost ($)
I. Channels				
A. Buchanan Wash				
A.1 Carefree to Dove Alley	224	51,850	3.00	155,550
A.2 Dove Alley to 43rd Ave	224	35,260	3.00	105,780
A.3 43rd Ave to NW Outer Loop	350	81,020	3.00	243,060
A.4 NW Out Loop to Dixileta	475	43,980	3.00	131,940
A.5 Dixileta Dr. to Patton Rd.	644	119,200	3.00	357,780
A.6 Patton Rd. To C.A.P.			*Natural	Channel
B. Tributary A				
B.1 I-17 to Dove Valley	116	6,450	3.00	19,350
B.2 Dove Valley to NW Outer Loop	150	28,890	3.00	86,670
B.3 NW Outerloop to Dixileta Dr.	275	58,060	3.00	174,180
B.4 Dixileta Dr. to C.A.P.	336	56,000	3.00	168,000
C. Tributary B				
C.1 51st Ave to Patton Rd.	100	18,250	3.00	55,560
D. Tributary C				
D.1 51st Ave to Dixileta Dr.	66	7,820	3.00	23,460
E. Tributary D				
E.1 51st Ave to NW Outer Loop	111	13,360	3.00	40,080
	Total	520,470		$1,561,410

Table 19. Alternate C.

	Channel Top Width (FT)	Bridge Width* (FT)	Area of Deck (SQ. FT)	Unit Cost ($/SQ.FT)	Total Cost ($)
II. Bridges					
A. Buchanan Wash	72	85	6970	60	418,200
A.1 At Dove Valley Rd.	72	85	6970	60	418,200
A.2 At 43rd Ave	115	85	10625	60	637,500
A.3 At NW Outer Loop	161	85	14535	60	872,100
A.4 At Dixileta Dr.	171	85	15385	60	923,100
A.5 At Patton Rd.					
B. Tributary A					
B.1 At Dove Valley Rd.	66	85	6460	60	387,600
B.2 At NW Outer Loop	70	85	6800	60	408,000
B.3 At Dixileta Dr.	120	85	11050	60	663,100
C. Tributary B					
C.1 At 51st Ave	50	85	5100	60	306,000
D. Tributary C					
D.1 At 57th Ave	41	85	4335	60	260,100
E. Tributary D					
E.1 At 51st Ave	49	85	5015	60	300,900
*Includes Abutments		Total	93,245		5,594,700

Table 19. Alternate C.	Size in Diameter	Length	Unit Cost ($/LF)	Total Cost ($)
III. Storm Drain				
A.1 Section from Dove Valley Rd. to 43rd Ave	21"	4250	56.26	239,105
A.2 Section from 43rd Ave to NW Outer Loop	30"	6250	66.93	418,313
A.3 Section from NW Outer Loop to Dixileta Drive	30	2500	66.93	167,325
A.4 Section from Dixileta Drive to Patton Road	30	5000	66.93	334,650
A.5 Section from Patton Road to the C.A.P.	30	3000	66.93	200,790
A.6 Lateral A-1	18	2300	55.29	127,167
A.7 Lateral A-2	18	2300	55.29	127,167
	21	1500	56.26	84,390
	24	1000	59.17	59,170
A.8 Lateral A-3	18	1300	55.29	71,877
	21	5000	56.26	281,300
A.9 Lateral A-4	36	500	78.57	39,285
	42	1000	96.03	96,030
A.10 Lateral A-5	18	2400	55.29	132,696
	30	1900	66.93	127,167
A.11 Lateral A-6	18	1900	55.29	105,051
A.12 Lateral A-7	18	3100	55.29	171,399
	27	1400	62.08	86,912
A.13 Lateral A-8	18	700	55.29	38,703
	21	800	56.26	45,008
	27	1500	62.08	93,120
A.14 Lateral A-9	18	1500	55.29	82,935
	27	950	62.08	58,976
A.15 Lateral A-10	18	1250	55.29	69,113
A.16 Lateral A-11	21	1150	56.26	64,699
B. Line B				
B.1 Section from 51st Ave to Dixileta Drive	30	3200	66.93	214,176
B.2 Lateral B-1	18	2950	55.29	163,106
B.3 Lateral B-2	18	900	55.29	46,761
B.4 Lateral B-3	18	2750	55.29	152,048
	21	2100	56.26	118,146

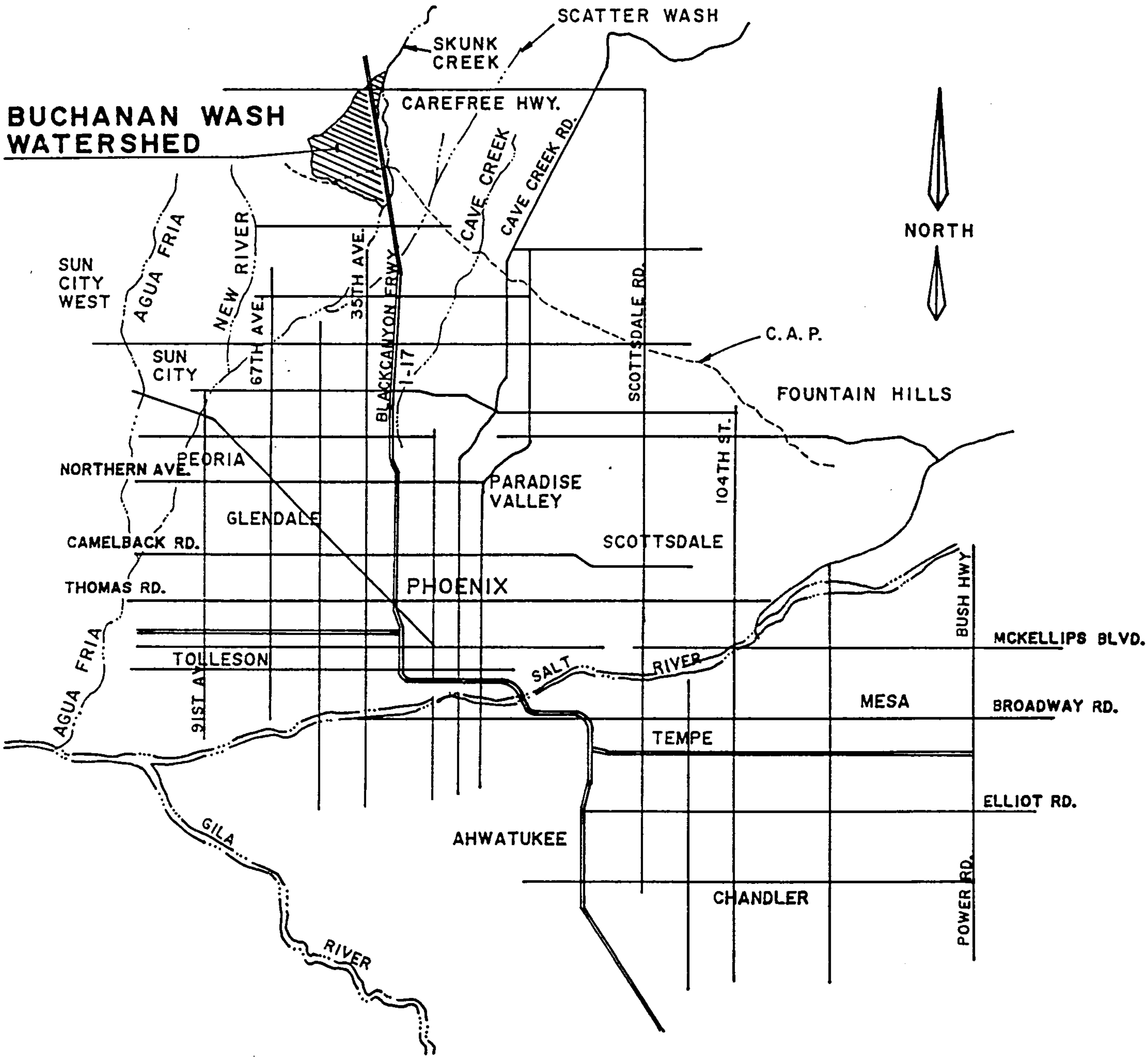
Table 19. Alternate C.	Diameter Size (in)	Length	Unit Cost ($/LF)	Total Cost ($)
C. Line C				
C.1 Section from 51st Ave to NW Outer Loop	30	3250	66.93	217,523
C.2 Lateral C-1	18	1400	55.29	77,406
C.3 Lateral C-2	18	900	55.29	49,761
D. Line D				
D.1 Section from 51st Ave to Outer Loop	30	3250	66.93	217,523
D.2 Lateral D-1	18	500	55.29	27,645
D.3 Lateral D-2	18	3200	55.29	176,928
E. Line E				
E.1 Section from Dove Valley Road to NW Outer Loop	21	5200	56.26	292,552
E.2 Section from NW Outer Loop to Dixileta Drive	30	5700	66.93	381,501
E.3 Section from Dixileta Drive to	30	4500	66.93	301,185
C.A.P.	30	3000	66.93	200,790
E.4 Lateral E-1	24	2000	59.17	118,340
	30	1700	66.93	113,781
E.5 Lateral E-2	21	1800	56.26	101,268
E.6 Lateral E-3	21	1500	56.26	84,390
	27	1300	62.08	80,704
E.7 Lateral E-4	18	1100	55.29	60,819
E.8 Lateral E-5	21	1000	56.26	56,260
		Total		6,577,960

Table 19. Alternate C.	Corridor Width	Corridor Length	Area (AC)	Total Cost* ($)
IV. Right-of-Way Recreation and Drainage Corridors				
A. Buchanan Wash				
A.1 Carefree to Dove Valley	200	6250	28.7	215,250
A.2 Dove Valley to 43rd Ave	200	4250	19.5	146,250
A.3 43rd Ave to NW Outer Loop	200	6250	28.7	215,250
A.4 NW Outer Loop to Dixileta	200	2500	11.5	86,250
A.5 Dixileta to Patton	201	5000	23.0	172,500
A.6 Patton to C.A.P.	201	3000	13.8	103,500
B. Tributary A				
B.1 I-17 to Dove Valley	200	1500	6.9	51,750
B.2 Dove Valley to NW Outer Loop	200	5200	23.9	179,250
B.3 NW Outer Loop to Dixileta	200	5700	26.2	196,500
B.4 Dixileta to C.A.P.	200	4500	20.7	155,250
C. Tributary B				
C.1 51st Ave to Patton Dr.	200	5000	23.0	172,500
D. Tributary C				
D.1 51st Ave to Dixileta Dr.	200	3200	14.7	110,250
E. Tributary D				
E.1 51st Ave to NW Outer Loop	200	3250	14.9	111,750
F. Additional Recreation and Drainage Corridors				
F.1 NW Outer Loop to Beyond 51st Ave	200	3625	16.6	124,500
F.2 Parallel to Patton Road	200	4100	18.8	141,000
Total		63325	290.9	2,181,750

*Based on unit cost of $7,500/acre.

Table 20. Summary of Costs Estimates
Buchanan Wash
Conceptual Drainage and Storm Drain Study

		Estimate
Alternate A: Earth Channels		
1) Channel Excavation		$1,561,410
2) Bridges		5,594,700
3) Storm Drains		6,577,960
4) Right-of-Way	164 acres	
Sub-Total		13,734,070
15% contingency for design, surveying and construction management		2,060,030
10% contingency for construction		1,373,400
Total		$17,167,500 Plus 164 Acres
Alternate B: Concrete Channels		
1) Channel Excavation		880,170
2) Concrete Liner		9,367,500
3) Bridges		3,355,800
4) Storm Drains		6,577,960
5) Right-of-Way	108 Acres	
Sub-Total		20,181,430
15% contingency for design surveying and construction management		3,045,300
10% contingency for construction		2,030,170
Total		$25,256,900 Plus 108 Acres
Alternate C: Earth Channels with Landscaping (200' R.O.W.)		
1) Channel Excavation		1,561,410
2) Bridges		5,594,700
3) Storm Drains		6,577,960
4) Right-of-Way	269 acres	
5) Landscaping		2,181,750
Sub-Total		15,915,820
15% contingency for design, surveying and construction management		2,362,700
10% contingency for construction		1,575,130
		$19,853,650 Plus 269 Acres
Total		

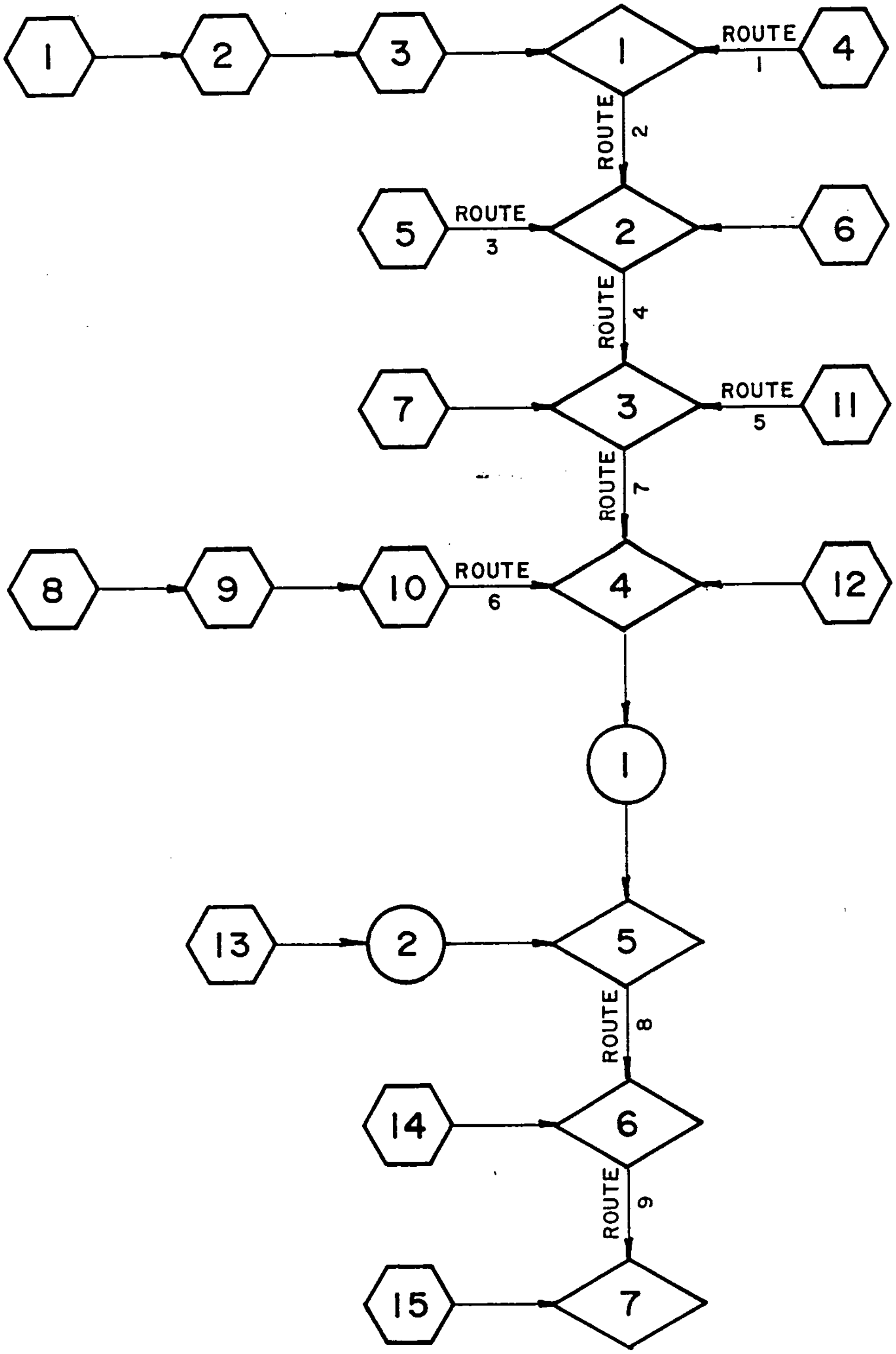


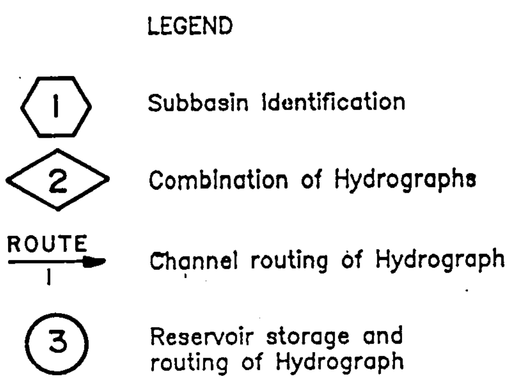
NOT TO SCALE

BUCHANAN WASH STUDY
CITY OF PHOENIX
VICINITY MAP
INDEX NO. ST - 886382

HUITT - ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

FIGURE I





BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 3: MAJOR SYSTEM ANALYSIS
INDEX NO. ST - 886382

HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

FIGURE 13

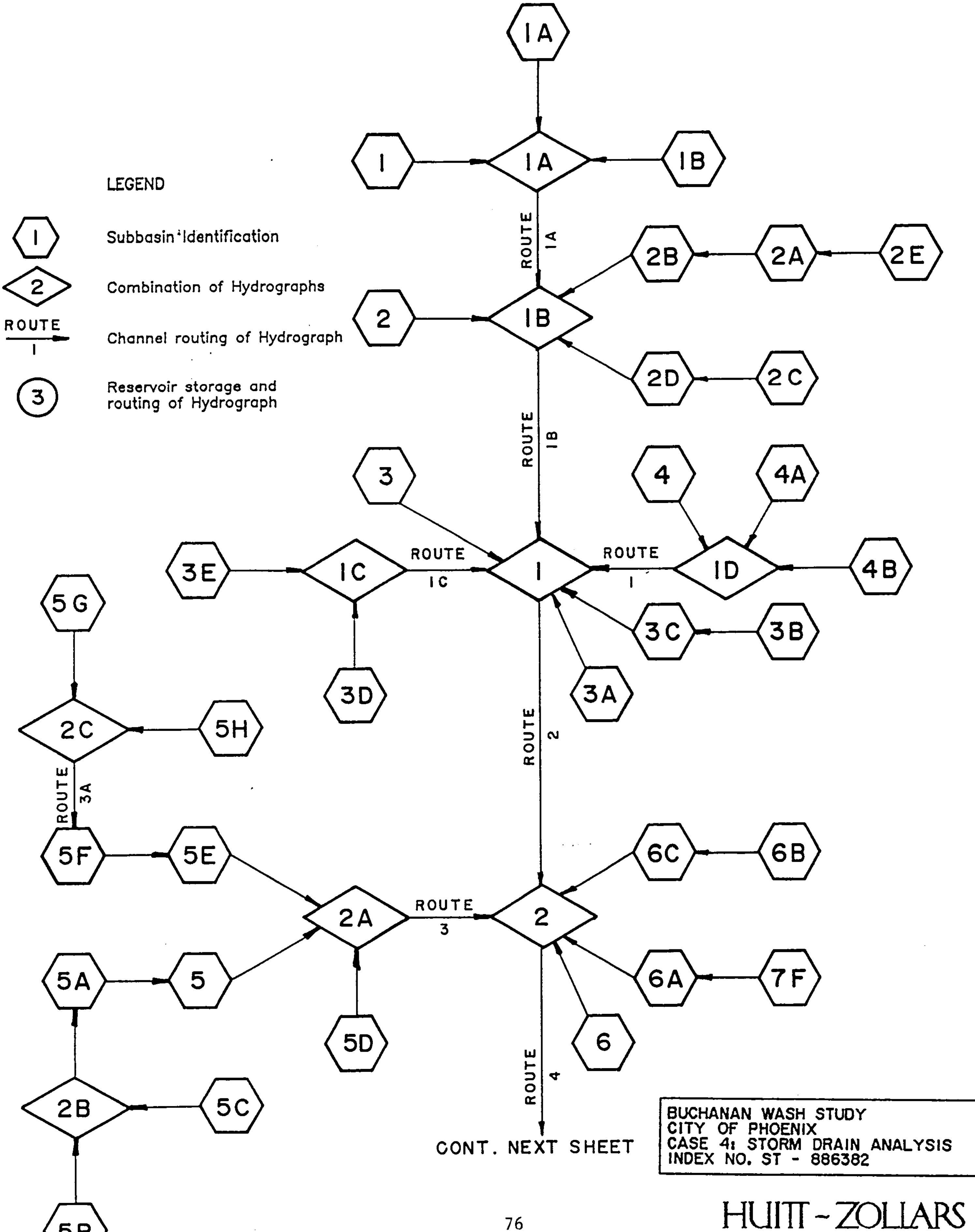
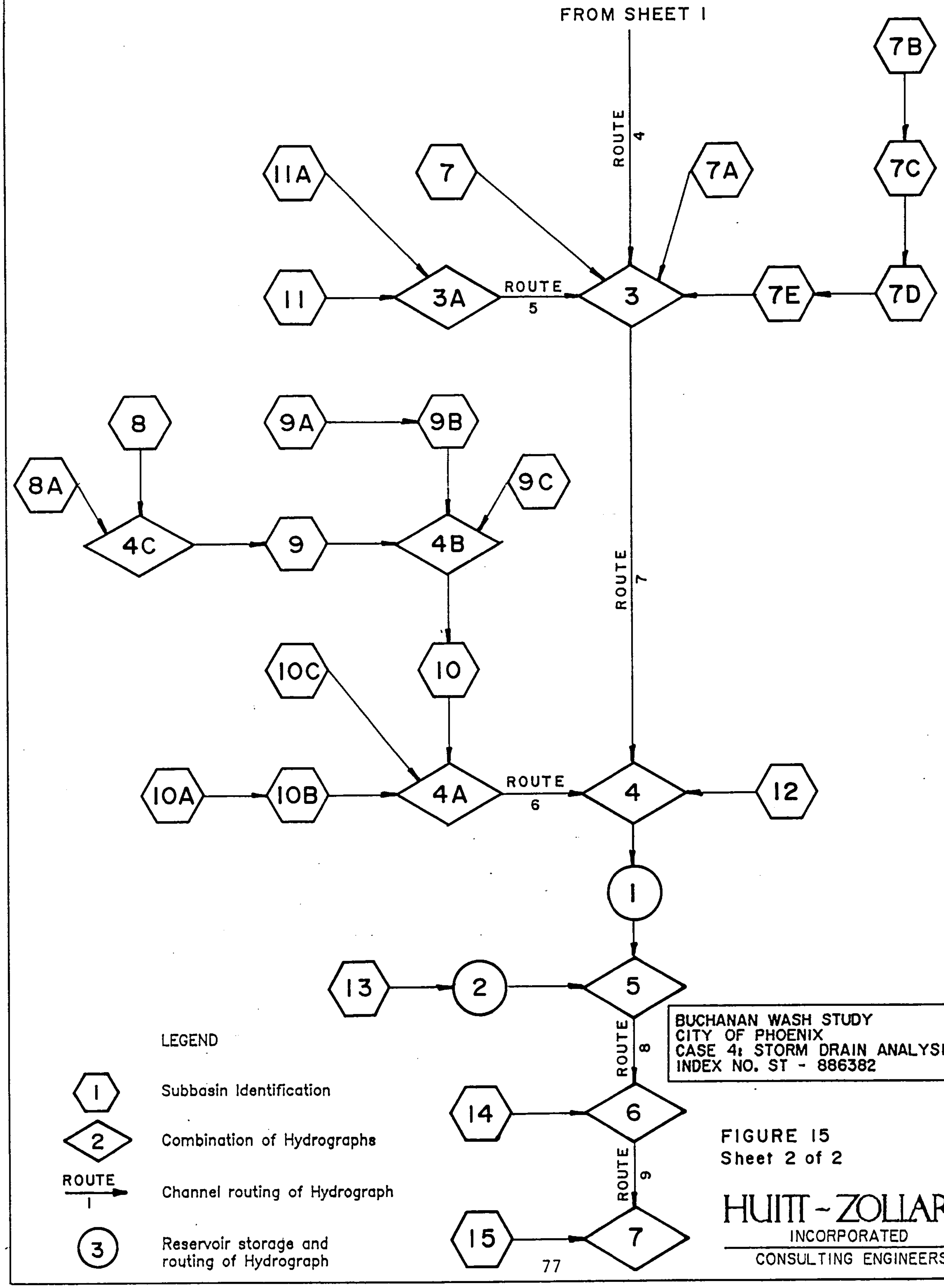


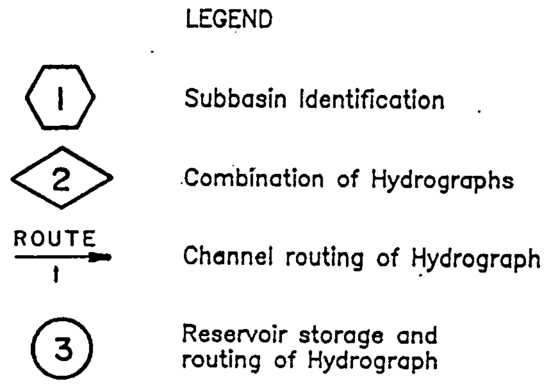
FIGURE 15
Sheet 1 of 2

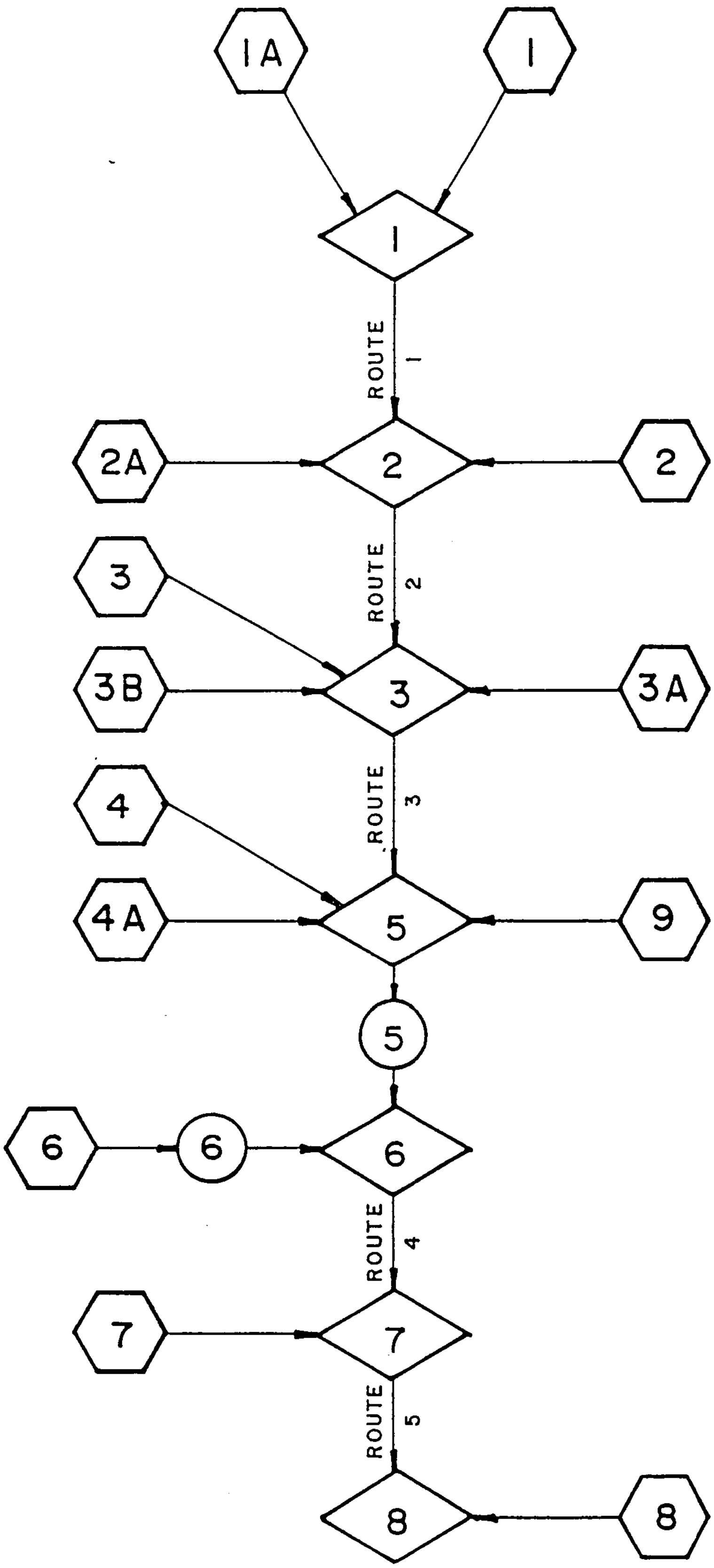


BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 4: STORM DRAIN ANALYSIS
INDEX NO. ST - 886382

FIGURE 15
Sheet 2 of 2

HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

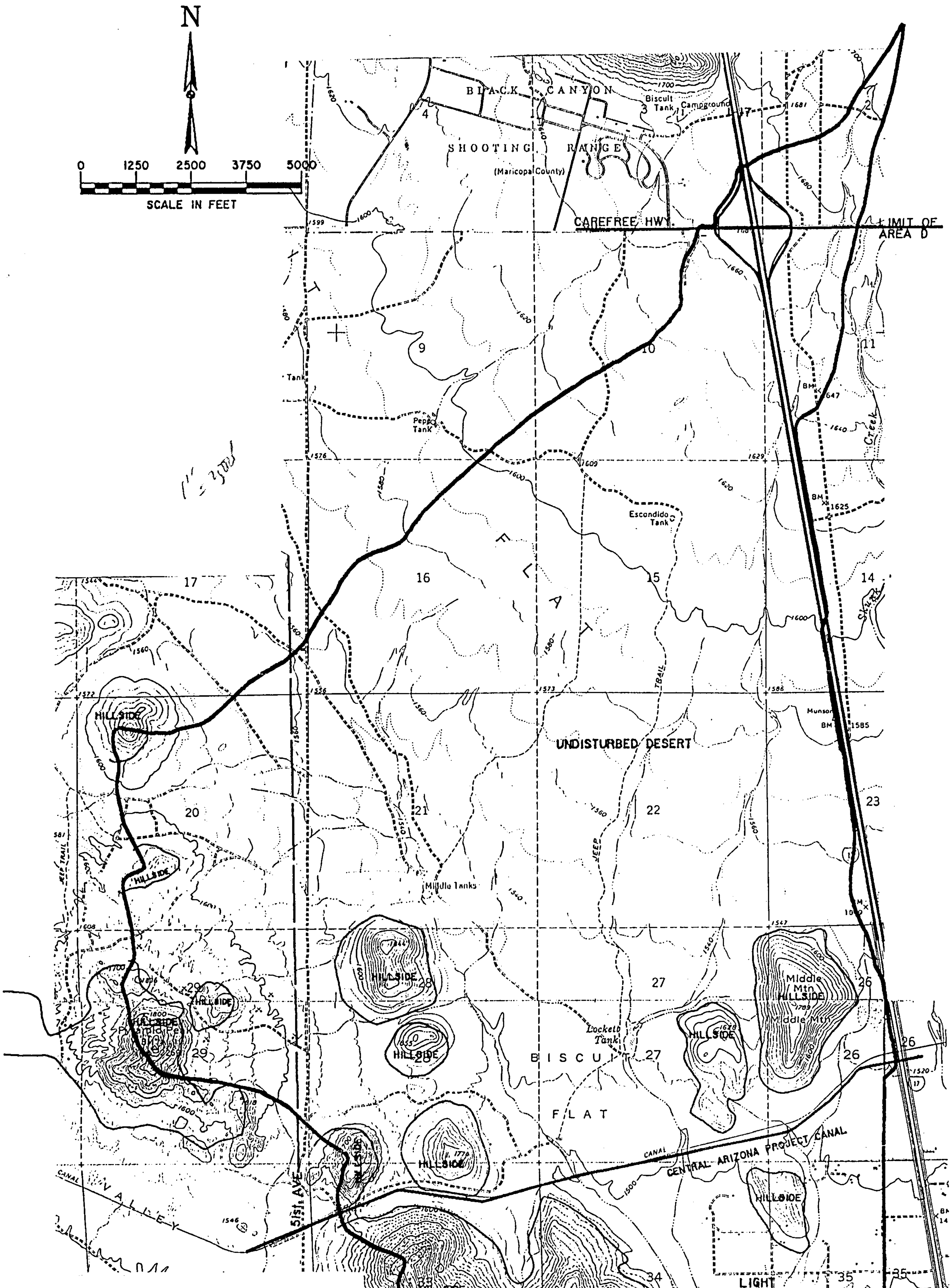




BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 2: FUTURE LAND USE ANALYSIS
INDEX NO. ST - 886382

HUITT - ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

FIGURE 10



LEGEND

——— MAJOR STREET CENTERLINE

——— EXISTING DIRT ROAD

BUCHANAN WASH STUDY
CITY OF PHOENIX
CURRENT LAND USE
INDEX NO. ST - 886382

HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

FIGURE 2

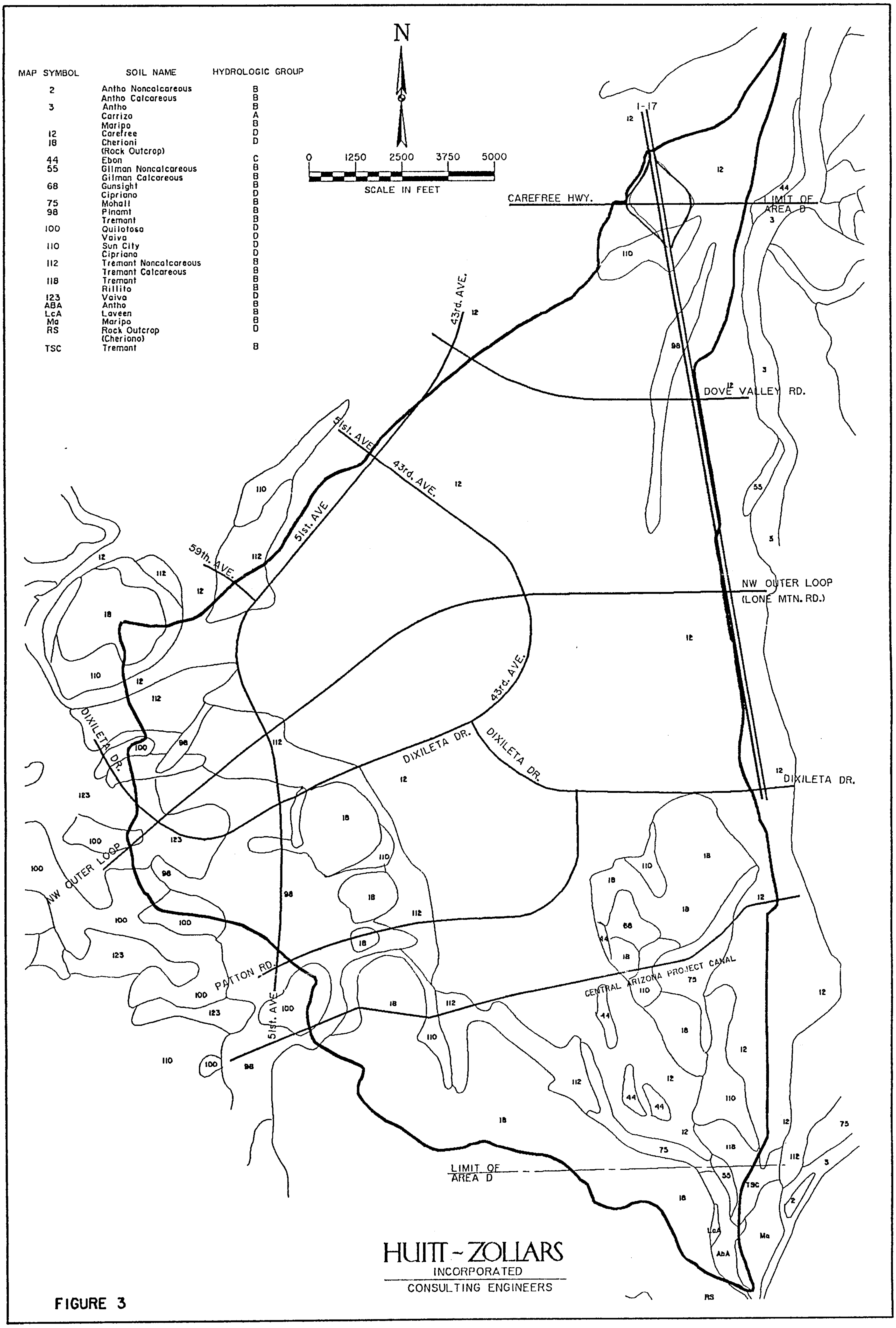
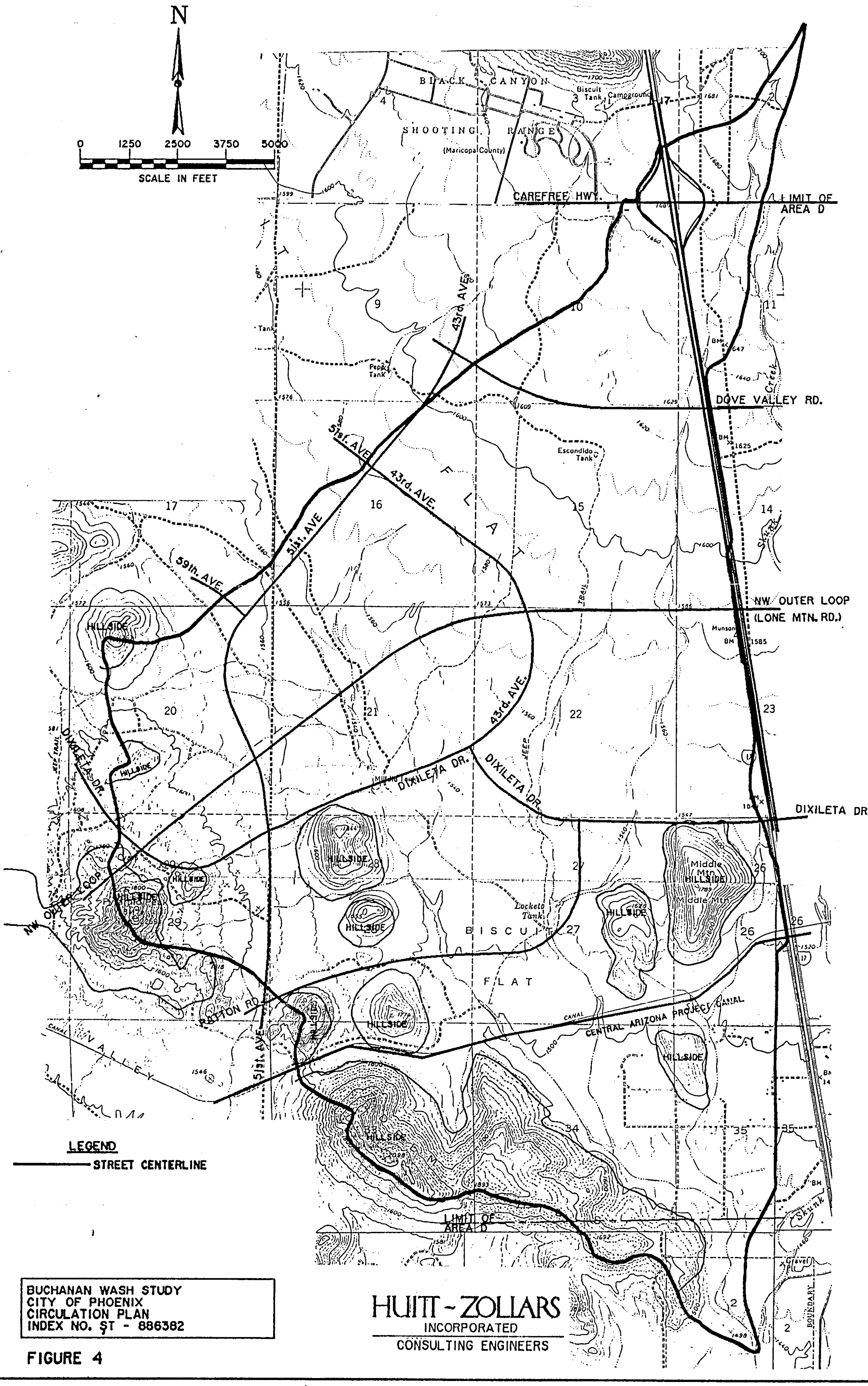

N
MAP SYMBOL SOIL NAME HYDROLOGIC GROUP
2 Antho Noncalcareous B
Antho Calcareous B
3 Antho B
Carrizo A
Maripo B
12 Carefree D
18 Cherioni D
(Rock Outcrop)
44 Ebon C
55 Gilman Noncalcareous B
Gilman Calcareous B
68 Gunsight B
Cipriano D
75 Mohall B
98 Pinamt B
Tremant B
100 Quilotosa D
Vaiva D
110 Sun City D
Cipriano D
112 Tremant Noncalcareous B
Tremant Calcareous B
118 Tremant B
Rillito B
123 Vaiva D
ABA Antho B
LcA Laveen B
Ma Maripo B
RS Rock Outcrop D
(Cheriono)
TSC Tremant B
0 1250 2500 3750 5000
SCALE IN FEET
I-17
CAREFREE HWY.
LIMIT OF AREA D
43rd. AVE.
DOVE VALLEY RD.
51st. AVE.
43rd. AVE.
59th. AVE.
NW OUTER LOOP (LONE MTN. RD.)
DIXILETA DR.
NW OUTER LOOP
PATTON RD.
CENTRAL ARIZONA PROJECT CANAL
LIMIT OF AREA D
HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

FIGURE 3



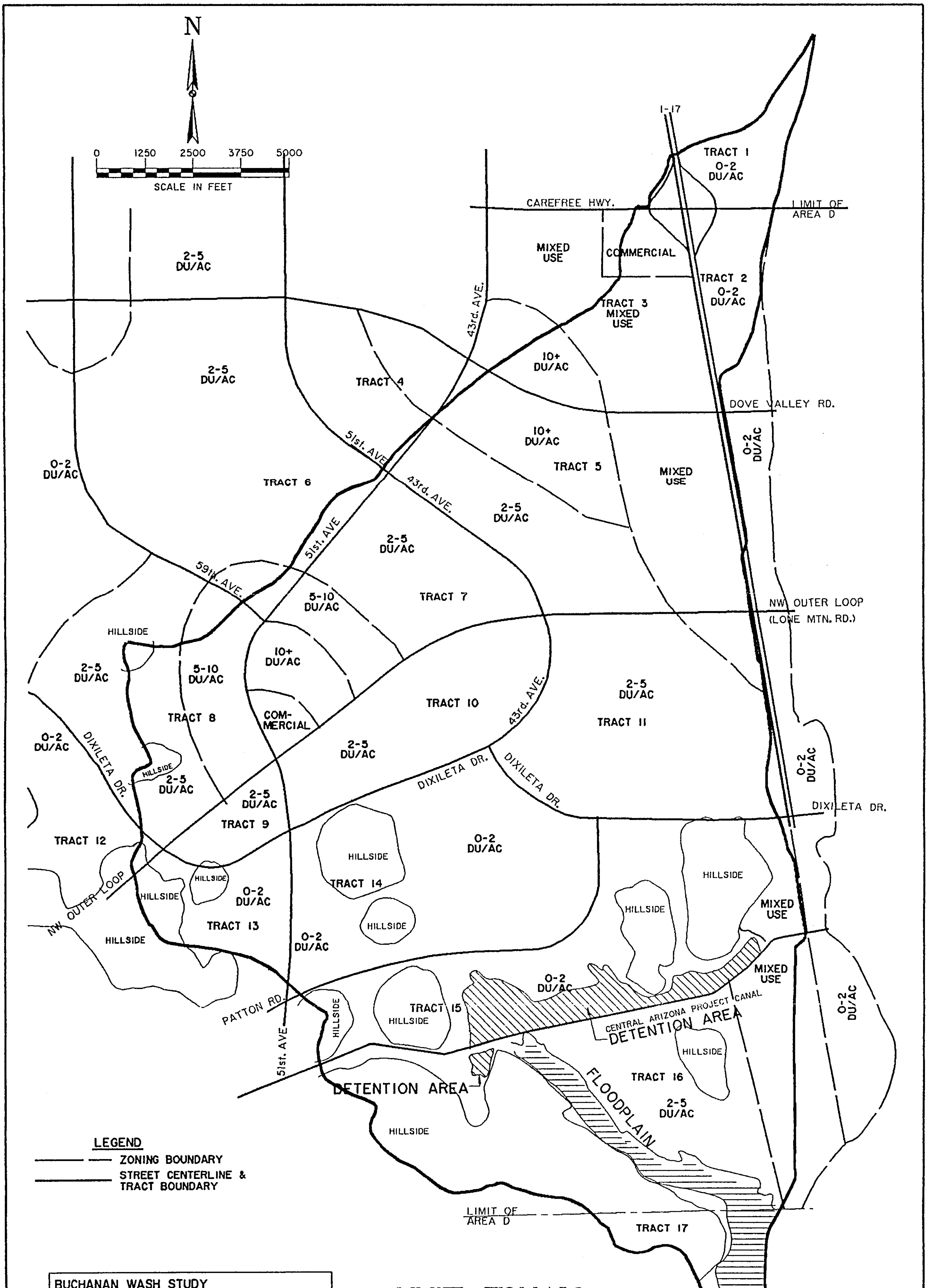
LEGEND

STREET CENTERLINE

BUCHANAN WASH STUDY
CITY OF PHOENIX
CIRCULATION PLAN
INDEX NO. ST - 886382

HUITT - ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

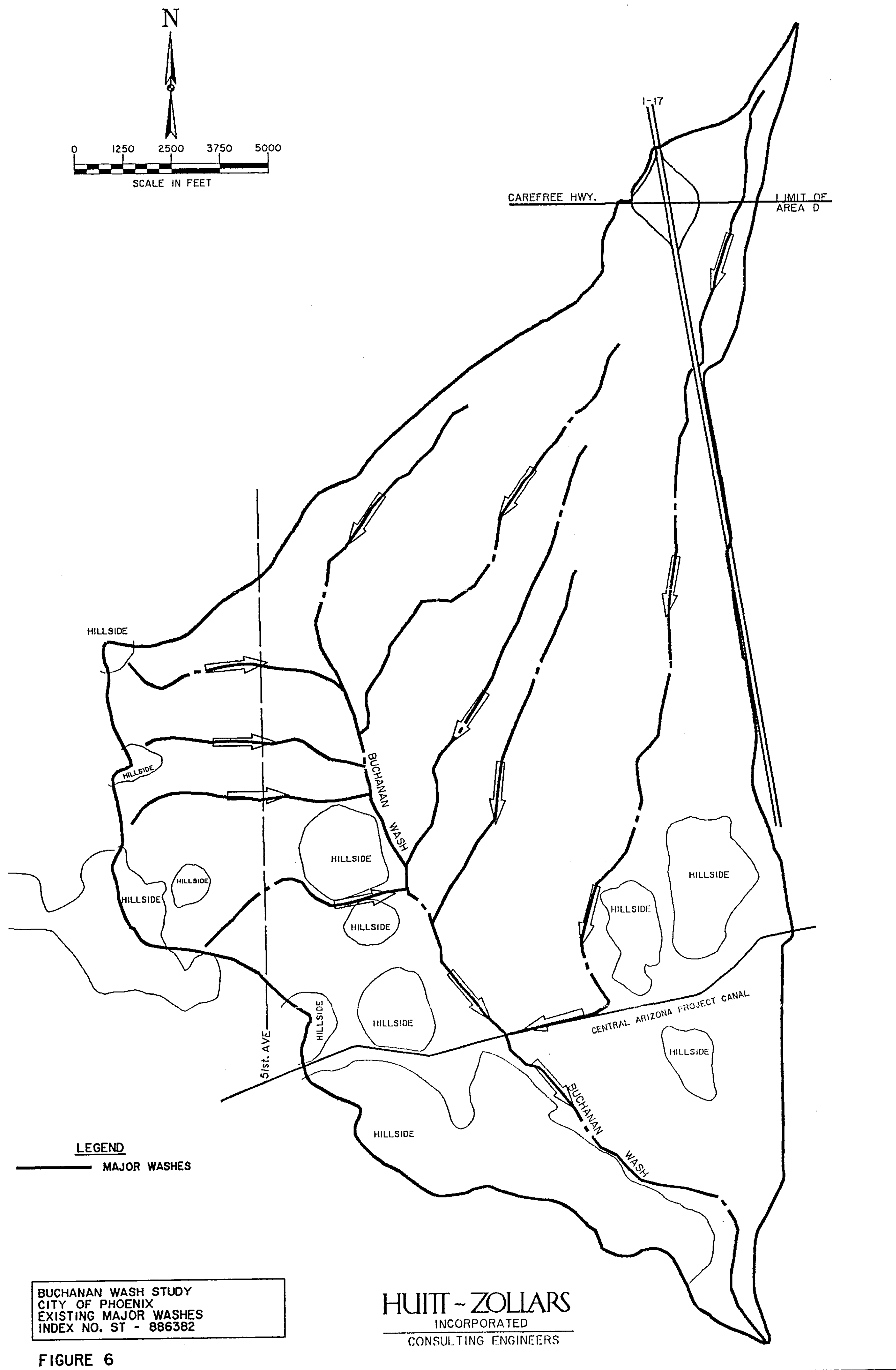
FIGURE 4



BUCHANAN WASH STUDY
CITY OF PHOENIX
LAND USE PLAN
INDEX NO. ST - 886382

HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

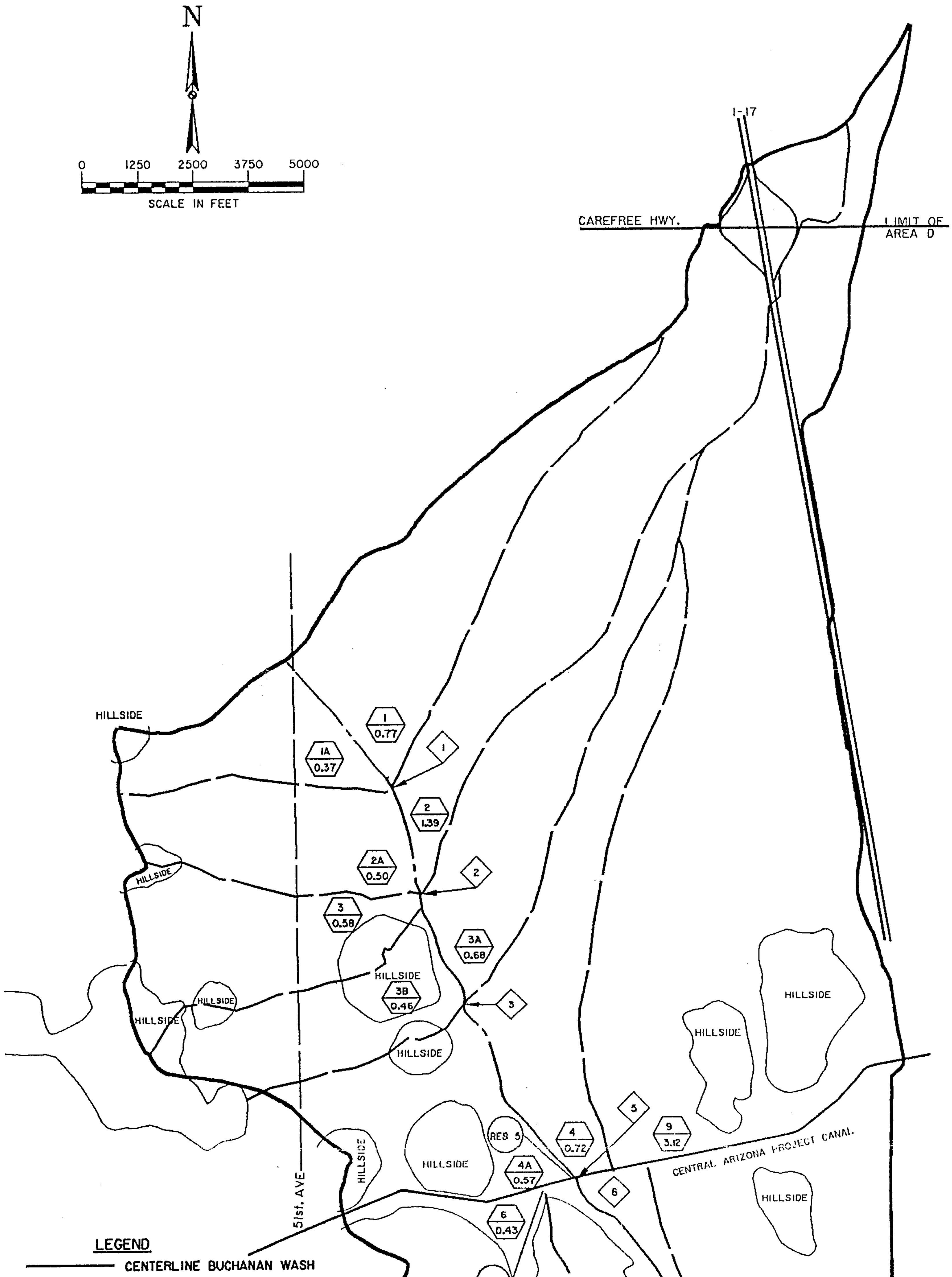
FIGURE 5



BUCHANAN WASH STUDY
CITY OF PHOENIX
EXISTING MAJOR WASHES
INDEX NO. ST - 886382

FIGURE 6

HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS



LEGEND

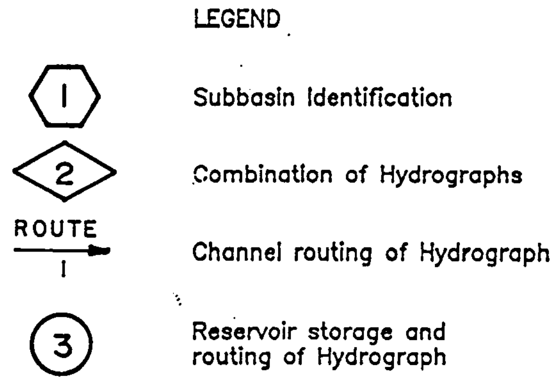
- CENTERLINE BUCHANAN WASH
- SUBBASIN DIVIDE
- BASIN DIVIDE BY ROAD
- 7A / 0.05 — SUBBASIN NUMBER / SUBBASIN AREA (SQ. MI.)
- 2 — COMBINATION OF HYDROGRAPHS
- RES 2 — RESERVIOR STORAGE AND ROUTING

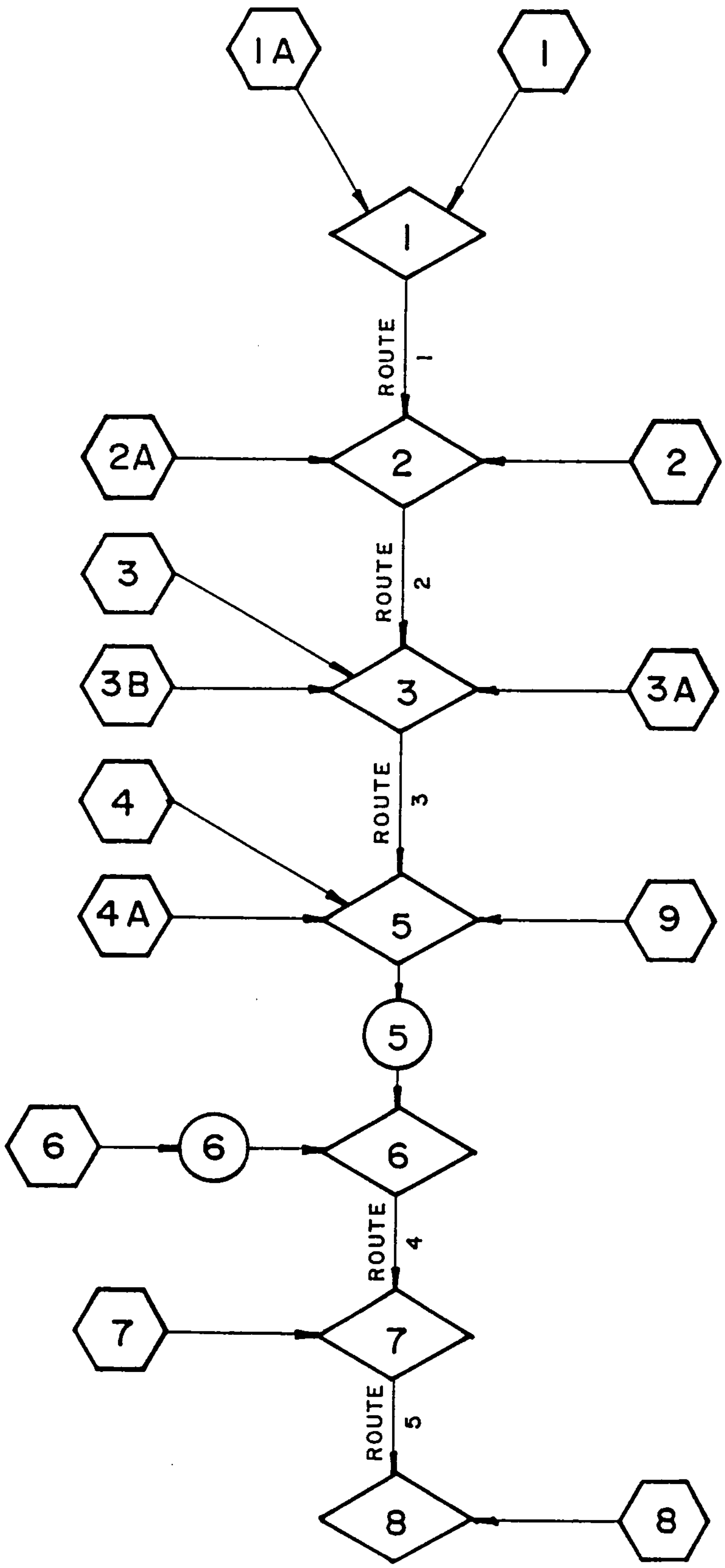
DRAINAGE AREA MAP

BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE I: EXIST. COND. ANALYSIS
INDEX NO. ST - 886382

HUITT - ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

FIGURE 7

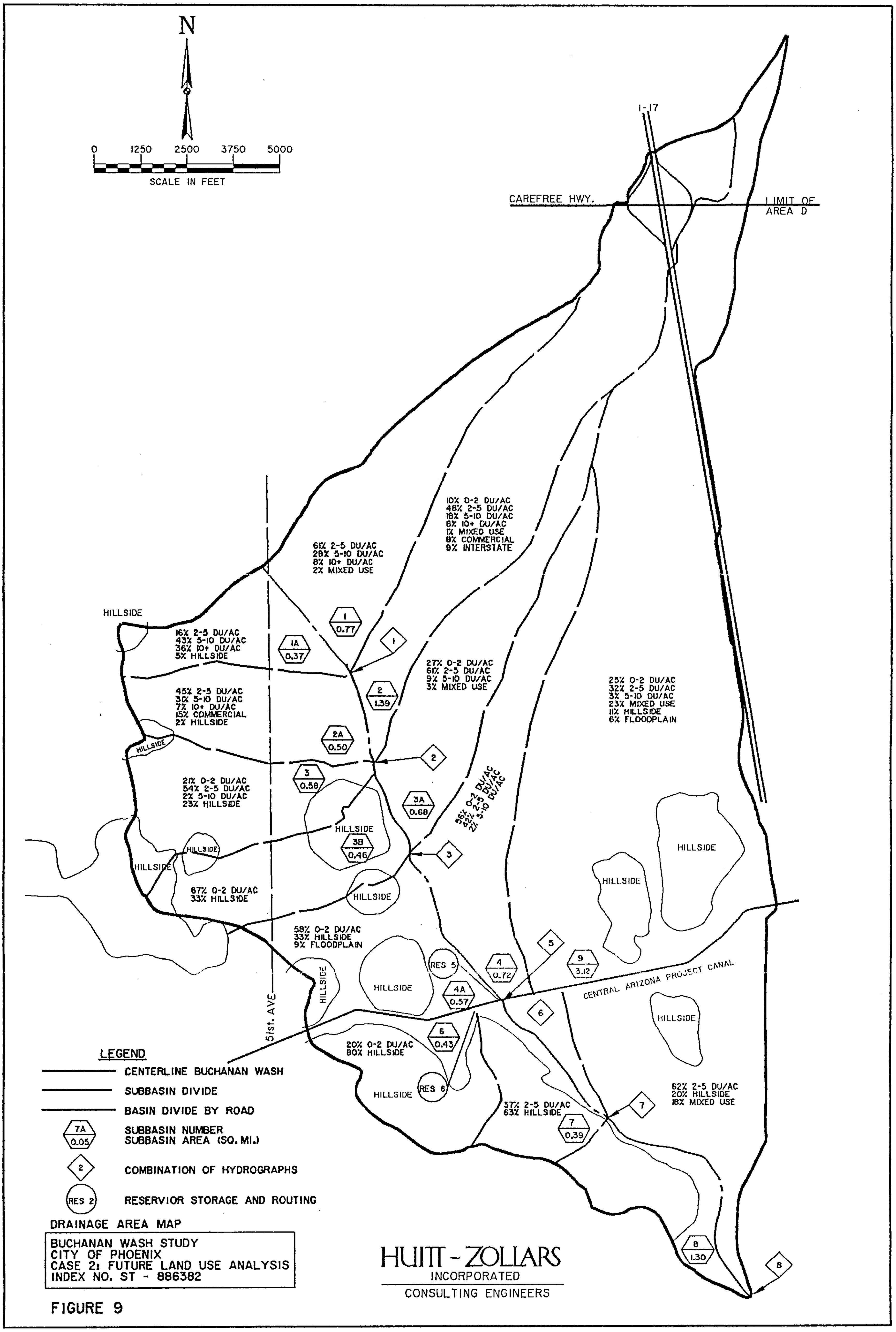




BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 1: EXIST. COND. ANALYSIS
INDEX NO. ST - 886382

HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

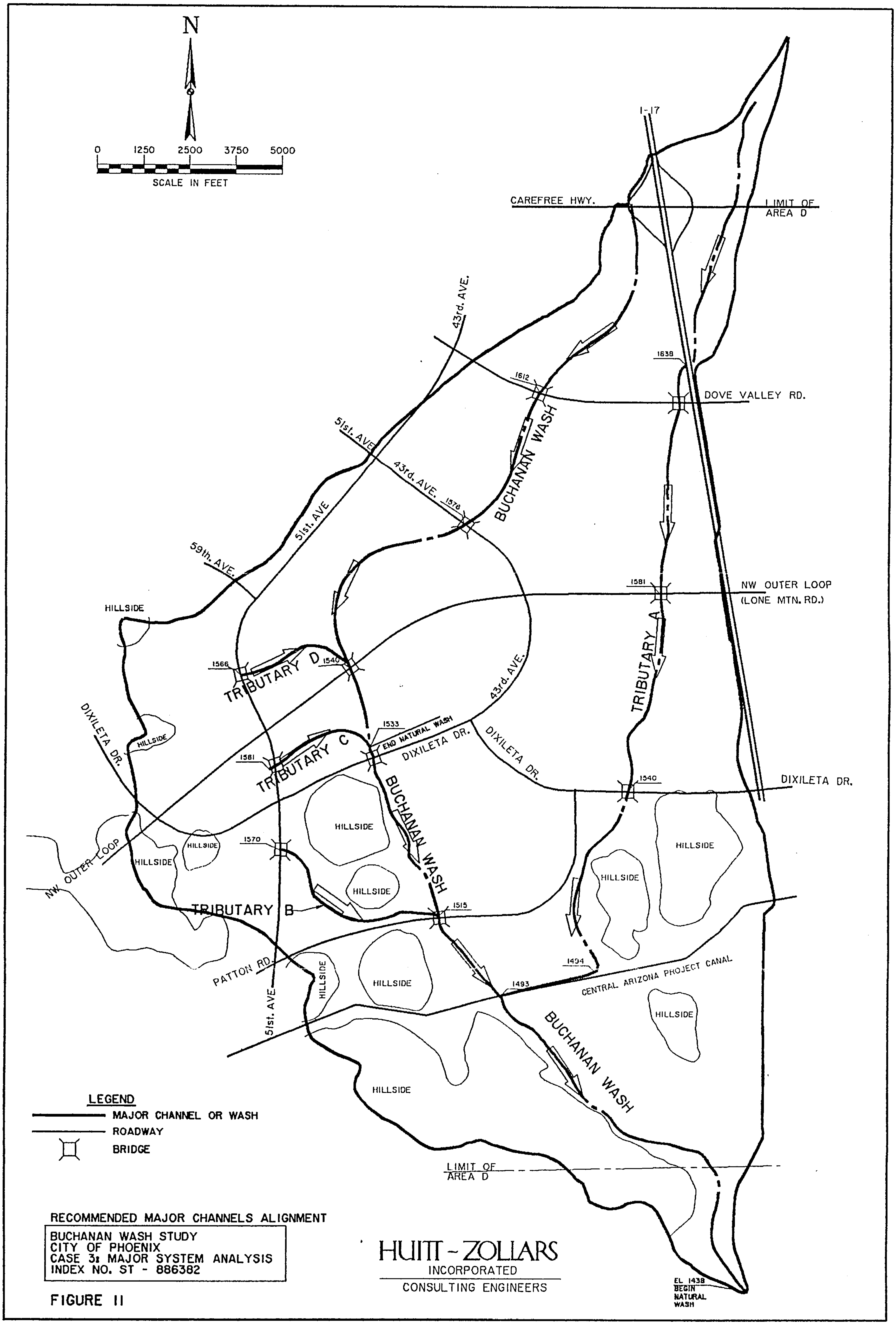
FIGURE 8



DRAINAGE AREA MAP

BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 2: FUTURE LAND USE ANALYSIS
INDEX NO. ST - 886382

FIGURE 9

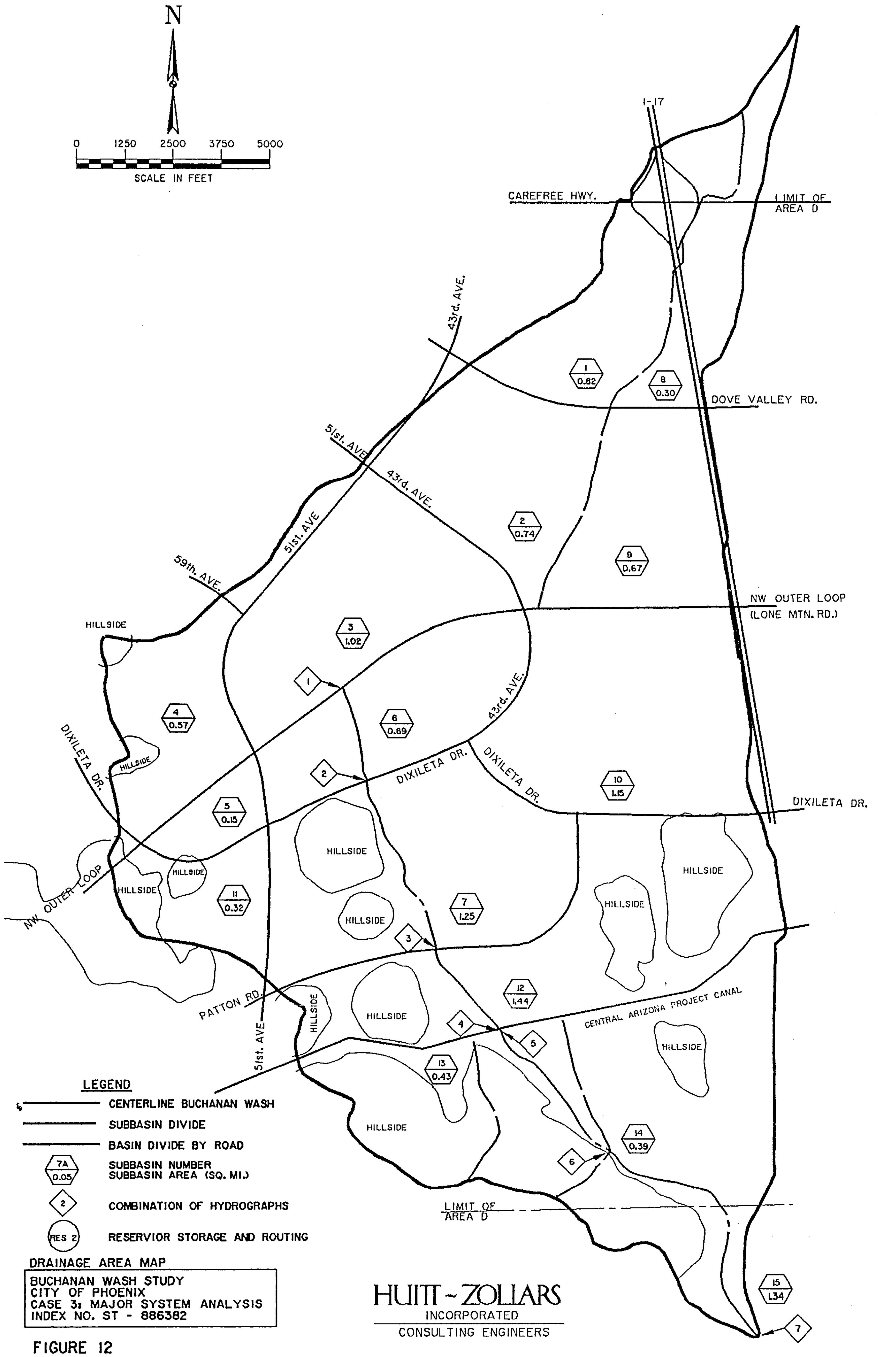


RECOMMENDED MAJOR CHANNELS ALIGNMENT

BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 3: MAJOR SYSTEM ANALYSIS
INDEX NO. ST - 886382

HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

FIGURE 11



DRAINAGE AREA MAP

BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 3: MAJOR SYSTEM ANALYSIS
INDEX NO. ST - 886382

FIGURE 12

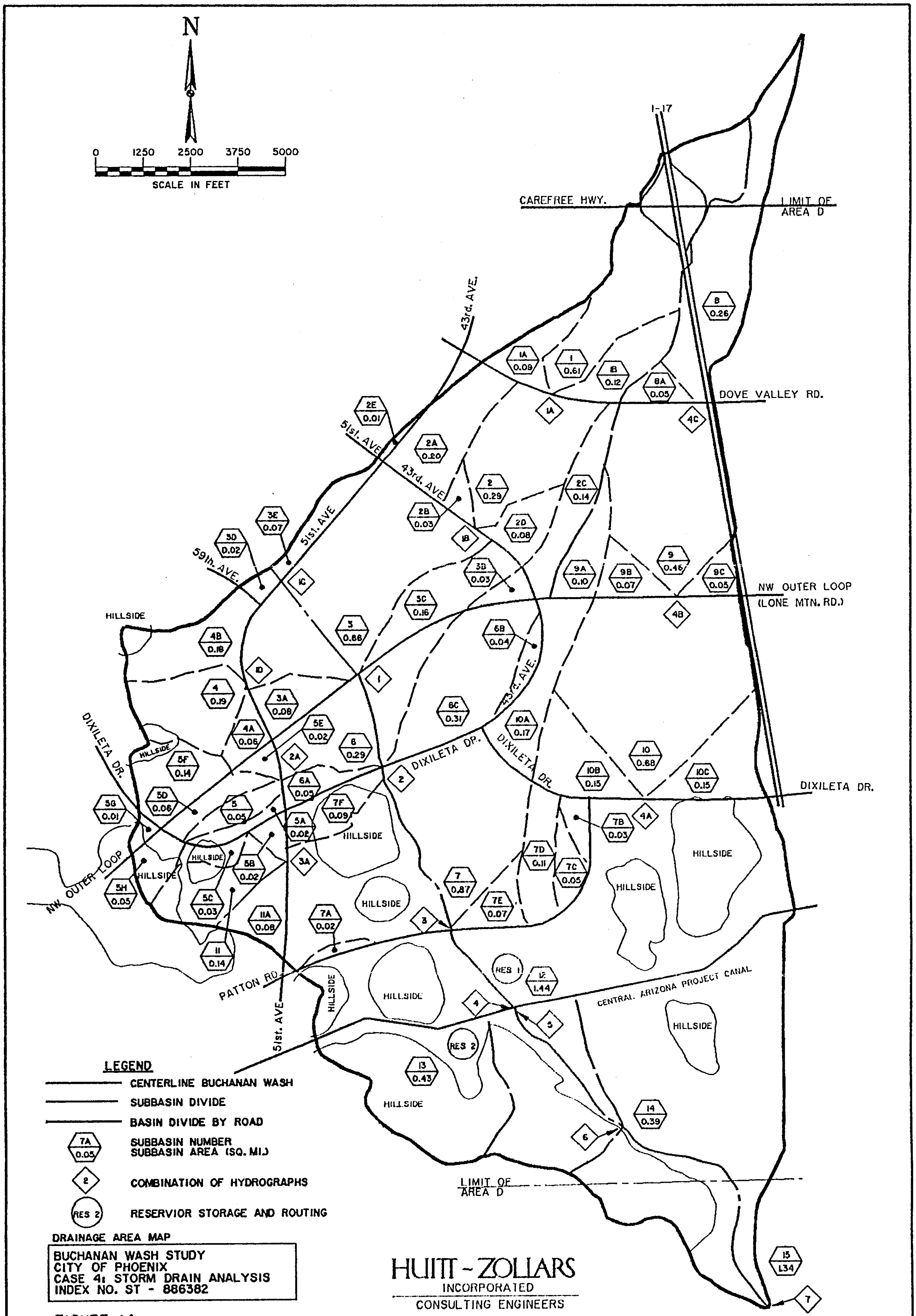
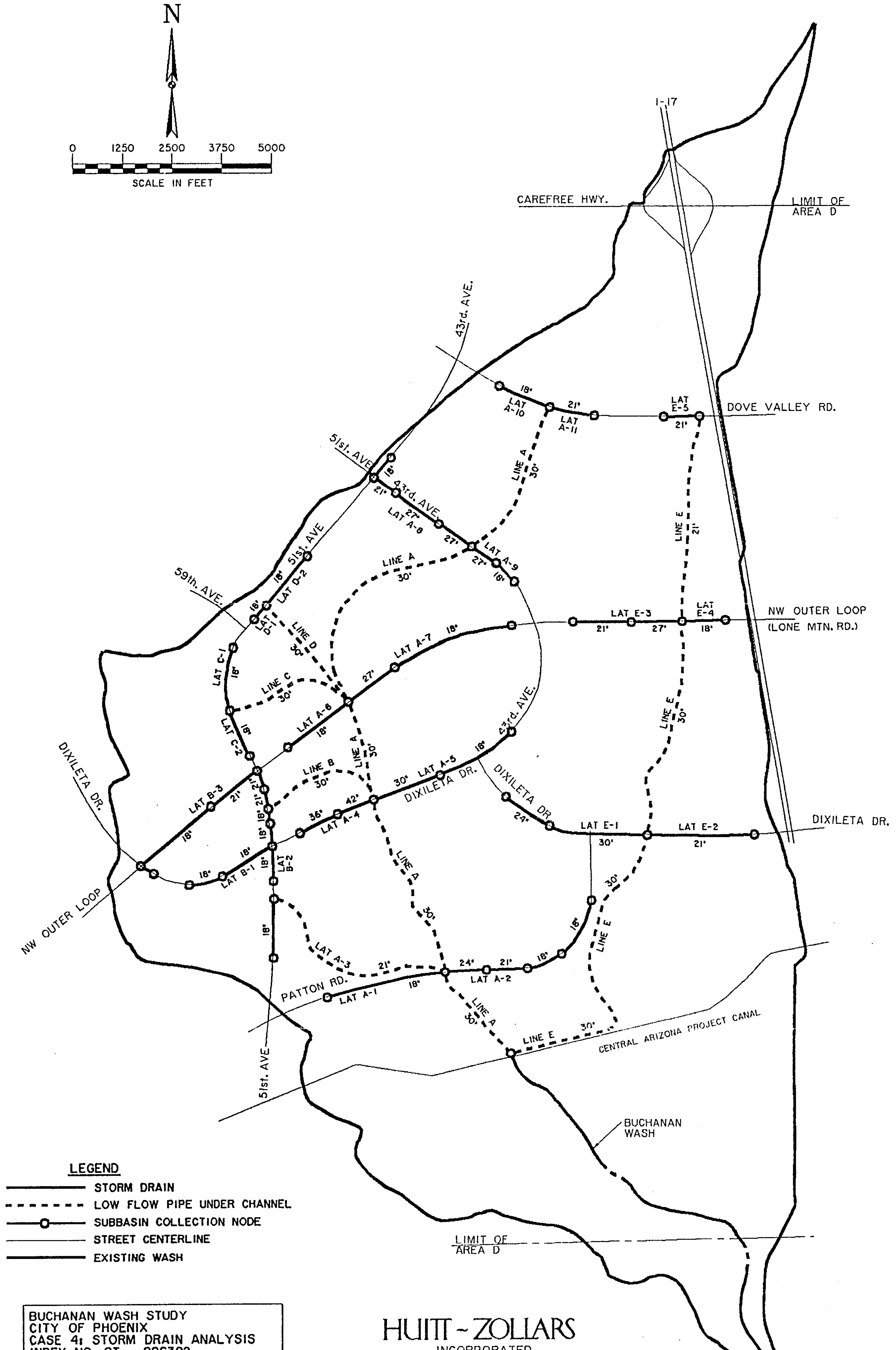
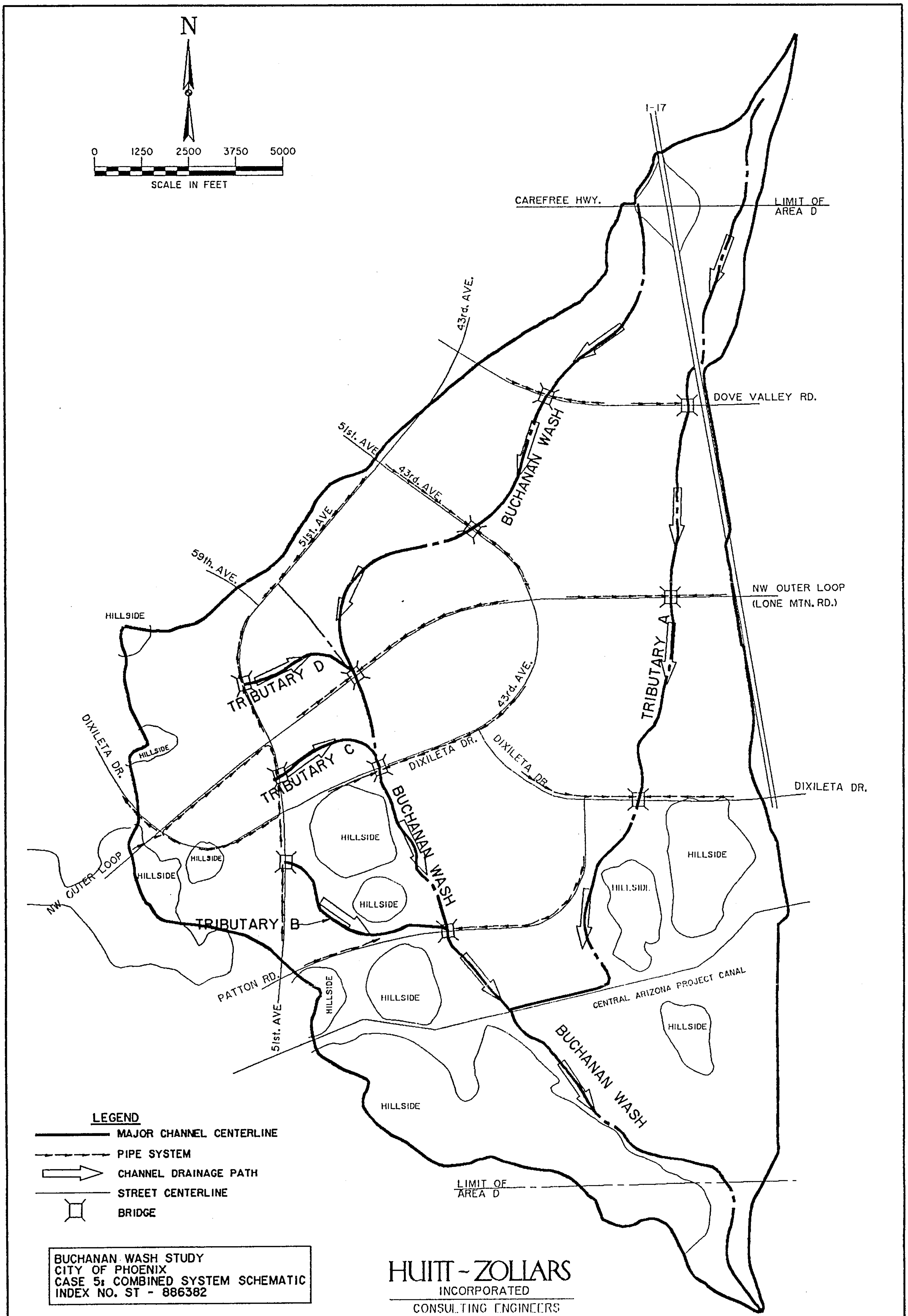

N
0
1250
2500
3750
5000
SCALE IN FEET
CAREFREE HWY.
LIMIT OF AREA D
I-17
43rd. AVE.
DOVE VALLEY RD.
51st. AVE
43rd. AVE
59th. AVE.
NW OUTER LOOP (LONE MTN. RD.)
HILLSIDE
DIXILETA DR.
NW OUTER LOOP
PATTON RD.
51st. AVE.
CENTRAL ARIZONA PROJECT CANAL
RES 1
RES 2
LIMIT OF AREA D
1A 0.08
1 0.61
1B 0.12
8A 0.05
8 0.26
2E 0.01
2A 0.20
2 0.29
2C 0.14
2B 0.03
2D 0.08
3E 0.07
3D 0.02
3B 0.03
9A 0.10
9B 0.07
9 0.46
9C 0.05
3C 0.16
3 0.86
6B 0.04
4B 0.18
4 0.19
3A 0.08
8C 0.31
10A 0.17
4A 0.06
5E 0.02
6 0.29
10 0.68
5F 0.14
10B 0.15
10C 0.15
6A 0.05
5G 0.01
5D 0.06
5 0.05
7F 0.09
5A 0.02
7B 0.03
7D 0.11
7C 0.05
5B 0.02
5H 0.05
5C 0.03
7 0.87
7E 0.07
11A 0.08
7A 0.02
11 0.14
12 1.44
13 0.43
14 0.39
15 1.34
LEGEND
CENTERLINE BUCHANAN WASH
SUBBASIN DIVIDE
BASIN DIVIDE BY ROAD
7A 0.05
SUBBASIN NUMBER
SUBBASIN AREA (SQ. MI.)
COMBINATION OF HYDROGRAPHS
RES 2
RESERVIOR STORAGE AND ROUTING
DRAINAGE AREA MAP
BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 4: STORM DRAIN ANALYSIS
INDEX NO. ST - 886382
HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

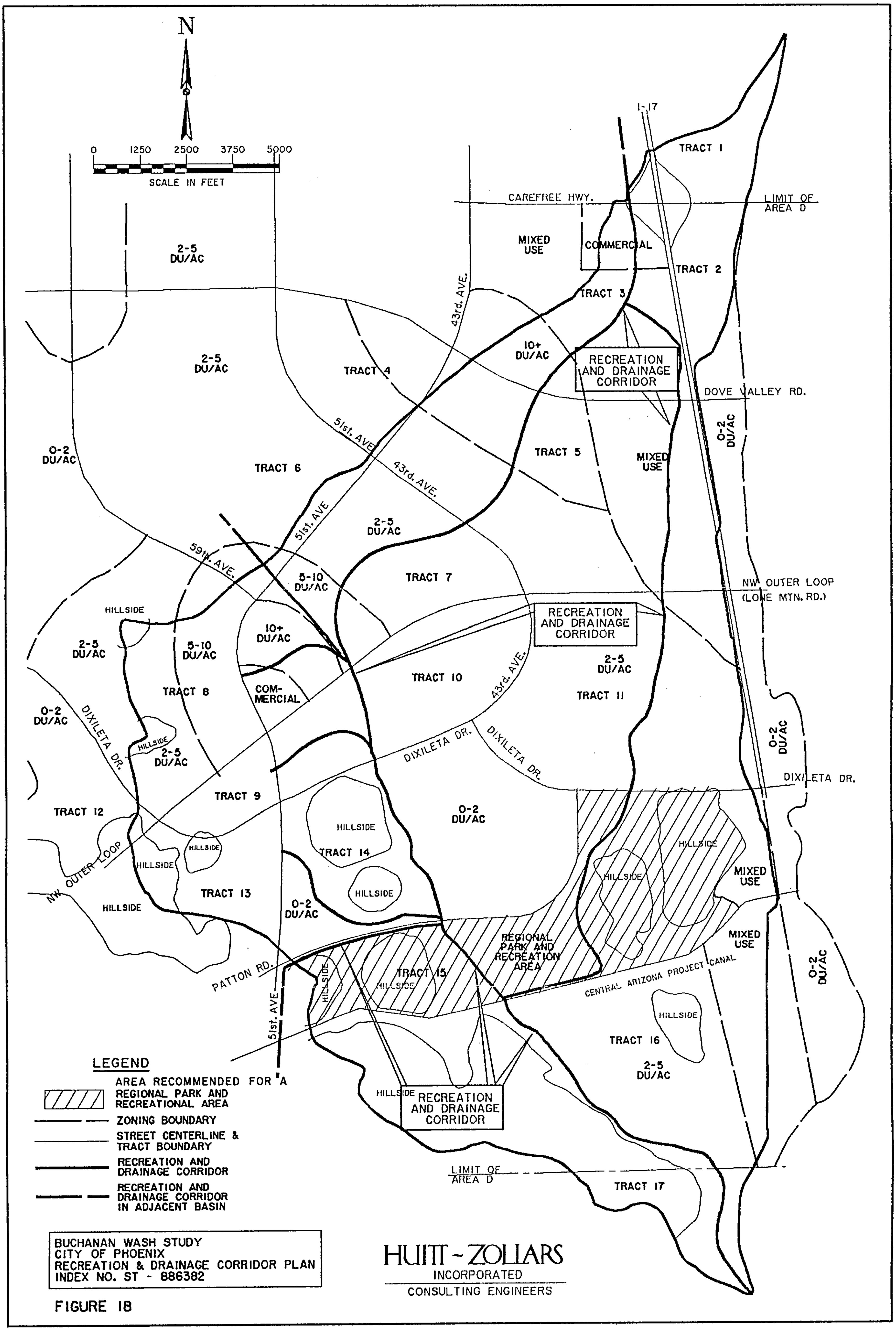
FIGURE 14



BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 4: STORM DRAIN ANALYSIS
INDEX NO. ST - 886382

FIGURE 16

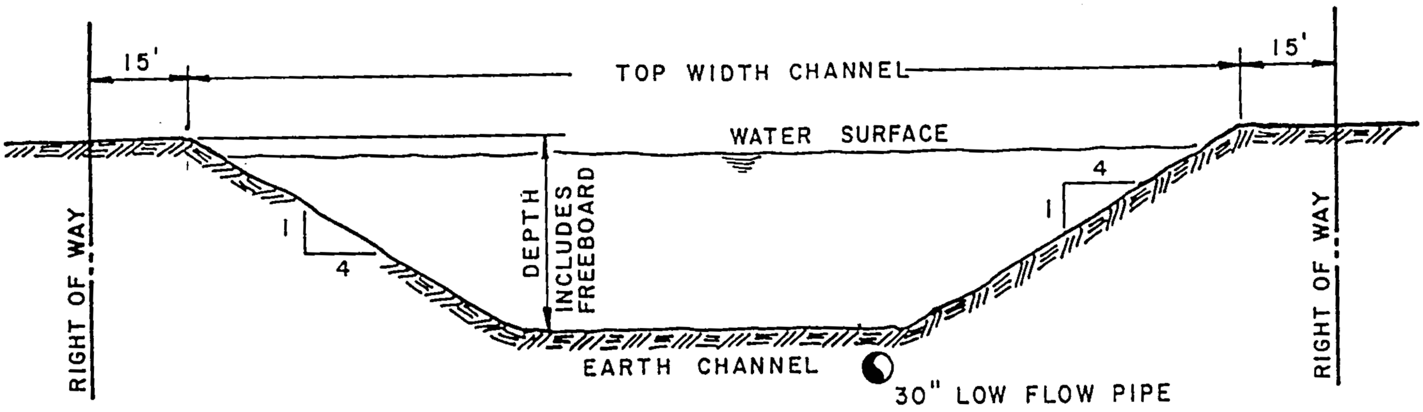

N
0 1250 2500 3750 5000
SCALE IN FEET
I-17
CAREFREE HWY.
LIMIT OF AREA D
43rd. AVE.
DOVE VALLEY RD.
51st. AVE.
43rd. AVE.
BUCHANAN WASH
51st. AVE
59th. AVE.
HILLSIDE
NW OUTER LOOP (LONE MTN. RD.)
TRIBUTARY D
TRIBUTARY A
43rd. AVE.
DIXILETA DR.
HILLSIDE
TRIBUTARY C
DIXILETA DR.
DIXILETA DR.
DIXILETA DR.
BUCHANAN WASH
HILLSIDE
HILLSIDE
HILLSIDE
HILLSIDE
NW OUTER LOOP
HILLSIDE
HILLSIDE
TRIBUTARY B
PATTON RD.
HILLSIDE
HILLSIDE
51st. AVE
CENTRAL ARIZONA PROJECT CANAL
HILLSIDE
BUCHANAN WASH
HILLSIDE
LIMIT OF AREA D
LEGEND
MAJOR CHANNEL CENTERLINE
PIPE SYSTEM
CHANNEL DRAINAGE PATH
STREET CENTERLINE
BRIDGE
BUCHANAN WASH STUDY
CITY OF PHOENIX
CASE 5: COMBINED SYSTEM SCHEMATIC
INDEX NO. ST - 886382
FIGURE 17
HUITT-ZOLLARS
INCORPORATED
CONSULTING ENGINEERS



BUCHANAN WASH STUDY
CITY OF PHOENIX
RECREATION & DRAINAGE CORRIDOR PLAN
INDEX NO. ST - 886382

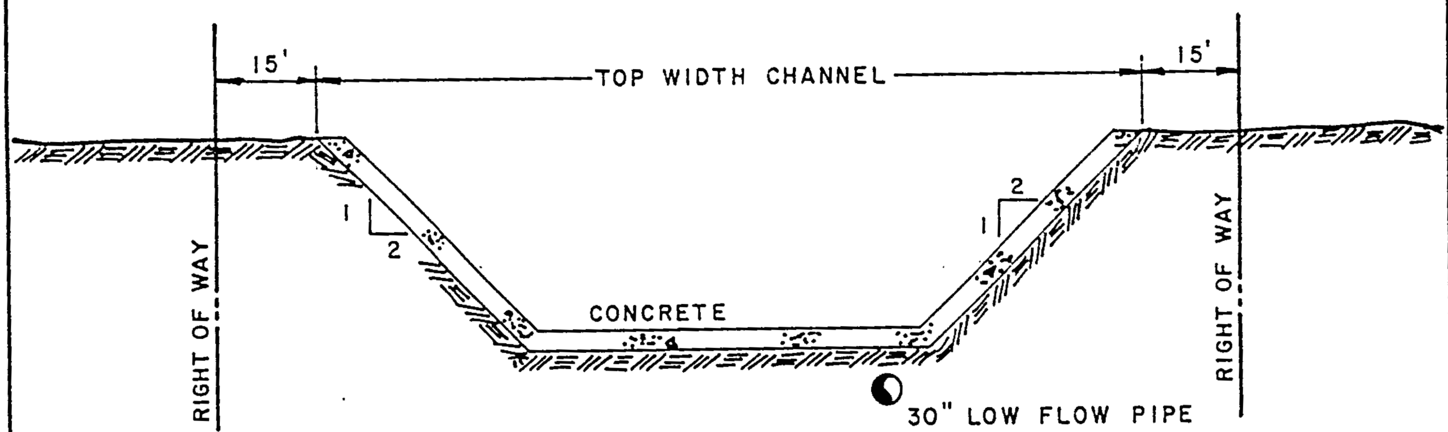
FIGURE 18

ALTERNATIVE A



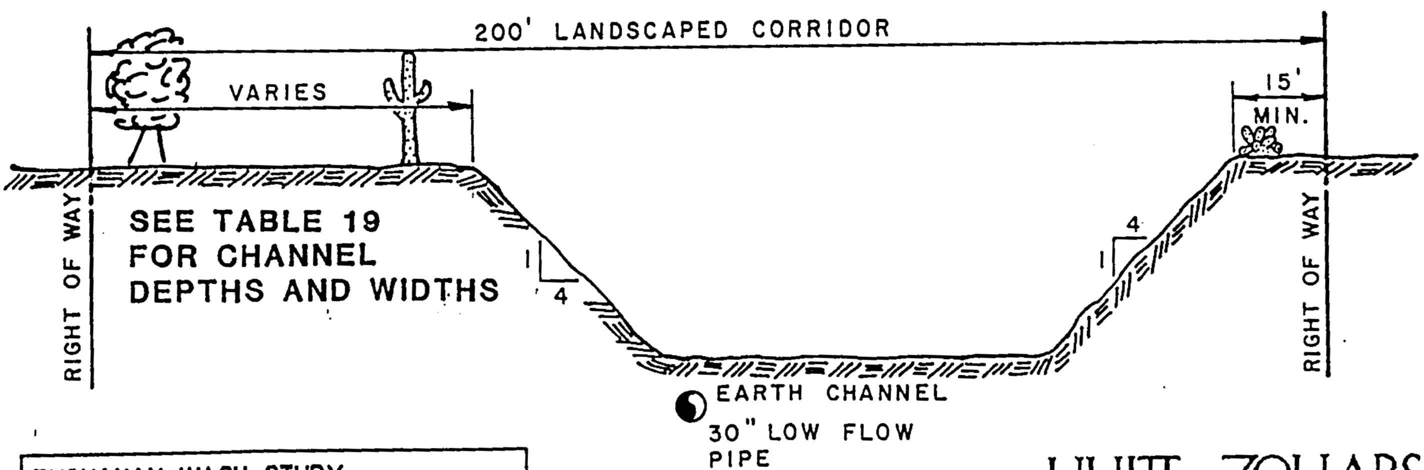
SEE TABLE 17 FOR CHANNEL DEPTHS AND WIDTHS

ALTERNATIVE B



SEE TABLE 18 FOR CHANNEL DEPTHS AND WIDTHS

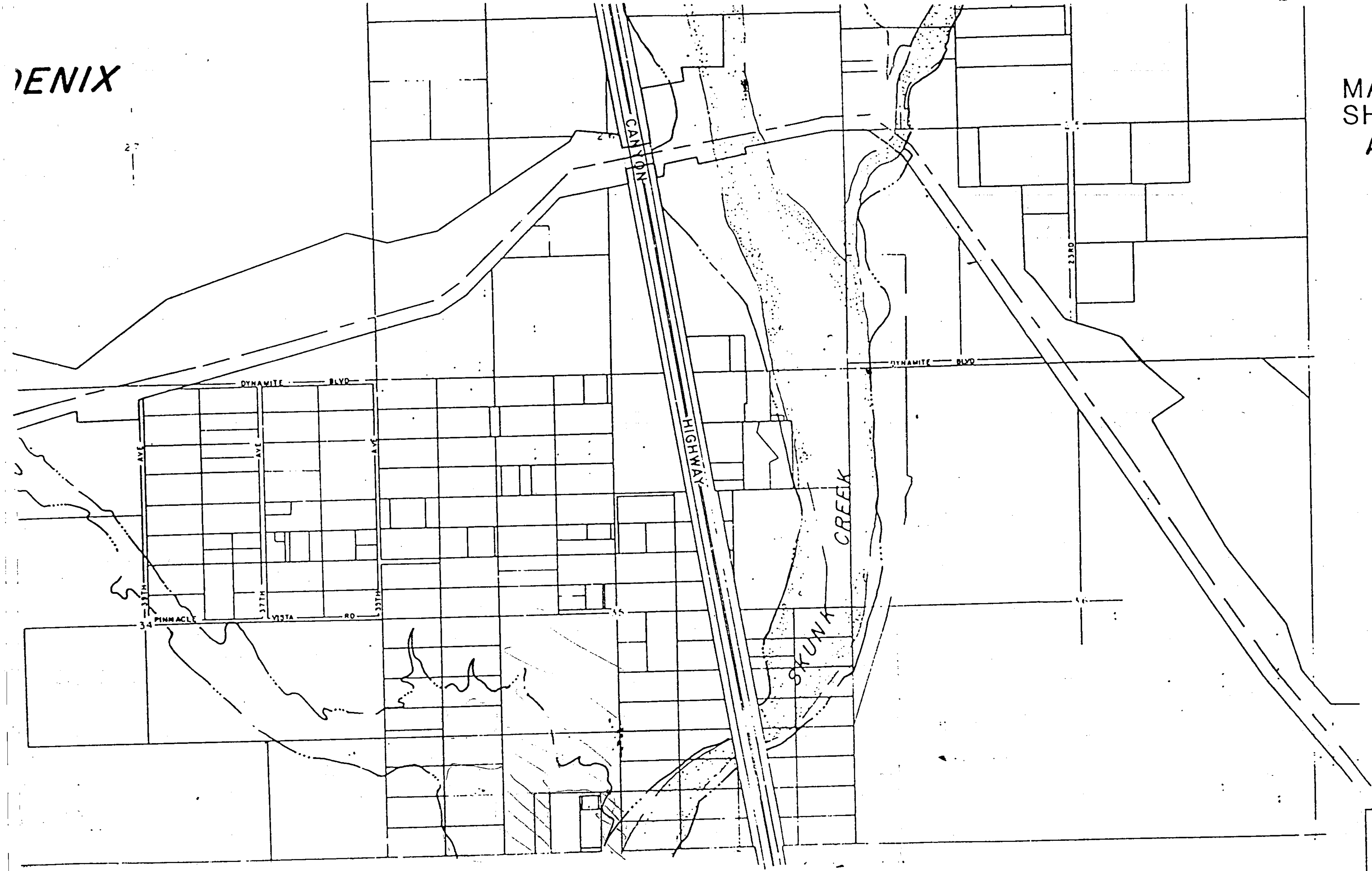
ALTERNATIVE C



BUCHANAN WASH STUDY
CITY OF PHOENIX
ALTERNATIVE MAJOR CHANNELS
INDEX NO. ST - 886382

HUITT - ZOLLARS
INCORPORATED
CONSULTING ENGINEERS

FIGURE 19



Z CASE	DATE	C	P
Z90-73	2-5-92		

REVISIONS

DATE	DATE
6 91 5 93	

TOWNSHIP 5 NORTH-RANGE 2 EAST, G.& S. R. B. M.
SOUTH HALF

MARICOPA COUNTY DEPARTMENT OF PLANNING & DEVELOPMENT

GRAPHIC SCALE IN FEET

0 600 1200 1800 2400 3000 3600

MAY 1958

MARICOPA COUNTY ARIZONA

A84

AREAS C AND D DRAINAGE STUDIES ROUTE SLIP

	ATTENTION		TELEPHONE	
	Mr. Roger Baele, P.E.	Jerry R. Jones & Assoc., Inc. (Area 2- Apache Wash)	602-956-9850	
	Mr. Tom Wilhite, P.E.	Huitt-Zollars, Inc. (Area 5 Buchannan Wash)	602-381-0125	
	Mr. Craig Smith, P.E.	SEA, Inc. (Area 6 Deadman Wash)	602-257-4699	
	Mr. Dennis Knudsen, P.E.	HKBW, Inc. (Area 3 East Biscuit Flat)	602-840-0280	
	Mr. Byron Glenn, P.E.	Collar, Williams & White (Area 7 Little Deer Valley	602-957-3350	
	Mr. Jeff Holzmeister, P.E.	Water Resources Assoc., Inc. (Area 1 Paradise Valley Fan Terrace)	602-381-1844	
*	Mr. Jim Burke	Parks, Recreation, & Library	602 262-4997	Vol I
*	Mr. Dwayne Williams, P.E.	Water & Wastewater Dept.	602-261-8355	Vol I
*	Mr. Bob Cafarella, A.I.P.	Planning Department	602-261-8682	Vol I
*	Mr. Don Park, P. E.	Acting Assistant Street Transportation Director	602-495-2050	Vol I
*	Mr. Lionel Lewis, P.E.	Flood Control District	602-262-1501	Vol I,II-D
*	Mr. Dempsey Helms	Arizona State Land Dept.	602-542-2671	Vol I,II-D
	Mr. Paul Kienow, P.E.	Floodplain Mgmt. Section	602-262-4960	
c:	Mr. John Baldwin, P.E.	Engineering Supervisor	602-256-4109	
*	Mr. Shane Shovestull, P.E.	Development Services Dept.	602-256-4103	Vol I
	Mr. Tom Graham	Landmark American Corp.	602-957-6816	
*	Ms. Corey Cox	Planning Department	602-261-8790	Vol I

TO: Addressees Listed Above DATE: 4/10/90

FROM: Paul Kienow *[signature]*

RE: BUCHANAN WASH ADMS ST-886382

RECEIVED
APR 13 1990

Final copy of report as noted. This completes this ADMS.

LCL

c: Don Herpe, Vol I - (Transportation Planning & Research)

Team (10th Floor Municipal Bldg.

Also with Paradise Valley Fan Terrace ADMS Vol I